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COMPENDIUM 16

Implementing Construction by Contract or Day Labor

Construcción por contrato o por administración

Exécution des travaux à l'entreprise ou en régie

TRANSPORTATION RESEARCH BOARD
NATIONAL ACADEMY OF SCIENCES

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W. G. WILSON, *International Road Federation (IRF liaison)*
ELDON J. YODER, *Purdue University*
JOHN P. ZEDALIS, *U.S. Agency for International Development (AID liaison)*

PROJECT STAFF AND LIAISON STAFF

PAUL E. IRICK, *Assistant Director for Special Technical Activities, TRB*
LLOYD R. CROWTHER, *Project Engineer, TRB*
H. STANLEY SCHOFER, *Manager, Information Systems Development and Operations, TRB*
JOHN W. GUINNEE, *Engineer of Soils, Geology, and Foundations, TRB (Division A liaison)*
THOMAS L. COPAS, *Project Engineer, TRB (NCHRP liaison)*
JANICE BAIN, *Librarian, TRB*
VICTOR RABINOWITCH, *Commission on International Relations, National Research Council (NRC liaison)*
MARY SECOY, *Administrative Assistant, TRB*
JUDITH L. FAULS, *Project Secretary, TRB*
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To share in the task of furthering science and engineering and of advising the federal government, the National Academy of Engineering was established on December 5, 1964, under the authority of the act of incorporation of the National Academy of Sciences. Its advisory activities are closely coordinated with those of the National Academy of Sciences, but it is independent and autonomous in its organization and election of members.

PN-AAJ-424

TRANSPORTATION TECHNOLOGY SUPPORT
FOR DEVELOPING COUNTRIES

COMPENDIUM 16

Implementing Construction by Contract or Day Labor

Construcción por contrato o por administración

Execution des travaux à l'entreprise ou en régie

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Notice

The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competence and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

Cover photo: Day-labor construction of a large drainage structure in Ethiopia.

Contents
Tabla de materias
Table des matières

PROJECT DESCRIPTION v
DESCRIPCION DEL PROYECTO
DESCRIPTION DU PROJET

FOREWORD AND ACKNOWLEDGMENTS ix
PREFACIO Y AGRADECIMIENTOS
AVANT-PROPOS ET REMERCIEMENTS

OVERVIEW xi
VISTA GENERAL
EXPOSE

SELECTED TEXTS 1
TEXTOS SELECCIONADOS
TEXTES CHOISIS

1. *Construction by Contract and by Day Labor* 3
(Construcción por contrato y por administración)
(Construction à l'entreprise et en régie)
Highway Research Board, 1943

2. *A Cost Comparison Study of Force Account and Contract Construction on Five Secondary Projects in North Carolina* 15
(Un estudio comparativo de costos de construcción por administración y por contrato en cinco proyectos secundarios en North Carolina)
(Etude comparative des coûts de construction en régie et à l'entreprise de cinq projets secondaires en Caroline du Nord)
Highway Research Board, 1956

3. *Preparation and Presentation of Project Documents* 27
(Preparación y presentación de los documentos del proyecto)
(Préparation et présentation de la documentation d'un projet)
The Indian Roads Congress, 1979

4. *Section 100 – General Provisions* 37
(Sección 100 — Provisiones generales)
(Section 100 — Provisions générales)
Federal Highway Administration, U.S. Department of Transportation, 1969

5. *Competitive Bidding and Award of Highway Construction Contracts* 77
(Licitación competitiva y adjudicación de contratos de construcción de carreteras)
(Appels d'offres et passation des marchés dans la construction routière)
Transportation Research Board, 1978

6. *Standard Specification for Road and Bridge Works* 153
(Especificación normal para caminos y puentes)
(Normes de construction pour les routes et les ponts)
Design Department, Ministry of Works and Supplies, Malawi, 1978

7. *Field Supervisors' Duties and Responsibilities, Volume 1, Contract Roadworks* 175
(Deberes y responsabilidades de los supervisores de campo, Volumen 1, Trabajos viales por contrato)
(Fonctions et charges des chefs de chantier, Volume 1, construction routière à l'entreprise)
National Association of Australian State Road Authorities, 1975

8. *Recommended Standards for the Responsibility, Authority, and Behavior of the Inspector* 197
(Normas recomendadas sobre la responsabilidad, autoridad y comportamiento del inspector)
(Normes recommandées pour la responsabilité, l'autorité et le comportement de l'inspecteur)
Proceedings of the American Society of Civil Engineers, June 1975

9. *The rural access roads programme, appropriate technology in Kenya* 207
(El programa de caminos rurales de acceso, tecnología apropiada en Kenia)
(Le programme des routes rurales de desserte, technologie adaptée au Kenya)
International Labour Office, 1980

10. *Optimum Working Time* 261
(Tiempo de trabajo óptimo)
(Temps optimal de travail)
Proceedings of the American Society of Civil Engineers, November 1977

11. *Optimum Number of Crews* 275
(Número óptimo de cuadrillas)
(Nombre optimal d'équipes)
Proceedings of the American Society of Civil Engineers, June 1978

12. *Critical path scheduling: an overview and a practical alternative* 289
(Programación por la ruta crítica: una vista general y una alternativa práctica)
(La programmation en utilisant la méthode du chemin critique: une vue d'ensemble et une alternative pratique)
Civil Engineering, ASCE, July 1980

BIBLIOGRAPHY 295
BIBLIOGRAFIA
BIBLIOGRAPHIE

INDEX 302
INDICE
INDEX

Project Description

The development of agriculture, the distribution of food, the provision of health services, and the access to information through educational services and other forms of communication in rural regions of developing countries all heavily depend on transport facilities. Although rail and water facilities may play important roles in certain areas, a dominant and universal need is for road systems that provide an assured and yet relatively inexpensive means for the movement of people and goods. The bulk of this need is for low-volume roads that generally carry only 5 to 10 vehicles a day and that seldom carry as many as 400 vehicles a day.

The planning, design, construction, and maintenance of low-volume roads for rural regions of developing countries can be greatly enhanced with respect to economics, quality, and performance by the use of low-volume road technology that is available in many parts of the world. Much of this technology has been produced during the developmental phases of what are now the more developed countries, and some is continually produced in both the less and the more developed countries. Some of the technology has been documented in papers, articles, and reports that have been written by experts in the field. But much of the technology is

Descripción del proyecto

En las regiones rurales de países en desarrollo, el desarrollo de la agricultura, la distribución de víveres, la provisión de servicios de sanidad, y el acceso a información por medio de servicios educacionales y otras formas de comunicación, dependen en gran parte de los medios de transporte. Aunque en ciertas áreas los medios de ferrocarril y agua desempeñan un papel importante, existe una necesidad universal y dominante de crear sistemas viales que provean un medio asegurado pero relativamente poco costoso para el movimiento de gente y mercancías. La mayor parte de esta necesidad se solucionaría con la construcción de caminos de bajo volúmen que generalmente moverían únicamente de 5 a 10 vehículos por día y que pocas veces moverían tanto como 400 vehículos por día.

El planeamiento, diseño, construcción y mantenimiento de caminos de bajo volúmen para regiones rurales de países en desarrollo pueden ser mejorados, con respecto al costo, calidad, y rendimiento, por el uso de la tecnología de caminos de bajo volúmen que se encuentra disponible en muchas partes del mundo. Mucha de esta tecnología ha sido producida durante las épocas de desarrollo de lo que ahora son los países más desarrollados, y alguna se produce contínuamente en estos países así como en los países menos desarrollados. Parte de la tecnología se ha documentado en disertaciones, artículos, e informes que han sido escritos por expertos en el campo. Pero mucha de la tecnología no está documentada y existe principalmente en la memoria de aquellos que han desa-

Description du projet

Dans les régions rurales des pays en voie de développement, l'exploitation agricole, la distribution des produits alimentaires, l'accès aux services médicaux, l'accès aux matériaux et aux marchandises, à l'information et aux autres services, dépendent en grande partie des moyens de transport. Bien que les transports par voie ferrée et par voie navigable jouent un rôle important dans certaines régions, un besoin dominant et universel existe d'un réseau routier qui puisse assurer avec certitude et d'une façon relativement bon marché, le déplacement des habitants, et le transport des marchandises. La plus grande partie de ce besoin peut être satisfaite par la construction de routes à faible capacité, capables d'accommoder un trafic de 5 à 10 véhicules par jour, ou plus rarement, jusqu'à 400 véhicules par jour.

L'utilisation des connaissances actuelles en technologie, qui sont accéssibles dans beau-

undocumented and exists mainly in the minds of those who have developed and applied the technology through necessity. In either case, existing knowledge about low-volume road technology is widely dispersed geographically, is quite varied in the language and the form of its existence, and is not readily available for application to the needs of developing countries.

In October 1977 the Transportation Research Board (TRB) began this 3-year special project under the sponsorship of the U.S. Agency for International Development (AID) to enhance rural transportation in developing countries by providing improved access to existing information on the planning, design, construction, and maintenance of low-volume roads. With advice and guidance from a project steering committee, TRB defines, produces, and transmits information products through a network of correspondents in developing countries. Broad goals for the ultimate impact of the project work are to promote effective use of existing information in the economic development of transportation infrastructure and thereby to enhance other aspects of rural development throughout the world.

In addition to the packaging and distribution of technical information, personal interactions with users are provided through field visits, con-

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rrollado y aplicado la tecnología por necesidad. En cualquier caso, los conocimientos en existencia sobre la tecnología de caminos de bajo volúmen estan grandemente esparcidos geográficamente, varían bastante con respecto al idioma y su forma, y no se encuentran fácilmente disponibles para su aplicación a las necesidades de los países en desarrollo.

En octubre de 1977 el Transportation Research Board (TRB) comenzó este proyecto especial de tres años de duración bajo el patrocinio de la U.S. Agency for International Development (AID) para mejorar el transporte rural en los países en desarrollo acrecentando la disponibilidad de la información en existencia sobre el planeamiento, diseño, construcción, y mantenimiento de caminos de bajo volúmen. Con el consejo y dirección de un comité de iniciativas para el proyecto, el TRB define, produce, y transmite productos informativos a través de una red de corresponsales en países en desarrollo. Las metas generales para el impacto final del trabajo del proyecto son la promoción del uso efectivo de la información en existencia en el desarrollo económico de la infraestructura de transporte y de esta forma mejorar otros aspectos del desarrollo rural a través del mundo.

Además de la recolección y distribución de la

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coup de pays, peut faciliter l'étude des projets de construction, tracé et entretien, de routes à faible capacité dans les régions rurales des pays en voie de développement, surtout en ce qui concerne l'économie, la qualité, et la performance de ces routes. La majeure partie de cette technologie a été produite durant la phase de développement des pays que l'on appelle maintenant développés, et elle continue à être produite à la fois dans ces pays et dans les pays en voie de développement. Certains aspects de cette technologie ont été documentés dans des articles ou rapports écrits par des experts. Mais une grande partie des connaissances n'existe que dans l'esprit de ceux qui ont eu besoin de développer et appliquer cette technologie. De plus, dans ces deux cas, les écrits et connaissances sur la technologie des routes à faible capacité, sont dispersés géographiquement, sont écrits dans des langues différentes, et ne sont pas assez aisément accessibles pour être appliqués aux besoins des pays en voie de développement.

En octobre 1977, le Transportation Research Board (TRB) initia ce projet, d'une duré de 3 ans, sous le patronage de l'U.S. Agency for International Development (AID), pour améliorer le transport rural dans les pays en voie de développement, en rendant plus accessible la documentation existante sur la conception, le tracé, la construction, et l'entretien des routes à faible capacité. Avec le conseil, et sous la conduite d'un comité de direction, TRB définit, produit, et transmet cette documentation à l'aide d'un réseau de correspondants dans les pays en voie de développement. Nous espérons que le résultat final de ce projet sera de favoriser l'utilisation de cette documentation, pour aider au développement économique de l'infrastructure des transports, et de cette façon mettre en valeur d'autres aspects d'exploitation rurale à travers le monde.

ferences in the United States and abroad, and other forms of communication

Steering Committee

The Steering Committee is composed of experts who have knowledge of the physical and social characteristics of developing countries, knowledge of the needs of developing countries for transportation, knowledge of existing transportation technology and experience in its use

Major functions of the Steering Committee are to assist in the definition of users and their needs, the definition of information products that match user needs, and the identification of informational and human resources for development of the information products Through its membership the committee provides liaison with project-related activities and provides guidance for interactions with users In general the Steering Committee gives overview advice and direction for all aspects of the project work

The project staff has responsibility for the preparation and transmittal of information products, the development of a correspondence network throughout the user community, and interactions with users

Information Products

Three types of information products are prepared compendiums of documented information on relatively narrow topics, syntheses of knowledge and practice on somewhat broader

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información técnica, se provee acciones recíprocas personales con los usuarios por medio de visitas de campo, conferencias en los Estados Unidos de Norte América y en el extranjero, y otras formas de comunicación

Comité de iniciativas

El comité de iniciativas se compone de expertos que tienen conocimiento de las características físicas y sociales de los países en desarrollo, conocimiento de las necesidades de transporte de los países en desarrollo, conocimiento de la tecnología de transporte en existencia, y experiencia en su uso

Las funciones importantes del comité de iniciativas son las de ayudar en la definición de usuarios y sus necesidades de productos informativos que se asemejan a las necesidades del usuario, y la identificación de recursos de conocimientos y humanos para el desarrollo de los productos informativos A través de sus miembros el comité provee vínculos con actividades relacionadas con el proyecto y también una guía para la interacción con los usuarios En general el comité de iniciativas proporciona consejos y dirección general para todos los aspectos del trabajo de proyecto

El personal de proyecto es responsable de la preparación y transmisión de los productos informativos, el desarrollo de una red de corresponsales a través de la comunidad de usuarios, y la interacción con los usuarios

Productos informativos

Se preparan tres tipos de productos informativos los compendios de la información documentada sobre temas relativamente limitados, la síntesis del conocimiento y práctica sobre temas

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En plus de la dissémination de cette documentation technique, des visites, des conférences aux Etats Unis et à l'étranger, et d'autres formes de communication permettront une interaction constante avec les usagers

Comité de direction

Le comité de direction est composé d'experts qui ont à la fois des connaissances sur les caractéristiques physiques et sociales des pays en voie de développement sur leurs besoins au point de vue transports sur la technologie actuelle des transports, et ont aussi de l'expérience quant à l'utilisation pratique de cette technologie

Les fonctions majeures de ce comité sont d'abord d'aider à définir les usagers et leurs besoins, puis de définir leurs besoins en matière de documentation, et d'identifier les ressources documentaires et humaines nécessaires pour le développement de cette documentation Par l'intermédiaire des ses membres, le comité pourvoit à la liaison entre les différentes fonctions relatives au projet, et dirige l'interaction avec les usagers En général, le comité de direction conseille et dirige toutes les phases du projet

Notre personnel est responsable de la préparation et de la dissémination des documents, du développement d'un réseau de correspondants pris dans la communauté d'usagers, et de l'interaction avec les usagers

La documentation

Trois genres de documents sont préparés, des recueils dont le sujet est relativement limité, des

subjects, and proceedings of low-volume road conferences that are totally or partially supported by the project. Compendiums are prepared by project staff at the rate of about 6 per year; consultants are employed to prepare syntheses at the rate of 2 per year. At least one conference proceedings will be published during the 3-year period. In summary, this project aims to produce and distribute between 20 and 30 publications that cover much of what is known about low-volume road technology.

Interactions With Users

A number of mechanisms are used to provide interactions between the project and the user community. Project news is published in each issue of ***Transportation Research News***. Feedback forms are transmitted with the information products so that recipients have an opportunity to say how the products are beneficial and how they may be improved. Through semiannual visits to developing countries, the project staff acquires first-hand suggestions for the project work and can assist directly in specific technical problems. Additional opportunities for interaction with users arise through international and in-country conferences in which there is project participation. Finally, annual colloquiums are held for students from developing countries who are enrolled at U.S. universities.

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un poco más amplios, y los expedientes de conferencias de caminos de bajo volúmen que están totalmente o parcialmente amparados por el proyecto. El personal de proyecto prepara los compendios a razón de unos 6 por año, se utilizan consultores para preparar las síntesis a razón de 2 por año. Se publicará por lo menos un expediente de conferencia durante el período de tres años. En breve, este proyecto pretende producir y distribuir entre 20 y 30 publicaciones que cubren mucho de lo que se conoce de la tecnología de caminos de bajo volúmen.

Interacción con los usuarios

Se utilizan varios mecanismos para proveer las interacciones entre el proyecto y la comunidad de usuarios. Se publican las noticias del proyecto en cada edición de la ***Transportation Research News***. Se transmiten, con los productos informativos, formularios de retroacción para que los recipientes tengan oportunidad de decir cómo benefician los productos y cómo pueden ser mejorados. A través de visitas semianuales a los países en desarrollo, el personal del proyecto adquiere directamente de fuentes originales sugerencias para el trabajo del proyecto y puede asistir directamente en problemas técnicos específicos. Surgen oportunidades adicionales para la interacción con los usuarios a través de conferencias internacionales y nacionales en donde participa el proyecto. Finalmente, se organizan diálogos con estudiantes de países en desarrollo que están inscriptos en universidades norteamericanas.

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synthèses de connaissances et de pratique sur des sujets beaucoup plus généraux, et finalement des comptes-rendus de conférences sur les routes à faible capacité, qui seront organisées complètement ou en partie par notre projet. Environ 6 recueils par an sont preparés par notre personnel. Deux synthèses par an sont écrites par des experts pris à l'extérieur. Les comptes-rendus d'au moins une conférence seront écrits dans une période de 3 ans. En résumé, l'objet de ce projet est de produire et disséminer entre 20 et 30 documents qui couvriront l'essentiel des connaissances sur la technologie des routes à faible capacité.

Interaction avec les usagers

Un certain nombre de mécanismes sont utilisés pour assurer l'interaction entre le personnel du projet et la communauté d'usagers. Un bulletin d'information est publié dans chaque numéro de ***Transportation Research News***. Des formulaires sont joints aux documents, afin que les usagers aient l'opportunité de juger de la valeur de ces documents et de donner leur avis sur les moyens de les améliorer. Au cours de visites semi-annuelles dans les pays en voie de développement notre personnel obtient de première main des suggestions sur le bon fonctionnement du projet et peut aider à résoudre sur place certains problèmes techniques spécifiques. En outre, des conférences tenues soit aux Etats Unis, soit à l'étranger, sont l'occasion d'un échange d'idées entre notre personnel et les usagers. Finalement, des colloques annuels sont organisés pour les étudiants des pays en voie de développement qui étudient dans les universités américaines.

Foreword and Acknowledgments

This book is the eighteenth product of the Transportation Research Board's project on Transportation Technology Support for Developing Countries under the sponsorship of the U S Agency for International Development The objective of this book is that it provide useful and practical information for those in developing countries who have direct responsibility for implementing construction by contract or day labor

Feedback from correspondents in developing countries will be solicited and used to assess the degree to which this objective has been attained and to influence the nature of later products

Acknowledgment is made to the following publishers for their kind permission to reprint the selected text portions of this compendium. Indian Roads Congress, New Delhi, Federal Highway Administration, Ministry of Works and Supplies, Malawi, National Association of Australian State Road Authorities, Sydney, American Society of Civil Engineers, and International Labour Office, Geneva.

Prefacio y agradecimientos

Este libro es el décimoctavo producto del proyecto del Transportation Research Board sobre Apoyo de Tecnología de Transporte para Países en Desarrollo bajo el patrocinio de la U.S Agency for International Development El objetivo de este libro es el de proveer información útil y práctica para aquellos en países en desarrollo quienes tienen responsabilidad directa para la construcción por contrato o por administración

Se pedirá a los corresponsales en los países en desarrollo información sobre los resultados, para utilizarse en el asesoramiento del grado al cual se ha obtenido ese objetivo, y para influenciar la naturaleza de productos subsequentes.

Se reconoce a los siguientes editores por el permiso dado para reimprimir las porciones de texto seleccionadas para este compendio: Indian Roads Congress, New Delhi; Federal Highway Administration; Ministry of Works and Supplies, Malawi; National Association of Australian State Road Authorities, Sydney; American Society of Civil Engineers; y International Labour Office, Geneva.

Avant-propos et remerciements

Ce livre représente le dix-huitième volume du projet Research Board sur la du Transportation Technologie des transports à l'usage des pays en voie de développement Ce projet est placé sous le patronage de l'U S Agency for International Development L'objet de ce recueil est de réunir une documentation pratique et utile qui puisse aider les personnes responsables de l'exécution des travaux à l'entreprise ou en régie. La réaction des correspondants des pays en voie de développement sera sollicitée et utilisée pour évaluer à quel point le but proposé de ce projet a été atteint, et pour influencer la nature des ouvrages à venir.

Nous remercions les éditeurs qui ont gracieusement donné leur permission de reproduire les textes sélectionnés pour ce recueil: Indian Roads Congress, New Delhi; Federal Highway Administration; Ministry of Works and Supplies, Malawi; National Association of Australian State Road Authorities, Sydney; American Society of Civil Engineers; et International Labour Office, Geneva.

Appreciation is also expressed to libraries and information services that provided references and documents from which final selections were made for the selected texts and bibliography of this compendium. Special acknowledgment is made to the U.S. Department of Transportation Library Services Division and to the Library and Information Service of the U.K. Transport and Road Research Laboratory (TRRL).

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Overview

Background and Scope

There are two principal methods of accomplishing public highway construction projects — by contract or day labor. In the contract system, the highway agency enters into a legal agreement with a contractor who usually promises (a) to furnish all labor, materials, and equipment required for the construction and (b) to complete the work according to plans and specifications. The contractor also agrees to protect the owner (i.e., the government) from all losses due to damage suits, liens, or other causes. The contractor assumes financial responsibility for the completion of the work (usually by means of a contract performance bond) and is usually required to complete the work within a specified time. There are several forms of contracts that include (a) cost plus percentage, (b) cost plus fixed fee, (c) negotiated lump sum, (d) competitive lump sum, and (e) unit price. In the day labor system, the highway agency itself undertakes the work with employees hired for the purpose. This method is frequently called force account work although the terms day labor and force account are not synonymous. Force account is the term used under a contract to designate extra work done by the contractor for which no price was bid in the contract.

These methods are basically methods of ex-

Vista General

Antecedentes y alcance

Hay dos métodos principales para ejecutar proyectos de construcción de carreteras públicas — por contrato o por administración. En el sistema por contrato, el organismo vial llega a un acuerdo legal con un contratista quien generalmente ofrece (a) proporcionar toda la mano de obra, materiales y equipo requeridos para la construcción, y (b) completar el trabajo de acuerdo a los planos y especificaciones. El contratista conviene también en proteger al propietario (esto es, el gobierno) de todas las pérdidas originadas por juicios por daños, embargos u otras causas. El contratista asume la responsabilidad financiera por la terminación del trabajo (por lo general mediante una fianza de buena ejecución del contrato) y usualmente debe terminar el trabajo dentro de un plazo especificado. Hay varias formas de contrato que incluyen (a) costo más porcentaje, (b) costo más un honorario fijo, (c) suma total negociada, (d) suma total competitiva, y (e) precio unitario. En el sistema por administración, el mismo organismo vial ejecuta el trabajo con personal contratado para ese propósito. Frecuentemente se

Exposé

Historique et description

Il y a deux méthodes principales pour l'exécution de travaux publics — par marché c'est à dire à l'entreprise ou en régie c'est à dire par l'administration des travaux publics. Dans le travail à l'entreprise, l'organisme routier signe un accord légal avec un entrepreneur qui promet normalement de (a) fournir toute la main d'œuvre, les matériaux et le matériel requis pour la construction, et (b) compléter les travaux suivant les plans et directives de réception. L'entrepreneur accepte aussi de garantir le propriétaire (c'est à dire le gouvernement) contre toutes pertes dûes aux procès en dommages-intérêts, au droit de rétention, ou à toute autre cause. L'entrepreneur assume la responsabilité financière de l'exécution des travaux (en général garantie par un cautionnement) et il est tenu de finir ceux-ci dans des délais spécifiés. Il y a plusieurs sortes de marches, parmi eux sont inclus (a) coût plus pourcentage, (b) coût plus un forfait fixe, (c) forfait total négocié, (d) forfait compétitif, et (e) prix unitaire. Quand le travail se

pending funds and are not to be confused with the concept of equipment-intensive versus labor-intensive construction methods. Local contractors engaged in low-volume road construction may very well find themselves actively engaged in labor-oriented construction methods because of the lower initial investment requirements. Many government agencies find that they have equipment time and capability that can be put to use by undertaking construction with their own personnel.

Both concepts, contract construction and day labor construction, connote a limited time frame such as an individual construction project. However, many developing country highway agencies use a construction capability on a permanent basis, augmenting it with construction contracts only to handle any construction overload. It is perhaps the implication of a short-lived employment opportunity in the term day labor construction that has encouraged the inaccurate use of the designation of force account construction to describe construction carried out by government personnel.

The concept of these different funding methods can obviously be used in other highway agency programs. Most notable are (a) highway design that uses consulting or government engineers and (b) contract or departmental maintenance activities. Other activities, such as equipment maintenance or repair, are also suitable candidates for contract or day labor funding.

Both types of construction funding (or other

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denomina a este método trabajo por administración delegada (o trabajos adicionales), aunque dichos términos no son sinónimos. Administración delegada es un término empleado en un contrato para designar un trabajo adicional ejecutado por un contratista por el que no se especificó ningún precio en el contrato original.

Estos métodos son básicamente para gastar los fondos disponibles y no deben confundirse con los conceptos relacionados con métodos de construcción con uso intensivo de equipo o empleo intensivo de mano de obra. Los contratistas locales involucrados con la construcción de caminos de bajo volumen pueden fácilmente involucrarse en forma activa con métodos de construcción orientados al uso de mano de obra, debido a los menores requerimientos de inversión inicial. Muchos organismos gubernamentales comprenden que disponen de equipo y de capacidad técnica que pueden emplear para encargarse de la construcción con su propio personal.

Ambos conceptos, la construcción por contrato y por administración, connotan un marco limitado de tiempo tal como occure con un proyecto de construcción individual. Sin embargo, muchos organismos viales de países en desarrollo emplean su capacidad constructiva sobre una base permanente, complementándola con contratos de construcción sólo cuando hay exceso de obras por ejecutar. Dado que el término construcción por administración implica una oportunidad de trabajo de corta duración, ha alentado quizás al uso inadecuado del término administración delegada o trabajo adicional para describir la construcción ejecutada por personal del gobierno.

Obviamente, se puede utilizar el concepto de estos diferentes métodos de inversión en cualquier otro programa de la administración vial.

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fait en régie, c'est l'administration routière elle-même qui se charge de l'exécuter avec de la main d'œuvre qu'elle embauche pour le projet. Fréquemment en anglais on a tendance à appeller ce système "force account" au lieu de "day labor" bien que ces deux termes ne soient pas du tout synonymes. "Force account" est le terme utilisé dans un marché pour désigner les travaux imprévus, mais essentiels à l'achèvement du projet, qui sont exécutés par un entrepreneur, et pour lesquels n'a été spécifié aucun prix lors de la passation du marché original.

Ces méthodes sont essentiellement différentes façons d'utiliser les fonds disponibles, et ne doivent pas être confondues non plus avec le concept du choix entre les techniques à forte intensité de main-d'œuvre, et les techniques à forte intensité de capital. Les entrepreneurs locaux, qui construisent des routes économiques, peuvent très bien se trouver amenés activement à l'utilisation de techniques orientées vers la main-d'oeuvre, car celles-ci requièrent un investissement initial moins important. Beaucoup d'administrations routières s'aperçoivent par ailleurs qu'elles ont du matériel, du temps, et des moyens qui peuvent être utilisés à bon escient en employant leur propre personnel pour la construction.

Les deux concepts, construction à l'entreprise et construction en régie, impliquent une periode de travaux limitée, telle qu'un certain projet de construction. En fait, beaucoup d'administrations routières de pays en voie de développement, ont une force de construction qu'elles utilisent

activity funding) require considerable highway agency involvement. The concept that contract construction relieves the owner (the government) of any responsibility for supervision and inspection of the construction activity is well recognized as false. However, the idea that day labor construction completely relieves the highway agency of proper planning, project evaluation, engineering design, use of specifications and plans, or time and financial constraints is still in vogue in some agencies.

Compendium 16 considers the similarities and differences of highway agency involvement in the preparation and execution of these two construction methodologies. It presents many of the procedural techniques currently in use and the reasons for their use. These agency activities are not limited to low-volume road construction but apply to all highway construction, although the degree of involvement (the financial expenditures warranted) will vary with the size of the undertaking.

Los más notables son (a) el diseño vial que emplea a ingenieros consultores o del gobierno, y (b) los contratos o las actividades de conservación de la organización vial. Otras actividades llegan también a ser candidatos adecuados para una inversión por contrato o por administración, tales como el mantenimiento o la reparación del equipo.

Ambos tipos de inversión en construcción (o en cualquier otra actividad) requieren de una participación considerable de parte del organismo vial. El concepto de que el contrato de construcción exonera al propietario (el gobierno) de cualquier responsabilidad en las actividades de supervisión e inspección de las obras, se reconoce bien que es totalmente falso. Sin embargo, la idea de que la construcción por administración exonera al organismo vial de una planificación adecuada, de una evaluación del proyecto, del diseño de ingeniería, del uso de especificaciones y de planos, o de limitaciones financieras y de plazos de ejecución, sigue aún de moda en algunos organismos.

El Compendio 16 considera las similitudes y diferencias en que el organismo vial se encuentra involucrado en la preparación y ejecución de estas dos metodologías de construcción. Presenta muchas de las técnicas de procedimientos utilizados corrientemente y las razones para su empleo. Estas actividades no están limitadas a la construcción de caminos de bajo volumen sino que se aplican a toda construcción de carreteras, aunque el grado de participación del organismo vial (considerando que están garantizados los gastos financieros) variará de acuerdo con el tamaño del trabajo a ejecutar.

El Compendio 16 se interesa en la mecánica de preparar y llevar a cabo los proyectos de construcción por contrato o por administración. No intenta ser una cartilla técnica para la implementación de un proyecto; en consecuencia, no trata sobre procedimientos para seleccionar un proyecto, detalles de diseños de ingeniería, o técnicas constructivas. Asume que el proyecto ha sido seleccionado, diseñado y financiado.

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de façon permanente, et elles l'augmentent en employant des entreprises seulement quand il y a une surcharge de travail. Cette implication de quelque chose de temporaire dans le terme anglais "day labor" c'est à dire, traduit littéralement, "travail à la journée", a peut être été la raison de l'emploi erroné du terme "force account construction" pour decrire des travaux faits en régie par le personnel de l'administration.

Le concept de ces différentes méthodes de financement peut évidemment être appliqué à d'autres programmes des administrations routières, particulièrement pour (a) les études de projets, en employant soit des ingénieurs routiers fonctionnaires, soit des cabinets d'étude privés, et (b) les travaux d'entretien, soit à l'entreprise, soit en régie. D'autres activités routières, telles que la réparation ou l'entretien du materiel, se prêtent aussi très bien au financement à l'entreprise ou en régie.

Ces deux sortes de financement de la construction (ou de toute autre activité), requièrent une participation considérable de la part de l'administration routière. Le concept que la construction à l'entreprise exonère complètement le propriétaire (i.e., le gouvernement) de toute responsabilité quant à la supervision et l'inspection des travaux routiers, est reconnu comme étant tout à fait inexact. Toutefois l'idée que la construction en régie exonère l'administration routière de l'étude de la planification, évaluation, et dimensionnement du projet, ainsi que de l'utilisation des plans et des spécifications, ou de contraintes financières ou de temps, est toujours en vogue dans certaines administrations.

Dans le recueil no. 16, nous allons étudier les similitudes et les particularités de la participation de l'administration routière, en la préparation et l'exécution de ces deux méthodologies de construction. On présente plusieurs techniques de

Compendium 16 is concerned with the mechanics of preparing for and carrying out contract or day labor construction projects. It is not intended as an engineering primer in project implementation; therefore, it does not dwell on project selection procedures, engineering design details, or construction techniques. It assumes that the project has been selected, engineered, and financed.

Rationale for This Compendium

Many countries use both contract and day labor construction. A few countries are limited to contract construction only because their highway departments do not have a day labor construction capability. Other countries are limited to day labor construction (especially for low-volume roads) because there are no local contractors currently available. However, as different capabilities are developed or increased, reevaluation is often necessary.

Normally, unit price contract construction is considered more efficient, while day labor construction is considered more flexible. The first conclusion is based on the assumptions that a contractor brings a certain expertise to a project, is more efficient because of competition, and has a higher degree of motivation than is found among some government employees. The second conclusion is based on the assumption that government forces may operate without a com-

Exposición razonada para este compendio

Muchos países emplean tanto la construcción por contrato como la construcción por administración. Algunos países están únicamente limitados a la construcción por contrato debido a que los organismos viales no tienen capacidad constructiva para hacer las obras por administración. Otros países están limitados a la construcción por administración (especialmente para caminos de bajo volumen), debido a que frecuentemente no disponen de contratistas locales. Sin embargo, a medida que se desarrolla o aumenta la capacidad de los países, se hace necesaria una reevaluación.

Normalmente se considera más eficiente el contrato de construcción por precios unitarios, mientras que la construcción por administración es más flexible. La primera conclusión se basa en asumir que un contratista trae cierta destreza para ejecutar un proyecto, que es más eficiente debido a la competencia, y que tiene un mayor grado de motivación que el que se encuentra entre algunos empleados gubernamentales. La segunda conclusión se basa en asumir que el personal del gobierno puede operar sin necesidad de una descripción detallada predeterminada y completa de cada actividad de trabajo, que puede alterar los métodos y procedimientos con mayor facilidad para satisfacer condiciones imprevistas, y que puede aumentar o disminuir rápidamente el personal de obreros según sea necesario.

En la práctica, la preparación de una evaluación detallada de los procedimientos de trabajo que conduce a la determinación de las partidas contractuales en un contrato de precios unita-

procédure actuellement en cours, et les raisons pour lesquelles on les utilise. Ces activités ne sont pas limitées à la construction des routes économiques, mais s'appliquent à toute construction routière bien que le degré de participation (le montant des fonds nécessaire) soit variable selon les dimensions du travail à exécuter.

Le recueil no. 16 traite du méchanisme, de la préparation, et de l'exécution de projets de constructions faits soit à l'entreprise, soit en régie. Ce n'est pas un manuel élémentaire sur la mise en oeuvre d'un projet, par conséquent, il ne traite pas des techniques de sélection et de construction, ni des détails de dimensionnement ou de calcul d'un projet. On présume que le projet a été décidé, calculé, et qu'on en a acquis le financement.

Objectif de ce recueil

Dans beaucoup de pays, on fait les travaux de construction routière à l'entreprise ou en régie. Quelques pays sont restreints à employer des entreprises, car leurs administrations routières n'ont pas les moyens de faire elles-mêmes le travail. D'autres pays sont obligés de faire le travail en régie, (spécialement la construction de routes économiques) car il n'y existe pas actuellement d'entreprises. Toutefois, il est souvent nécessaire de ré-évaluer les choses, au fur et à mesure que les moyens se développent ou augmentent.

Normalement, la construction au prix unitaire est considérée comme étant la plus efficiente, et la construction en régie comme étant la plus

plete predetermined detailed description of every work activity, they may alter methods or procedures more readily to meet unanticipated conditions, and day labor forces may be rapidly increased or decreased as necessary.

In practice, the preparation of a detailed evaluation of the work procedures, which leads to the determination of contract items in a unit price contract, should be made for both construction methodologies. This will ensure that day labor forces, especially if they are permanent employees, will also work expeditiously. If management is reluctant to define the job requirements of its own construction division, it is usually because the true costs of day labor construction are less obvious than those that appear in contract tenders. This same apparent lack of management sensitivity to true day labor construction costs sometimes obstructs employee training and serious attempts to properly motivate the employees. Such management inattention can reflect unfairly on the production capabilities of a day labor construction group.

A well-defined package of documents is generally included with any construction contract offered for tender. This package normally contains highway construction plans and specifications that all become a part of the contract. The specifications are further subdivided into (a) Standard Specifications, (b) Supplemental Specifications, and (c) Special Provisions.

Standard Specifications consist of three categories of explicit specifications. They are

1. General Provisions covering such items as

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rios, debe hacerse para ambos métodos de construcción. Esto aseguaría que el personal del gobierno, especialmente si se trata de empleados permanentes, también trabaje expeditamente. Si la administración es renuente a definir los requerimientos de trabajo de su propia división de construcción, se debe generalmente a que los costos reales de la construcción por administración son menos evidentes que los que aparecen en las propuestas de los contratistas. Esta misma falta aparente de sensibilidad administrativa a los costos reales de la construcción por administración, obstaculiza algunas veces el entrenamiento del empleado y los intentos serios de motivar adecuadamente a los empleados gubernamentales. Dicha falta de atención administrativa puede reflejarse falsamente en la capacidad de producción de un grupo de construcción por administración.

Generalmente se incluye en cualquier contrato de construcción por licitar, un juego de documentos bien definidos. Este juego contiene normalmente planos y especificaciones de construcción de carreteras que forman parte del contrato. Las especificaciones se subdividen adicionalmente en (a) Especificaciones Normales, (b) Especificaciones Suplementarias, y (c) Provisiones Especiales.

Las Especificaciones Normales consisten de tres categorías de especificaciones explícitas. Ellas son:

1. Provisiones Generales que cubren partidas tales como definiciones, procedimientos de contrato, relaciones legales, prosecución y progreso, y reglas generales de medición y de pago;

2. Detalles Constructivos que definen en cada actividad principal de construcción, parti-

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souple. La première assertion découle du fait que l'on suppose qu'un entrepreneur possède une certaine compétence en la matière, est plus efficient à cause de la concurrence, et est motivé à un plus haut degré que certains fonctionnaires. La deuxième assertion se base sur l'hypothèse que la main d'oeuvre en régie peut opérer sans avoir une description détaillée, complète, et prête à l'avance, de toutes les tâches, qu'elle peut plus facilement modifier les méthodes et procédures pour faire face à l'imprévu, et qu'on peut augmenter ou diminuer son effectif.

En pratique, la préparation de l'évaluation détaillée des procédés de travail, qui mène à la détermination des articles contractuels dans un marché à prix unitaires, devrait être faites pour les deux méthodologies de construction. On aura ainsi l'assurance que les ouvriers en régie, particulièrement si leur emploi est inamovible, travaillerons de façon expéditive. Si l'administration est hésitante à définir ce que requiert sa propre division de construction, c'est la plupart du temps parce le coût véritable de la construction en régie est moins manifeste que ceux qui apparaissent dans les appels d'offre. Ce même manque ostensible de sensibilité administrative à l'égard du coût véritable du travail en régie, obstrue quelquefois la formation technique des employés, et prévient parfois tout essai sérieux de motiver de façon adéquate ces mêmes employés.

Une documentation précise accompagne généralement les marchés sur appel d'offres. Cette documentation contient normalement les plans et spécifications de construction de la route, et

definitions, contract procedures, legal relations, prosecution and progress, and general rules of measurement and payment.

2. Construction Details that define for each major construction activity such items as description of work, materials used, methods of construction, methods of measurement, and basis of payment; and

3. Materials Specifications that define the materials referenced in the construction details section and the acceptance tests to be made or required by the supervisory engineer.

Supplemental Specifications amend, delete, or add to the Standard Specifications. They also provide information related, in general, to all projects.

Special Provisions serve the same purpose as the Supplemental Specifications, except that they are single-project oriented (i.e., they apply only to the project to be constructed). In order of importance, a Special Provision, because it is prepared specifically for the project under consideration, assumes priority over any other part of a legal contract. The plans, which are also prepared for the project under consideration, are next in importance. The Supplemental Specifications, which serve to update the Standard Specifications, have priority only over Standard Specifications. With the exception of the General Provisions and the bases of payment, the same type of package should be prepared for day labor construction projects if such projects are to be economically viable.

Several selected texts in Compendium 16

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das tales como descripción del trabajo, materiales empleados, métodos de construcción, métodos de medida y bases de pago; y

3. Especificaciones de Materiales que definen los materiales mencionados en la sección de detalles de construcción y en los ensayos de aceptación que deben hacerse o que exige el ingeniero supervisor.

Las Especificaciones Suplementarias corrigen, suprimen o se agregan a las Especificaciones Normales. También proporcionan información relacionada, en general, con todos los proyectos.

Las Provisiones Especiales sirven el mismo propósito que las Especificaciones Suplementarias, excepto que están orientadas a un proyecto individual (ésto es, sólo se aplican al proyecto por construir). En orden de importancia, una Provisión Especial desde que es preparada específicamente para el proyecto bajo consideración, asume prioridad sobre cualquier otra parte de un contrato legal. Los planos, que también son preparados para el mismo proyecto, son los siguientes en importancia. Las Especificaciones Suplementarias que sirven para actualizar las Especificaciones Normales, tienen prioridad sobre éstas. Con excepción de las Provisiones Generales y las bases de pago, debe prepararse el mismo tipo de juegos de planos y documentos para los proyectos de construcción por administración, si se desea que éstos resulten económicamente viables.

Varios textos seleccionados del Compendio 16 se concentran en las Provisiones Generales de las Especificaciones Normales, debido a que dichos artículos definen la implementación de un contrato de construcción. Aunque se mencionan otros tipos de contratos, los textos selec-

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les spécifications qui deviennent partie du marché. Les spécifications sont de plus subdivisées en (a) spécifications du cahier des charges, (b) spécifications supplémentaires, et (c) clauses spéciales.

Les spécifications du cahier des charges contiennent trois catégories de spécifications explicites qui sont:

1. Clauses générales — couvrant les définitions, procédures de passation du marché, relations légales, poursuites, vitesse d'exécution, et régles générales de mesure et paiement.

2. Détails de construction qui définissent pour chaque activité principale de construction, la description du travail, les matériaux à utiliser, les méthodes de construction, les méthodes de mesure et la base de paiement.

3. Spécifications des matériaux qui définissent les matériaux dont il est question dans la section "Détails de construction" et les essais de réception qui doivent être faits, ou qui sont exigés par l'ingénieur en chef.

Les spécifications supplémentaires modifient, suppriment, ou s'ajoutent aux spécifications du cahier des charges. Elles fournissent aussi des informations relatives, en général, à tous les projets.

Les clauses spéciales s'adressent aux mêmes fins que les spécifications supplémentaires, sauf qu'elles sont orientées vers un seul projet (c'est à dire qu'elles ne s'appliquent qu'à la construction projetée). En ordre d'importance, une clause spéciale, puisqu'elle est écrite spécifiquement pour le projet considéré, a priorité sur

concentrate on the General Provisions of the Standard Specifications because these articles define the implementation of a construction contract. Although other types of contracts are mentioned, the selected texts are primarily concerned with unit price contracts because these contracts offer the best possibility for open competition in bid submission. When parts of the work cannot be properly defined, lump sum competitive bids can be taken for such items in the contract. Negotiated lump sum and cost plus contracts are not seriously considered in this compendium because of the possibility that (a) they may not result in the lowest obtainable contract price and (b) they afford an opportunity for favoritism or for collusion between the negotiators.

Once a contract is awarded, the highway agency must oversee the contractor's execution of the work involved. Because the relation between the government and the contractor is a legal one, both parties should understand their proper role as defined by the contract documents. Usually the contract specifies that the contractor must provide competent experienced personnel. Highway agency management should realize that the contractor expects that the supervisory and inspection personnel assigned by the government will possess the same qualifications and that it is in the government's best interest to provide such personnel. Two of the selected texts discuss the duties and responsibilities of the government's representatives on contract construction projects.

As indicated, the documentation of work procedures for day labor construction should be the same as those for a construction contract for a similar road. Day labor forces should be expected to produce the same quality of work demanded of a contractor. The agency responsible

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cionados se relacionan principalmente con contratos a precios unitarios debido a que ofrecen la mejor posibilidad para competir abiertamente en la presentación de una propuesta. Cuando no es posible definir adecuadamente algunas partes del trabajo, se pueden tomar para ellas dentro del contrato, propuestas competitivas a suma alzada. Los contratos negociados a suma alzada (monto total) o a costo más porcentaje, no han sido seriamente considerados en este compendio, por la posibilidad de que (a) no pueda obtenerse así un precio contractual más bajo, y (b) brinden una oportunidad para el favoritismo o confabulación entre los negociadores.

Una vez que se adjudica un contrato, la organización vial debe inspeccionar la ejecución del trabajo a cargo del contratista. Debido a que la relación entre el gobierno y el contratista es legal, ambas partes deben comprender su verdadero rol de acuerdo a lo definido por los documentos del contrato. Este especifica generalmente que el contratista debe proporcionar un personal experimentado competente. La administración del organismo vial deberá comprender que el contratista espera que el personal de supervisión y control asignado por el gobierno debe poseer las mismas calificaciones y que es de interés del gobierno proporcionar ese nivel de personal. Dos de los textos seleccionados analizan los deberes y responsabilidades de los representantes del gobierno en los proyectos de construcción por contrato.

Como se indicó anteriormente, la documentación de los procedimientos de trabajo para la

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n'importe quelle autre partie d'un contrat légal. Ensuite, en deuxième ordre d'importance, viennent les plans qui sont aussi préparés spécifiquement pour le projet en question. Les spécifications supplémentaires, qui servent à mettre à jour les spécifications du cahier des charges, n'ont priorité que sur ces dernières. A l'exception des clauses générales et des bases de paiement, la même documentation devrait être préparée pour les projets de construction en régie si l'on désire qu'ils soient économiquement viables.

Dans plusieurs textes choisis de ce recueil, on se concentre sur les clauses générales des spécifications du cahier des charges car celles-ci définissent l'exécution d'un contrat de construction. Bien qu'on fasse mention d'autres genres de contrats, on parle principalement dans les textes choisis de marchés à prix unitaires, car ceux-ci offrent la meilleure possibilité d'établissement d'une concurrence réelle lors des appels d'offre. Lorsqu'il est impossible de définir exactement certaines parties des travaux, des appels d'offre à prix forfaitaire peuvent être faits pour celles-ci. Les marchés à forfait négocié, et ceux à coût plus pourcentage, ne sont pas sérieusement considérés dans ce recueil, parce qu'ils offrent (a) le risque de ne pas obtenir le prix contractuel le plus bas possible et (b) ils laissent la porte ouverte au favoritisme, ou même à la collusion entre les négociateurs.

Après la passation d'un marché, l'administration routière doit surveiller l'exécution des travaux faits par l'entrepreneur. Puisque le rapport entre le gouvernement et l'entrepreneur est légal, les deux devraient comprendre leur rôle

for the design and specifications for low-volume roads should ensure that the specifications define the material and workmanship required to achieve the necessary level of service. Specifications defining unnecessarily high standards for either contract or day labor construction will result in a larger capital outlay with no corresponding benefits.

Day labor construction projects often lack the same system of verification (by a separate inspection team) used to supervise contractors. The personnel managing day labor construction projects sometimes suffers from lack of motivation (i.e., they are not spending their own money). Therefore, a highway agency should (a) use only experienced personnel, (b) conduct a continuing training program to assure a pool of capable personnel, and (c) provide proper motivation for their construction supervisors. Compendium 16 contains a selected text that describes a day labor construction program that uses labor-intensive construction techniques. The proper management of labor-intensive construction is even more critical than the management of equipment-intensive construction.

The proper allocation of resources is also an important consideration in both contract and day labor construction programs. It is important for a highway agency to determine the availability of construction materials before undertaking any construction effort. It is equally important to determine the allocation of manpower and equipment for each construction project. Without such evaluations, it is impossible for a highway agency to predetermine the proper time schedule or the necessary staffing and equipment allocation. This information is necessary to evaluate the qualifications of a contractor or to

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construcción por administración debe ser la misma que para una construcción por contrato de un camino similar. Se espera que el personal de administración produzca la misma calidad de trabajo que se demanda de un contratista. La agencia responsable del diseño y de las especificaciones de caminos de bajo volumen, debe asegurarse que las especificaciones definan el material y la capacidad requerida para obtener el nivel de servicio necesario. Las especificaciones que definan normas innecesariamente altas tanto para la construcción por contrato o por administración, darán por resultado un mayor desembolso de capital sin que se obtengan los beneficios adicionales correspondientes.

Los proyectos de construcción por administración carecen a menudo del mismo sistema de verificación (a cargo de un equipo separado de inspección) empleado para supervisar a los contratistas. El personal que administra los proyectos por administración sufre algunas veces de falta de motivación (ésto es, ellos no están gastando su propio dinero). En consecuencia, un organismo vial debe (a) usar sólo personal experimentado, (b) conducir un continuo programa de entrenamiento para asegurar un equipo con personal capaz, y (c) proporcionar una motivación adecuada a sus supervisores de construcción. El Compendio 16 contiene un texto seleccionado que describe un programa de construcción por administración usando técnicas de construcción con mano de obra intensiva. La propia adminstración de la construcción con mano de obra intensiva es aún más crítica que la administración de construcción con equipo intensivo.

La adecuada asignación de recursos es tam-

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propre, tel qu'il est défini par les documents contractuels. D'habitude, le contrat précise que l'entrepreneur doit fournir du personnel compétent et expérimenté. La direction de l'administration routière devrait réaliser que l'entrepreneur, de son coté, s'attend à ce que le personnel de direction et de contrôle affecté par le gouvernement, possède les mêmes qualifications, et que c'est dans l'intérêt du governement de fournir du personnel de valeur. Dans deux textes choisis, on va discuter les fonctions et les charges des représentants du gouvernement dans les projets de construction routière à l'entreprise.

Comme nous l'avons indiqué précédemment, la documentation sur les procédures pour la construction en régie devrait être la même que celle dés travaux faits à l'entreprise pour une route similaire. Les ouvriers qui travaillent en régie devraient fournir la même qualité de travail que celle qui est exigée d'un entrepreneur. Les responsables du dimensionnement et des specifications d'une route économique, devraient s'assurer que les spécifications définissent les matériaux et la main d'oeuvre exigés pour obtenir le niveau de service nécessaire. Des spécifications qui demandent, sans nécessité, des normes trop élevées pour la construction en régie ou à l'entreprise, auront pour résultat une plus grosse mise de fonds initiale, sans avantages correspondants.

Souvent, les projets de construction en régie ne bénéficient pas du système de vérification

properly schedule day labor forces. Once a construction project has begun, it should be carefully monitored to make sure that the proposed schedule is followed or to identify activities that need to be expedited by management.

This allocation of resources is sometimes slighted in low-volume road project planning and often overlooked during the construction phase. However, proper construction implementation requires strict adherence to planned schedules if the work is to be economically effective. Compendium 16 contains two selected texts that discuss basic manpower and equipment resource scheduling and a text that describes a critical path scheduling technique that can be used to determine scheduling compliance.

Discussion of Selected Texts

The first text, ***Construction by Contract and by Day Labor***, appeared in ***Proceedings of the Twenty-Third Annual Meeting*** (Highway Research Board, 1943). It reports the results of two surveys indicating that 40 years ago in the United States unit price contract construction methods were favored for state construction projects. These projects included the major high-volume routes throughout the country. These projects usually involved large quantities of materials that the text indicates were handled most economically by unit price contract construction. However, low-volume road construction, usually carried out by lower levels of government (i.e., counties and towns), was normally

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bién una consideración importante tanto en los programas por contrato como por administración. Es importante que el organismo vial determine la disponibilidad de materiales de construcción antes de emprender cualquier esfuerzo de construcción. Es igualmente importante determinar la asignación de mano de obra y de equipo para cada proyecto de construcción. Sin dicha evaluación, es imposible que un organismo de carreteras pueda determinar con anticipación el programa apropiado o la asignación del personal y equipo requeridos. Esta información es necesaria para evaluar las calificaciones de un contratista o programar adecuadamente al personal de administración. Una vez que se ha iniciado un proyecto de construcción, debe supervisársele cuidadosamente para asegurar que se sigue el programa propuesto o para identificar las actividades que necesitan ser aceleradas por la administración.

Algunas veces se descuida esta asignación de recursos durante el planeamiento de proyectos para caminos de bajo volumen y, a menudo, se la pasa por alto durante la fase de construcción. Sin embargo, una adecuada implementación de construcción requiere de una adhesión estricta a los programas planeados, si se desea que el trabajo resulte económicamente efectivo.

(par une équipe de contrôle spéciale) que l'on utilise pour la supervision des travaux faits à l'entreprise. Le personnel qui dirige les ouvriers en régie souffre parfois d'un certain manque de motivation (c'est à dire que ce n'est pas leur propre argent qu'ils dépensent). C'est pourquoi un organisme routier devrait: (a) utiliser seulement du personnel expérimenté, (b) avoir en permanence un programme de formation technique, afin d'être sûr d'avoir toujours une équipe qualifiée, et (c) faire le nécessaire pour que les chefs des équipes de construction soient motivés de façon adéquate. Un des textes choisis de ce recueil no. 16, fait la description d'un programme de construction en régie utilisant des techniques à forte intensité de main d'oeuvre. L'administration d'un tel programme est encore plus critique que celle d'un programme de construction utilisant les techniques à forte intensité de capital.

L'attribution correcte des ressources est aussi un point essentiel des programmes de construction en régie ou à l'entreprise. Il est important pour une administration routière, de déterminer la disponibilité des matériaux de construction, avant d'entreprendre celle-ci. Il est également important de déterminer l'attribution de la main d'oeuvre et du matériel pour chaque projet de construction. Si l'on ne fait pas ces évaluations, il est impossible pour une administration routière de déterminer à l'avance la programmation correcte des travaux, ou l'attribution de main d'oeuvre et de matériel requis. Ces connaissances sont nécessaires pour évaluer les qualifications d'un entrepreneur, ou pour programmer correctement la main d'oeuvre en régie. Un fois qu'un projet de construction commence, il devrait être supervisé soigneusement pour s'assurer que la programmation des travaux est bien suivie, ou pour identifier les activités qui devraient être accélérées par la direction.

Quelquefois on fait peu de cas de cette attribution des ressources, lors de la conception et planification de routes à faible capacité, et elle est souvent perdue de vue durant la construction.

undertaken by day labor forces. At that time, local government day labor construction projects were frequently carried out without plans, specifications, or detailed cost estimates. The final costs of day labor construction projects were often unknown until long after the work was completed.

The second text, ***A Cost Comparison Study of Force Account and Contract Construction on Five Secondary Projects in North Carolina***, was published in ***Proceedings of the Thirty-Fifth Annual Meeting*** (Highway Research Board, 1956). It describes a study made several years after the surveys described in the previous selected text. For this study, plans and specifications were developed for both types of construction. The cost of each item of work was carefully monitored by employees of the federal government. Both the state government and the contractors made all of their records available to the study personnel.

The purpose of this study was to develop facts on the comparative costs of the two methods of doing work. It was generally accepted that the usefulness of the study results would be principally in furnishing certain factual background on each method, in minimizing unsubstantiated claims as to excessive economies of one method over the other, and in keeping minor un-

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El Compendio 16 contiene dos textos seleccionados que analizan la programación básica de recursos de mano de obra y de equipo, y un texto que describe una técnica de programación de la ruta crítica que puede usarse para determinar el cumplimento del programa.

Presentación de los textos seleccionados

El primer texto, ***Construction by Contract and by Day Labor*** (Construcción por contrato y por administración), apareció en los ***Proceedings of the Twenty-Third Annual Meeting*** (Highway Research Board, 1943). Informa sobre los resultados de dos estudios que indican que hace 40 años los métodos de construcción por contrato a precios unitarios eran los favoritos en los Estados Unidos de Norteamérica para los proyectos estatales de construcción. Estos proyectos incluían las vías con volúmenes de tránsito más altos en todo el país. Involucraban generalmente grandes cantidades de materiales que de acuerdo a lo que indica el texto, eran manipulados en forma más económica mediante la construcción por contrato a precios unitarios. Sin embargo, la construcción de caminos de bajo volumen, ejecutada por lo general por los niveles gubernamentales más bajos (ésto es, condados y ciudades), se realizaba normalmente con personal de administración. En aquél tiempo, los proyectos locales gubernamentales de construcción por administración, se ejecutaban frecuentemente sin planos, especificaciones ni estimados de costo detallados. A menudo

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Cependant, l'exécution correcte de la construction demande que l'on suive à la lettre le programme prévu, si l'on veut que les travaux soient valables au point de vue économique. Dans le recueil no. 16, nous avons inclus deux textes choisis, où l'on discute de la programmation de base des ressources en main d'oeuvre et en matériel, et un texte qui décrit une technique, la méthode des réseaux (ou méthode du chemin critique) qui peut être utilisée pour déterminer si les travaux sont faits conformément à la programmation.

Discussion des textes choisis

Le premier texte, ***Construction by Contract and by Day Labor*** (Construction à l'entreprise et en régie) a été publié dans les ***Proceedings of the Twenty-Third Annual Meeting*** (Highway Research Board, 1943). On y rapporte les résultats, de deux études qui indiquent qu'aux Etats Unis d'Amérique, il y a 40 ans, on préférait les méthodes de construction par marché à prix unitaire pour les projets de construction des états. Ces projets englobaient les routes principales à haut volume de trafic de tout le pays et comprenaient généralement de grosses quantités de matériaux, et l'on indique dans le texte que, du point de vue économique, les marchés à prix unitaire étaient les plus avantageux. Toutefois, la construction de routes économiques, d'habitude exécutée à un niveau gouvernemental moins élevé (c'est-à-dire des comtés et des villes) était normalement faite en régie. A cette époque, les projets de construction locaux en régie, étaient fréquemment exécutés sans planification, spécifications ou estimation détaillée des coûts. On ne determinait le prix de revient final de ces projets que longtemps après la complétion des travaux.

Le deuxième texte, ***A Cost Comparison Study of Force Account and Contract Construction on Five Secondary Projects in North Carolina*** (Etude comparative des coûts de construction en régie et à l'entreprise de cinq projets secon-

resolved details from complicating the main issues.

The study does not analyze the social and economic benefits of the two methods nor does it evaluate the inherent managerial and operational advantages of each method. Although the small number of projects studied precludes any conclusive findings about the general superiority of one method over the other, this text serves as an example of the evaluation methodology that should be used in such studies rather than for its final cost comparison.

The third text, ***Preparation and Presentation of Project Documents***, was excerpted from ***Manual on Route Location, Design, Construction, and Maintenance of Rural Roads*** (Indian Roads Congress, 1979). It describes the documentation that should be prepared for a typical project. This documentation (i.e., a project report, estimate, and drawings) should be completed for either construction method.

Sample drawings are included with this text. Sheet size and methods of presenting the necessary data will, of course, vary from country to country; however, the organization of project drawings is fairly standardized. The scale of 1:2500 or 1 in = 200 ft for simple plans is quite common as is the expansion of the vertical scale of the road profile to 10 times the horizontal scale. All the information necessary to locate

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se desconocían los costos finales de los proyectos de construcción por administración, hasta mucho después de haber terminado el trabajo.

El segundo texto, ***A Cost Comparison Study of Force Account and Contract Construction on Five Secondary Projects in North Carolina*** (Un estudio comparativo de costos de construcción por administración y por contrato en cinco proyectos secundarios en North Carolina), fué publicado en los ***Proceedings of the Thirty-Fifth Annual Meeting*** (Highway Research Board, 1956). Describe un estudio hecho muchos años después de los proyectos descritos en dicho texto seleccionado. Durante este estudio, se desarrollaron planos y especificaciones para ambos tipos de construcción. Se controló cuidadosamente con empleados del gobierno federal, el costo de cada partida de trabajo. Tanto el gobierno estatal como los contratistas pusieron a disposición del personal a cargo del estudio, todos sus archivos.

El propósito de este estudio fué desarrollar un conjunto de hechos sobre los costos comparativos de los dos métodos de ejecutar el trabajo. Se aceptó generalmente que la utilidad de los resultados del estudio estaría principalmente en suministrar ciertos antecedentes reales de cada método, en reducir al mínimo los reclamos inconsistentes tales como las economías excesivas de un método con respecto al otro, y en evitar que los detalles menores sin resolver compliquen los aspectos principales.

El estudio no analiza los beneficios sociales y económicos de los dos métodos ni evalúa las ventajas administrativas y operacionales inherentes a cada método. Aunque el pequeño número de proyectos estudiados impiden cualquier descrubrimiento concluyente sobre la su-

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daires en Caroline du Nord) a été publié dans les ***Proceedings of the Thirty-Fifth Annual Meetings*** (Highway Research Board, 1956). On y décrit une étude entreprise plusieurs années après celles que nous venons de décrire dans le texte précédent. Pour l'étude dont il est question dans ce second texte, des plans et des spécifications furent developpés pour les deux types de construction. Le coût de chaque article de travail fut contrôlé soigneusement par les employés du gouvernement fédéral. L'administration routière de l'état et les entrepreneurs donnérent tous leurs documents au personnel étudiant la question.

L'étude en question avait pour but d'éclairer la situation sur les coûts comparés des deux méthodes de travail. Il fût généralement accepté que l'utilité des résultats de l'étude, se trouverait principalement dans le fait de fournir certains éléments concrets sur chaque méthode, de réduire au minimum les assertions non prouvées d'économies excessives d'une méthode par rapport à l'autre, et d'éviter que des détails non résolus, mais secondaires, masquent les questions principales.

Cette étude n'est pas une analyse des avantages sociaux et économiques des deux méthodes, et non plus une évaluation des avantages de gestion et d'exploitation de chaque méthode. Bien que le petit nombre de projets étudiés ne permette pas de découvertes concluantes quant à la supériorité générale d'une méthode sur l'autre, ce texte est plus valable comme exemple de la méthodologie d'evaluation qui devrait être utilisée dans ce genre d'études, que pour la comparaison des prix de revient.

Le troisième texte, ***Preparation and Presentation of Project Documents*** (Préparation et présentation de la documentation d'un projet) est extrait de ***Manual on Route Location, Design,***

and construct the road in the field should be included on the plans for either contract or labor-based construction projects

A highway agency should attempt to standardize its plan format for all low-volume roads so that contractors and agency employees will clearly understand the plans for various projects as they move from district to district

The fourth text, ***Section 100 – General Provisions***, was excerpted from ***Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, FP-69*** (Federal Highway Administration, U S Department of Transportation 1969) These Standard Specifications are closely patterned after the AASHO Guide Specifications for Highway Construction, thus establishing uniformity and consistency in specifications and contractual matters in U S highway construction The specifications were issued primarily for use in the construction of highway projects under the direct administration of the Federal Highway Administration When so designated in the project contract, the entire publication becomes part of the contract document and binds the parties signatory to the contract

All Federal Highway Administration construction contracts are governed by the Federal Procurement Regulations (FPR), and such regulations apply and shall prevail in the event of any conflict in the contract provisions Portions of Standard Form 22 (Instructions to Bidders) and

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periodidad general de un método sobre el otro, este texto sirve como un ejemplo de la metodología de evaluación que debe usarse en dichos estudios, más que para la comparación de sus costos finales

El tercer texto, ***Preparation and Presentation of Project Documents*** (Preparacion y presentacion de los documentos del proyecto), fué extractado del ***Manual on Route Location, Design, Construction and Maintenance of Rural Roads*** (Manual de trazado, diseño, construcción y conservación de caminos rurales) (Indian Roads Congress, 1979) Describe la documentación que debe prepararse para un proyecto típico Esta documentación (ésto es, informe del proyecto, estimado y dibujos) debe completarse para cualquiera de los métodos de construcción

Se incluyen en el texto dibujos de muestra. El tamaño de las hojas y los métodos para presentar la información necesaria variará, por supuesto, de país, a país, sin embargo la organización de los planos del proyecto está bastante uniformizada La escala 1 2,500 ó 1 pulgada = 200 pies para planos simples, es muy común como lo es la expansión de la escala vertical del perfil del camino a 10 veces la escala horizontal Debe incluirse, tanto en los proyectos de construcción por contrato como por administración, toda la información necesaria para localizar en el campo y construir el camino

Una organización vial debe intentar uniformi-

Construction and Maintenance of Rural Roads (The Indian Road Congress, 1979) On y décrit la documentation qui devrait être préparée pour un projet typique Cette documentation (i e , dossier du projet, estimation et plans) devrait être complétée pour l'une ou l'autre méthode de construction

Des exemples de plans sont inclus dans le texte La taille des feuilles et les méthodes de présentation des données diffèrent, bien sûr, d'un pays à l'autre mais l'organisation des plans d'un projet est plus ou moins normalisée L'échelle de 1 2500 ou 1 pouce 200 pieds est très commune ainsi que le développement de l'échelle verticale du profil de la route à dix fois l'échelle horizontale Toutes les informations nécessaires au trace et à la construction sur le chantier devraient être incluses dans le dossier, aussi bien pour la construction en régie que pour la construction à l'entreprise

Un organisme routier devrait essayer de normaliser le format de ses dossiers pour toute la construction de routes à faible capacité, afin que ses propres employés et les entrepreneurs puissent comprendre clairement les plans des divers projets quand ils se déplacent d'un district à l'autre

Le quatrième texte, ***Section 100 – General Provisions*** (Section 100 — Provisions générales) est extrait de ***Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, FP-69*** (Normes de construction de routes et ponts pour les projets routiers fédéraux), publié par la Federal Highway Administration, U S Department of Transportation en 1969 Ces normes de construction se modèlent étroitement sur le Guide de normes pour la construction routière de l'AASHO, établissant ainsi pour la construction routière des Etats Unis d'Amérique, uniformité et conformité de la documentation contractuelle et des normes Ces normes furent créées principalement pour la construction de projets routiers placés directement sous la gestion de la Federal Highway

Standard Form 23A (General Provisions) of the FPR which apply specifically to construction contracts have been interspersed throughout the selected text to provide a reasonably complete collection of contractual provisions within a single book of standard construction specifications

These General Provisions cannot of course, be adopted in total by any other country The items pertaining particularly to U S law (e g , the Buy American clause and the Davis-Bacon Act clause) are not transferable to any other set of General Provisions However, many of the sections contained in this selected text can be modified for use in other General Provisions that may not be as comprehensive

Items in General Provisions that do not apply to a specific project are deemed not to apply (e g Item 105 07, Cooperation Between Contractors, is not relevant when only one contractor is working in an area) These provisions are included in the Standard Specifications because the highway agency cannot always anticipate all eventualities and because the items may be inadvertently left out of the actual contract document when they do apply (See Item 109 04

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zar su formato de planos para todos los caminos de bajo volumen, de modo que los contratistas y el personal del gobierno comprendan claramente los planos para los diversos proyectos cuando se desplacen a las diversas oficinas regionales

El cuarto texto ***Section 100 – General Provisions*** (Seccion 100 Provisiones generales) fue extractado de ***Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, FP-69*** (Especificaciones normales para la construcción de caminos y puentes en proyectos federales de carreteras FP-69 Federal Highway Administration U S Department of Transportation, 1969) Estas Especificaciones siguen muy de cerca las Especificaciones Guia de la AASHO para la construccion de carreteras, estableciendose asi uniformidad y consistencia en especificaciones y asuntos contractuales para la construccion de carreteras en los Estados Unidos de Norteamerica Se emitieron las especificaciones especialmente para su empleo en proyectos de construccion de carreteras bajo la administracion directa del Federal Highway Administration (Administración Federal de Carreteras) Cuando se indica asi en el contrato del proyecto, toda la publicacion llega a formar parte del documento del contrato y compromete a las partes que firman el contrato

Todos los contratos de construccion de la Federal Highway Administration están gobernados por Federal Procurement Regulations (FPR – Regulaciones de las adquisiciones federales) Dichas regulaciones se aplican y prevaleceran en caso de cualquier conflicto en las provisiones del contrato Se han entremezclado a lo largo del texto seleccionado algunas porciones del Formato Normal 22 (Instrucciones a los licitantes) y el Formato Normal 23A (Provisiones Generales) del FPR, que se aplican especificamente a los contratos de construcción, para proporcionar una colección razonablemente completa de las provisiones contractuales dentro de un solo

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Administration Quand elle est designée comme telle dans le marché la publication entiere fait partie des documents contractuels et engage la responsabilite des signataires du marché

Tous les contrats de construction de la Federal Highway Administration sont regis par les Federal Procurement Regulations (FPR Arrêtes federaux pour les acquisitions) Ces arrêtés s appliquent et prevalent en cas de conflit avec les clauses du contrat Des extraits de Standard Form 22 (Instructions to Bidders Instructions pour les soumissionaires) et de Standard Form 23A (General Provisions Clauses Générales) inclus dans les FPR, qui s appliquent de façon spécifique aux marches de construction, sont interpoles dans les textes choisis, pour fournir une collection à peu pres complete de clauses contractuelles dans un seul livre de clauses classiques de construction

Ces "Clauses Générales" ne peuvent pas bien sûr, être adoptées intégralement par un autre pays quel qu'il soit Les articles qui sont propres au système legal des Etats Unis d'Amerique (par exemple la clause "Achetez Américain et la clause du David Bacon Act) ne peuvent être transférés a aucun autre groupe de "Clauses Générales Toutefois, beaucoup de sections contenues dans ce texte choisi peuvent être modifiees et utilisées dans d'autres "Clauses Générales" qui peuvent ne pas être aussi complètes

Les articles dans les "Clauses Generales" qui ne s adressent pas a un projet specifique sont consideres comme non-applicables Par exemple l'article 105 7, "Cooperation between contractors" (Cooperation entre les entrepreneurs) n'est pas pertinent lorsqu'il y a seulement un entrepreneur qui fait les travaux dans une ré-

Force Account Work, for a description of the method of determining payment to the contractor for any extra work he does for which no price was bid in the contract.) This publication (FP-69) was last updated in 1979 by FP-79 (same title, see Additional Text 16). Since FP-79 does not include the informational inserts from SF 22 and SF 23A, it is not included here.

The fifth text, ***Competitive Bidding and Award of Highway Construction Contracts***, was taken from ***Selected Studies in Highway Law, Volume 3*** (Transportation Research Board, 1978). It describes legal bases of the procedures used for the selection of contractors to construct, maintain, improve, and repair public highways in the United States. These procedures are based on a

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libro de especificaciones normales de construcción.

Estas Provisiones Generales no pueden, por supuesto, ser adoptadas en su integridad por ningún otro país. Los artículos que pertenecen particularmente a la legislación norteamericana (por ejemplo, la cláusula para adquirir productos norteamericanos y la del Acto Davis-Bacon) no son transferibles a ningún otro sector de las Provisiones Generales. Sin embargo, muchas de las secciones contenidas en este texto seleccionado pueden ser modificadas para utilizarse en otras Provisiones Generales que no tienen que ser tan amplias.

Los acápites de las Provisiones Generales que no se aplican a un proyecto específico se consideran como no aplicables (por ejemplo, el Acápite 105.07, Cooperation Between Contractors, no es pertinente cuando sólo un contratista está trabajando en el área). Estas provisiones están incluidas en las Especificaciones Normales debido a que el organismo vial no puede anticipar siempre todas las eventualidades y porque podrían haberse omitido inadvertidamente dichos artículos en el documento de contrato en casos en que realmente se aplicaban (Ver el Acápite 109.04, Force Account Work, donde se da una descripción del método para determinar el pago al contratista por cualquier trabajo extraordinario que haga y por el que no se ha propuesto ningún precio en el contrato). Esta publicación (FP-69) fué actualizada últimamente en 1979 con el FP-79 (con igual título; ver el texto 16 adicional). Dado que el FP-79 no incluye la información contenida en las secciones SF 22 y SF 23C, no se le incluye en este texto.

El quinto texto, ***Competitive Bidding and Award of Highway Construction Contracts*** (Licitación competitiva y adjudicación de contratos de construcción de carreteras) fué tomado de ***Selected Studies in Highway Law, Volume 3*** (Estudios seleccionados sobre leyes viales, Volumen 3, Transportation Research Board, 1978). Describe las bases legales de los procedimientos usados para la selección de constructores para construir, conservar, mejorar y reparar carreteras públicas en los Estados Unidos de Norteamérica. Estos procedimientos se basan en un

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gion. Ces clauses sont incluses dans les Normes de Construction, car l'organisme routier ne peut pas toujours anticiper toutes les éventualités, et parce que ces articles peuvent être omis par inadvertance dans la documentation contractuelle, dans des cas où ils s'appliquent effectivement. (Voir l'article 109.04 — Force Account Work, où l'on décrit une méthode pour déterminer comment payer l'entrepreneur pour un travail additionnel, pour lequel aucun prix n'avait été offert dans le marché). Cette publication (FP-69) a été actualisée en 1979 (FP-79, même titre, voir Texte Supplémentaire no. 16). Puisque FP-79 ne contient pas la documentation des sections SF 22 et SF 23A, nous ne l'avons pas non plus incluse.

Le cinquième texte, ***Competitive Bidding and Award of Highway Construction Contracts*** (Appels d'offres et passation des marchés dans la construction routière) est extrait de ***Selected Studies in Highway Law, Volume 3*** (Etudes choisies de législation routière, volume 3) Transportation Research Board, 1978. On y décrit les bases légales des procédés sur lesquels on s'appuit pour faire la selection d'entrepreneurs pour la construction, l'entretien, l'amélioration et la réparation des routes publiques des Etats Unis d'Amérique. Ces procédés sont basés sur un corpus bien défini de règles administratives et légales. Bien entendu, ces régles ne s'appliquent directement qu'à la construction routière aux Etats Unis d'Amérique, mais elles constituent un exemple logique pour la construction à l'entreprise que les pays qui n'ont pas encore une expérience profonde en ce sujet peuvent prendre en considération.

Les cas cités complètent et définissent les conditions requises pour les appels d'offre et les passations de marché dont il est question dans les Clauses Générales du texte choisi no. 4. Ces cas fournissent les régles qui assurent le bon fonctionnement des appels d'offre en (a) protégeant le public contre des marchés collusoires, (b) assurant une concurrence franche, à condi-

well-defined body of legislative and administrative rules. These rules apply directly only to highway construction in the United States, but they offer a logical approach to contract construction for evaluation by other countries that do not yet have a depth of experience in this field.

The cases cited fill out and define the requirements for competitive bidding and contract award that appear in the previous General Provisions (Selected Text No. 4). These cases provide the rules that make such competitive bidding work by (a) protecting the public against collusive contracts, (b) securing fair competition on equal terms to all bidders, (c) removing not only collusion but temptation for collusion and opportunity for gain at public expense, (d) closing all avenues to favoritism and fraud in its various forms, (e) securing the best values for the public at the lowest possible expense, and (f) affording equal advantage to all desiring to do business with the public through exact comparison of bids.

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conjunto bien definido de reglas legislativas y administrativas. Estas reglas se aplican directamente no sólo a la construcción de carreteras en los Estados Unidos de Norteamérica sino que ofrecen un acercamiento logico para contratar construcciones de carreteras, que puede ser evaluado por otros paises que no tienen aún una experiencia profunda en este campo.

Los casos citados completan y definen los requerimientos para una licitación competitiva y la adjudicación de contratos que aparecen en las Provisiones Generales previas (Texto Seleccionado N° 4). Estos casos proporcionan las reglas que regulan dicha licitación competitiva (a) protegiendo al público contra contratos colusorios, (b) asegurando una competencia limpia y en iguales términos para todos los postores, (c) eliminando no sólo la colusión sino la tentación de coludir y la opportunidad de beneficiarse a expensas del público, (d) cerrando todas las vias al favoritismo y al fraude en sus diversas formas, (e) asegurando los mejores productos para el público al costo más bajo posible, y (f) brindando igual ventaja a todos los que desean hacer negocio con el público mediante la comparación correcta de las propuestas.

Los aspectos siguientes son los que se analizan, entre otros, en este texto: (a) principios esenciales de la licitación competitiva, (b) criterios para adjudicar el contrato, (c) autoridad para rechazar una propuesta, (d) requerimientos generales y contenido de los avisos de licitación, (e) elegibilidad de los postores, (f) forma de licitación, (g) autoridad de los organismos contratantes, (h) presentación, apertura y aceptación de propuestas, (i) determinación del postor responsable más bajo, y (j) efecto de los errores en la propuesta para la adjudicación de los contratos.

El sexto texto fué extractado de ***Standard Specification for Road and Bridge Works*** (Especificación normal para caminos y puentes, Design Department, Ministry of Works and Supplies, Malawi, 1978). Los extractos incluyen ***Series 100, General*** y ***Series 200, Site Clearance and Earthworks*** (Serie 100, Generalidades y Serie 200, Limpieza del lugar y movimiento de tierras). La Serie 100 es la sección de Provisiones Generales de esta Especificación Normal. Fué escrita para las condiciones especificas que se encuentran en Malawi. Estas Provisiones Generales se refieren al Acto de Caminos Públi-

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tions egales, pour tous les soumissionaires, (c) éliminant non seulement la collusion, mais aussi la tentation de collusion, et l'occasion de gains aux dépens du public, (d) bloquant tout accès au favoritisme et à la fraude sous toutes leurs formes, (e) assurant au public les meilleurs produits aux prix les plus bas, et (f) donnant un avantage égal à tous ceux qui désirent négocier avec les Travaux publics en comparant leurs offres correctement.

Les sujets suivants sont discutés dans le texte: (a) principes essentiels des appels d'offre, (b) critères pour la passation du marché, (c) jurisprudence pour non-adjudication, (d) Conditions requises et contenu des appels d'offre, (e) éligibilité des soumissionaires, (f) modèle de soumission, (g) jurisprudence des entreprises, (h) soumission, lancement des appels d'offre, et réception des offres, (i) détermination du mieux-disant, et (j) effet des erreurs d'offre sur la passation des marchés.

Le sixième texte est extrait de ***Standard Specification for Road and Bridge Works*** (Normes de construction pour les routes et les ponts), Design Department, Ministry of Works and Supplies, Malawi, 1978. Les extraits comprennent ***Series 100, General*** et ***Series 200, Site Clearance*** and Earthworks (Série 100, Généralités, et Série 200, Défrichement et terrassements). La série 100 est la section "Clauses générales" de ces normes et a été écrite spécifiquement pour les conditions trouvées au Malawi. Ces "Clauses générales" s'adressent au "Public Roads Act" et aux "Conditions of Contract" qui s'appliquent à

The following topics are among those discussed in this text: (a) essential principles of competitive bidding, (b) criteria for award of contract, (c) authority to reject a bid, (d) general requirements and content of bid advertisements, (e) eligibility of bidders, (f) form of bid, (g) authority of contracting agencies, (h) submission, opening, and acceptance of bids, (i) determination of lowest responsible bidder, and (j) effect of bid mistakes in contract awards.

The sixth text was excerpted from ***Standard Specification for Road and Bridge Works*** (Design Department, Ministry of Works and Supplies, Malawi, 1978). The excerpts include ***Series 100, General*** and ***Series 200, Site Clearance and Earthworks***. Series 100 is the General Provisions section of this Standard Specification. It was written for the specific conditions found in Malawi. These General Provisions refer to the Public Roads Act and the Conditions of Contract that apply to all highway contracts in Malawi in the same manner that the Instructions to Bidders and General Provisions sections of the FPR apply to all highway contracts in the United States as described in Selected Text No. 4. Series 100 is presented here to show that General Provisions do not have to be all-encompassing documents that attempt to account for every possibility such as Selected Text No. 4. They can be written in a simple clear format

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cos y a las Condiciones de Contrato que se aplican a todos los contratos de carreteras en Malawi, de la misma manera que las secciones sobre Instrucciones a los Postores y Provisiones Generales del FPR se aplican a todos los contratos viales en los Estados Unidos de Norteamérica, según se describe en el Texto Seleccionado Nº 4. Se presenta aquí la Serie 100 para demostrar que las Provisiones Generales no tienen que ser documentos sumamente completos que pretendan tomar en cuenta cualquier eventualidad, tal como ocurre con el Texto Seleccionado Nº 4. Pueden escribirse en un formato simple, claro y se pueden ocupar solamente de los problemas del país para el que han sido escritos.

Se incluye acqui la Serie 200 (empezando con la Cláusula Nº 201) como un ejemplo de la segunda área de las Especificaciones Normales (ésto es, Detalles de Construcción). Esta área describe el trabajo por ejecutar, los materiales a emplear, y los métodos de construcción que deben seguirse.

El séptimo texto, ***Field Supervisor's Duties and Responsibilities, Volume 1, Contract Roadworks*** (Deberes y responsabilidades de los supervisores de campo: Volumen 1, Trabajos viales por contrato, National Association of Australian State Road Authorities, 1975), fué escrito como una guía para los supervisores responsables por la supervisión de trabajos viales ejecutados por contrato. Esta posición puede llevar consigo el título de Oficial Superintendente, Oficial de Obras, Inspector de Obras, algún título similar que indique que el supervisor de campo es el representante de, y responsable ante, el Ingeniero que supervisa el trabajo de parte del propietario (el gobierno).

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tous les marchés de construction routière au Malawi de la même façon que les "Instructions to Bidders" et "General Provisions" des FPR s'appliquent aux marchés de construction routière aux Etats Unis d'Amérique, ainsi que nous l'avons expliqué dans le texte choisi no. 4. Nous présentons la série 100 ici pour montrer que les clauses générales n'ont pas besoin d'être des documents universels qui puissent parer à toute éventualité ainsi qu'il en est question dans le texte no. 4. Elles peuvent être écrites de façon simple et claire, et avoir trait seulement aux problèmes du pays auxquelles elles sont destinées.

La série 200 (en commençant par la clause 201) est incluse ici comme exemple de la seconde partie des Standard Specifications (c'est à dire Détails de normes de construction). Cette partie décrit le travail à faire, les matériaux à utiliser et les méthodes de construction à suivre.

Le septième texte, ***Field Supervisors' Duties and Responsibilities, Volume 1, Contract Roadworks*** (Fonctions et charges des chefs de chantier, volume 1, construction routière à l'entreprise), National Association of Australian State Road Authorities, 1975, a été écrit comme guide pour les chefs de chantier responsables de la supervision de la construction routière faite à l'entreprise. Cette fonction de chef de chantier peut avoir différents titres, tous indiquant que le chef de chantier représente le Maitre d'oeuvre et relève de celui-ci, le Maitre d'oeuvre à son tour dirigeant les travaux pour le compte du Maître de l'ouvrage (le gouvernement).

Le chef de chantier est la personne en charge des activités quotidiennes, sur le chantier, nécessaires à la supervision et au contrôle des travaux faits par l'entrepreneur. Il est responsable (a) des actes de quelqu'autres inspecteurs supplémentaires détachés au projet, (b) de la pré-

and can deal with the problems of the country for which they are written.

Series 200 (beginning with Clause No. 201) is included here as a sample of the second area of Standard Specifications (i.e. Construction Details). This area describes the work to be done, the materials to be used, and the methods of construction to be followed.

The seventh text, ***Field Supervisors' Duties and Responsibilities: Volume 1, Contract Roadworks*** (National Association of Australian State Road Authorities, 1975), was written as a guide for supervisors responsible for the supervision of roadworks carried out by contract. This position may carry the title of Superintending Officer, Clerk of Works, Works Inspector, or some similar title indicating that the field supervisor is the representative of, and is responsible to, the Engineer supervising the work on behalf of the owner (the government).

The field supervisor is the person who is in charge of the day-to-day field activities necessary to the supervision and inspection of the contractor's work. He is responsible for (a) the actions of any additional inspectors on the project, (b) the preparation of progress reports, (c) the compilation of a project diary, (d) the compilation of a work progress book (a measurement book), (e) the sampling and testing of materials on site and the collection of samples for laboratory testing, and (f) the certification of quantities for progress payments.

The field supervisor cannot (a) make decisions reserved to the engineer, (b) waive any

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El supervisor de campo es la persona que está a cargo de las actividades diarias de campo necesarias para la supervisión e inspección del trabajo del contratista. Es responsable por (a) las acciones de cualquier inspector adicional destacado al proyecto, (b) la preparación de informes de avance, (c) la recopilación de un diario del proyecto, (d) la recopilación de un libro del progreso de obra (libro de mediciones), (e) la toma de muestras y pruebas de materiales en sitio y la colección de muestras para los ensayos de laboratorio, y (f) la certificación de cantidades para los pagos por avance de obras.

El supervisor de campo no puede (a) tomar decisiones reservados para el ingeniero, (b) permitir divergencias con los planos o con las especificaciones, (c) autorizar adiciones o deducciones al contrato, (d) detener la operación del contratista, o (e) dar instrucciones u órdenes a los trabajadores del contratista (ésto es, el supervisor sólo debe tratar can el contratista o con su representante autorizado).

El óctavo texto, ***Recommended Standards for the Responsibility, Authority, and Behaviour of the Inspector*** (Normas recomendadas sobre la responsabilidad, autoridad y comportamiento del inspector), apareció en ***Journal of the Construction Division*** (Proceedings of the American Society of Civil Engineers, junio 1975). Informa sobre las recomendaciones de un comité sobre inspecciones de la ASCE, desarrolladas en base a la revisión de un proyecto de encuesta integral en que se da una oportunidad a todos los segmentos de la industria de la construcción para expresar sus puntos de vista sobre el aspecto de la inspección, sus problemas y sus soluciones. Los Inspectores trabajan a un nivel inferior a los supervisores de campo — que es el

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paration des rapports sur l'avancement du projet, (c) de la compilation du journal de chantier, (d) de la compilation d'un carnet de progrés des travaux (carnet de mesures), (e) de l'échantillonage et des essais des matériaux sur le terrain, et de la collection d'échantillons pour les essais en laboratoire, et (f) des certificats de quantités pour les paiements en cours. Le chef de chantier ne peut (a) prendre des décisions reservées à l'ingénieur, (b) permettre de changer les plans ou les spécifications, (c) autoriser des suppléments ou des déductions au marché, (d) arréter les travaux de l'entrepreneur, ou (e) donner des instructions ou des ordres aux ouvriers de l'entrepreneur (c'est à dire qu'il ne doit traiter qu'avec l'entrepreneur ou son représentant autorisé).

Le huitième texte, ***Recommended Standards for the Responsibility, Authority and Behavior of the Inspector*** (Normes recommandées pour la responsabilité, l'autorité et le comportement de l'inspecteur) a été publié dans le ***Journal of the Construction Division*** (Proceedings of the American Society of Civil Engineers, Juin 1975). On y rapporte les recommandations d'un comité de l'ASCE sur l'inspection. Ces recommandations furent developpées à partir de l'étude d'un projet de questionnaire intégral dans lequel on donna à tous les secteurs de l'industrie de la construction, l'opportunité d'exprimer leurs vues sur le sujet de l'inspection, ses problèmes et leur solution. Les inspecteurs travaillent au niveau au dessous de celui des chefs de chantier dont nous avons parlé dans le texte no. 7.

Dans ce texte, on définit la responsabilité comme étant les charges ou obligations de l'inspecteur, l'autorité comme étant le pouvoir ou le droit de donner des ordres, d'agir, ou de pren-

departures from the plans or specifications, (c) authorize extras or deductions to the contract, (d) stop the contractor's operation, or (e) give instructions or orders to the contractor's workers (i.e., he may deal only with the contractor or his authorized representative).

The eighth text, ***Recommended Standards for the Responsibility, Authority, and Behavior of the Inspector***, appeared in ***Journal of the Construction Division*** (Proceedings of the American Society of Civil Engineers, June 1975). It reports the recommendations of an ASCE Committee on Inspection developed from the review of a comprehensive questionnaire project in which all segments of the construction industry were given an opportunity to express their views on the subject of inspection, its problems, and their solutions. Inspectors work at the level below the field supervisors — the subject of Selected Text No. 7.

In this text, responsibility is the duty or obligation of the inspector; authority is the power or right to give orders, take action, or make final decisions; and behavior is the way in which an inspector conducts himself with other inspectors, his supervisors, and the contractor.

The ninth text is excerpted from ***The rural access roads programme, appropriate technology in Kenya*** (International Labour Office, 1980). It describes a major rural road-building program intended to build 14 000 km of all-weather farm-to-market low-volume roads by using labor-intensive construction methods and a day labor construction system.

The excerpted portions deal with (a) the concept and initiation of the project; (b) the organizational structure of the program; (c) the planning, reporting, control, and procurement at Rural Access Roads Programme (RARP) headquarters; (d) planning and survey at the unit

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tema del Texto Seleccionado N° 7.

En este texto, responsabilidad es el deber o las obligaciones del inspector; autoridad es el poder o derecho de dar órdenes, tomar acción, o hacer las decisiones finales; y comportamiento es la forma como el inspector actúa con otros inspectores, sus supervisores y el contratista.

El noveno texto ha sido extractado de ***The rural access roads programme, appropriate technology in Kenya*** (El programa de caminos rurales de acceso, tecnología apropiada en Kenia, International Labour Office, 1980). Describe un programa importante de construcción de construir 14.000 km de camions de todo tiempo, para bajo volumen de tránsito y del tipo de caminos de productor al mercado, empleando métodos de construcción con mano de obra intensiva y un sistema de construcción por administración.

Las porciones extractadas tratan sobre (a) el concepto y la iniciación del proyecto; (b) la estructura organizativa del programa; (c) el planeamiento, informe, control y gestión en las oficinas principales del Programa de Caminos Rurales de Acceso (RARP); (d) el planeamiento y diseño a nivel de unidad (cada unidad es responsable de la implementación del programa en un área específica que contiene diversos emplazamientos individuales de construcción); (e) reclutamiento y motivación del personal supervisor empleado permanentemente, el personal de apoyo empleado mensualmente, y los empleados ocasionales (ésto es, la mano de obra empleada diariamente entre los pobladores locales en cada lugar de construcción); (f) preparación e implementación de los trabajos en los emplazamientos individuales de construcción; y (g) entrenamiento del personal del RARP con ex-

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dre les décisions finales, et le comportement comme étant la façon dont un inspecteur se conduit vis-a-vis des autres inspecteurs, de ses supérieurs et de l'entrepreneur.

Le neuvième texte est extrait de ***The rural access road programme, appropriate technology in Kenya*** (Le programme des routes rurales de desserte, technologie adaptée au Kenya), publié par l'International Labour Office en 1980. On y décrit un programme important de construction de routes rurales, où l'on propose de construire 14000 km de routes économiques tous temps, permettant aux cultivateurs d'écouler leurs produits. On utilisera des techniques de construction à forte-intensité de main-d'oeuvre en régie.

Les sections que nous avons choisies traitent (a) de la conception et du lancement du projet, (b) de la structure organisationnelle du programme, (c) de la planification, les comptes rendus, le contrôle et les acquisitions au niveau de la direction principale du Rural Access Roads Programme (RARP), (d) de la planification et des relevés topographiques au niveau de la brigade unitaire (chaque brigade est responsable de l'exécution du programme dans un secteur spécifique qui embrasse plusieurs chantiers individuels, (e) du recrutement et de la motivation des cadres permanents responsables de la supervision, des employés au mois, et des ouvriers temporaires (c'est-à-dire la main d'oeu-

level (each unit is responsible for the implementation of the program in a specified area that contains several individual construction sites); (e) recruitment and motivation of permanently employed supervisory staff, monthly employed support staff, and casual employees (i.e., the daily employed labor force recruited from among local inhabitants at each construction site); (f) preparation and implementation of the works at the individual construction sites; and (g) training of RARP personnel other than casual employees.

Several appendixes are also excerpted, including (a) procurement, along with a sample list of hand tools required to equip a construction unit of 300 casual laborers; (b) planning, programming, and reporting at site and unit level, including quantities of work and productivity norms for each operation; and (c) payment system for casual labor used in the RARP.

Selected Text No. 9 describes the systems and procedures developed for the RARP and shows how problems were overcome. It does not provide an analytical evaluation of the RARP

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cepción de los empleados ocasionales.

Se han extractado también varios anexos, incluyendo (a) adquisición, conjuntamente con una lista de muestra de herramientas manuales para equipar una unidad de construcción de 300 obreros ocasionales, (b) planeamiento, programación e informe a nivel de sitio y de unidad, incluyendo cantidades de trabajo y normas de productividad para cada operación; y (c) sistemas de pago para la mano de obra ocasional utilizada en el RARP.

El Texto Seleccionado N° 9 describe los sistemas y procedimientos desarrollados por el RARP y muestra la forma como pueden superarse los problemas. No proporciona una evaluación analítica del RARP o un intento para evaluar sus costos y beneficios. Se pretende presentar el material de referencia básico para los ingenieros y planificadores de los países en desarrollo interesados en establecer programas similares.

El décimo texto, ***Optimum Working Time*** (Tiempo de trabajo óptimo), apareció en ***Transportation Engineering Journal of the ASCE*** (Proceedings of the American Society of Civil Engineers, noviembre 1977). Bosqueja un método para determinar el tiempo óptimo de construcción y, en consecuencia, el número más económico de cuadrillas requeridas para las operaciones de construcción de capital intensivo. El método se basa en la premisa de que el tiempo óptimo de trabajo para una operación de construcción ocurre cuando el costo total de los gastos generales variables (ésto es, supervisión y administración, que son costos que dependen del tiempo), es igual al costo total para movilizar y desmovilizar todas las cuadrillas (que es un costo fijo por cuadrilla).

Las ecuaciones y reglas de optimización presentadas dan a los administradores de construcción un marco importante de referencia para el planeamiento del proyecto y para la evalua-

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vre employée à la journée et qui est recrutée parmi la population locale pour chaque chantier), (f) de la préparation et de l'exécution des travaux de chaque chantier, et (g) de la formation technique du personnel de RARP, les journaliers étant exclus.

Plusieurs annexes sont incluses: (a) acquisitions, ceci comprenant une liste, que l'on peut utiliser comme modèle, des outils manuels nécessaires à l'équipement d'une brigade unitaire de 300 journaliers, (b) planification, programmation et comptes rendus, au niveau du chantier et au niveau de la brigade unitaire, y compris le montant de travail et les normes de productivité pour chaque opération, et (c) méthodes de rémunération de la main-d'oeuvre journalière du RARP.

Dans le texte choisi no. 9 on donne une description des systèmes et procédés developpés pour le RARP et on explique comment on vient à bout des problèmes. On ne fournit pas une évaluation analytique du RARP, et on n'essaie pas de déterminer les coûts-avantages du programme. L'objectif est de présenter une référence de base, à laquelle les ingénieurs et planificateurs des pays en voie de développement voulant organiser des programmes similaires, puissent se rapporter.

Le dixième texte, ***Optimum Working Time*** (Temps optimal de travail) a été publié dans ***Transportation Engineering Journal of ASCE*** (Proceedings of the American Society of Civil Engineers, November 1977). On y esquisse une méthode pour déterminer le temps optimal de construction et, par conséquent, le nombre le plus économique d'équipes nécessaires pour la construction à forte intensité de capital. La méthode est basée sur le principe que le temps de travail optimal d'une opération de construction se trouve lorsque le coût total des frais généraux variables (c'est à dire supervision et administration qui sont des coûts qui dépendent de la du-

or attempt to assess its costs and benefits. It is intended to present basic reference material for engineers and planners in developing countries interested in setting up similar programs.

The tenth text, ***Optimum Working Time***, appeared in ***Transportation Engineering Journal of ASCE*** (Proceedings of the American Society of Civil Engineers, November 1977). It outlines a method for determining the optimum construction time and, consequently, the most economic number of crews required for capital-intensive construction operations. The method is based on the premise that the optimum working time for a construction operation occurs when the total cost for variable overheads (i.e., supervision and administration, which are time-dependent costs) equals the total cost to mobilize and demobilize all of the crews (which is a fixed cost per crew).

The optimizing equations and rules presented give construction administrators an important frame of reference for project planning and for the evaluation of contractor claims. The techniques are equally applicable to contract construction and day labor construction because substantial cost differences are associated with varying working times and numbers of crews in

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ción de los reclamos del contratista. Las técnicas son igualmente aplicables a la construcción por contrato y por administración debido a que las diferencias substanciales de costo están asociadas con los tiempos variables de trabajo y el número de brigadas utilizados en ambos métodos. El sistema es simple y puede ser aplicado manualmente con eficacia a todas las partidas de la ruta crítica, siempre que se utilice el planeamiento de la red.

El undécimo texto, ***Optimum Number of Crews*** (Número óptimo de cuadrillas), publicado en el ***Journal of the Construction Division*** (Proceedings of the American Society of Civil Engineers, junio 1978), es una variación y continuación del Texto Seleccionado N° 10. En este texto se formula claramente el número óptimo de cuadrillas que se requieren para las operaciones de construcción con mano de obra intensiva. El costo permutable en el texto está comprendido entre el costo de gastos generales variables y el costo de las cuadrillas, modificado por el fenómeno de la curva experiencia (Ley de Wright). Esta ley establece que el tiempo promedio acumulado para hacer trabajos repetitivos varía exponencial e inversamente, a medida que aumenta geométricamente el número de repeticiones (ésto es, el rendimiento total de 100 cuadrillas trabajando un día, es menor que el rendimiento total de una cuadrilla trabajando 100 días, debido a que la experiencia de una cuadrilla se acumula al repetir la misma operación).

Debido a la teoría de la curva experiencia, la forma matemática de determinar los valores óptimos del número de cuadrillas y el tiempo total de construcción con mano de obra intensiva, es algo más compleja que las ecuaciones dadas para la construcción con capital intensivo. Las características de las curvas experiencia varían dependiendo de la dificultad y variedad de las operaciones requeridas de las cuadrillas. Las actividades de construcción de carreteras con mano de obra intensiva son normalmente muy simples y repetitivas y se ubicarían en la catego-

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rée des travaux) égale le coût total de mobiliser et démobiliser toutes les équipes (coût fixe par équipe).

Les règles et équations d'optimisation qui sont présentées ici, donnent aux administrateurs de construction un outil de référence important pour la planification des projets et l'évaluation des demandes de l'entrepreneur. Ces techniques s'appliquent également à la construction en régie et à l'entreprise, car des différences substantielles de coût sont associées avec des durées de travail et des nombres d'équipes variés dans les deux systèmes. Cette méthode est simple et l'on peut l'appliquer manuellement avec efficacité à tous les points du chemin critique chaque fois que l'on utilise la planification du réseau.

Le onzième texte, ***Optimum Number of Crews*** (Nombre optimal d'équipes) publié dans le ***Journal of the Construction Division***, (Proceedings of the American Society of Civil Engineers, 1978) est une variation et une continuation du texte choisi no. 10. Dans ce texte, le nombre optimal d'équipes est formulé pour la méthode de construction à forte intensité de main-d'oeuvre. Le coût permutable dans ce texte est entre le coût des frais généraux variables et le coût des équipes modifié par le phénomène de la courbe de l'expérience (Loi de Wright). Cette loi établit que le temps moyen accumulé nécessaire pour faire des travaux répétitifs varie exponentiellement et inversement à mesure que le nombre de répétitions augmente géométriquement (c'est à dire que le rendement total de 100 équipes travaillant un jour est moins que le rendement total d'une équipe travaillant 100 jours à cause de l'expérience que cette équipe accumule en répétant la même opération).

both methods. The method is simple and can be effectively applied manually to all items on the critical path whenever network planning is used.

The eleventh text, ***Optimum Number of Crews***, published in ***Journal of the Construction Division*** (Proceedings of the American Society of Civil Engineers, June 1978), is a variation and continuation of Selected Text No. 10. In this text, the optimum number of crews is formulated for labor-intensive construction operations. The cost trade-off in this text is between the cost of variable overheads and the cost of the crews as modified by the experience curve phenomenon (Wright's Law). This law states that the cumulative average time to do repetitive works varies exponentially and inversely as the number of repetitions increases geometrically (i.e., the total output of 100 crews working one day is less than the total output of one crew working 100 days because of the experience the one crew accumulates from repeating the same operation).

Because of the experience curve theory, the mathematics of determining the optimum values for the number of crews and the total construction time for labor-intensive construction is somewhat more complex than the equations given for capital-intensive construction. The characteristics of the experience curves vary depending on the difficulty and variety of the operations required of the crews. Labor-intensive highway construction activities are normally quite simple and very repetitive and would fall in the 80 percent experience curve category, which is the most susceptible to time

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ría 80% de la curva experiencia, que es la más susceptible a una reducción de tiempo basada en la experiencia.

La sensibilidad del análisis anterior aumenta a medida que disminuye la relación del costo diario de los gastos generales del trabajo (supervisión y administración) al costo diario de una cuadrilla. Hablando en general, cuando la relación es menor que la unidad, una desviación de la solución teórica del número óptimo de cuadrillas dará por resultado un aumento significativo en el costo total de construcción. Cuando la relación excede la unidad, la sanción por no emplear el número óptimo teórico de cuadrillas no resulta significativo para un alcance más amplio.

El duodécimo texto es un artículo titulado ***Critical path scheduling: an overview and a practical alternative*** (Programación por la ruta crítica: una vista general y una alternativa práctica, ***Civil Engineering***, ASCE, julio 1980). Este artículo explica un procedimiento simple para programar tanto proyectos de construcción por contrato o por administración empleando el método del diagrama de flechas tiempo-escala de la programación que emplea el Método de la Ruta Crítica (CPM). Los tres pasos básicos para preparar un programa CPM son (a) planear o graficar en secuencia las actividades, (b) estimar la duración de las actividades, y (c) programar o calcular la ruta crítica o el menor tiempo para completar una serie de actividades, cada una de las cuales dependientes de la terminación previa de todas las actividades anteriores. Los primeros dos pasos deben hacerse manualmente, y el tercero, que normalmente se hace con computadora, usando la técnica descrita en el texto también puede hacerse muy fácilmente en forma manual.

El texto describe la determinación convencional de la ruta crítica tanto manualmente como

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A cause de la théorie de la courbe de l'expérience, les mathématiques pour déterminer les valeurs optimales du nombre d'équipes et le temps total de construction pour les travaux faits en utilisant les techniques à forte intensité de main-d'oeuvre, sont tant soit peu plus complexes que les équations données pour les techniques de construction mécanisée. Les caractéristiques des courbes de l'expérience varient selon la difficulté et la variété des opérations requises des équipes. Les techniques de construction à forte intensité de main-d'oeuvre sont normalement très simples et répétitives et se trouvent dans la catégorie 80% de la courbe de l'expérience, celle qui est la plus sensible à la réduction du temp de travail basée sur l'expérience.

La sensibilité des analyses ci-dessus augmente à mesure que diminue le rapport des frais généraux par jour (supervision et administration) au coût par jour d'une équipe. En général, quand le rapport est moins que l'unité, une déviation de la solution théorique du nombre optimal d'équipes résultera en une augmentation importante du coût total de construction. Quand le rapport excède l'unité, la sanction pour la non-utilisation du nombre optimal d'équipes n'est pas importante pour un plus grand écart de nombre d'équipes.

Le douzième texte est un article intitulé ***Critical Path Scheduling: an Overview and a Practical Alternative*** (La programmation en utilisant la méthode du chemin critique: une vue d'ensem-

reduction through experience.

The sensitivity of the above analyses increases as the ratio of the daily cost of job overhead (supervision and administration) to the daily cost of one crew decreases. Generally speaking, when the ratio is less than unity, a departure from the theoretical solution of the optimum number of crews will result in a significant increase in the total cost of construction. When the ratio exceeds unit, the penalty for not employing the theoretical optimum number of crews is not significant for a broader range.

The twelfth text is an article entitled ***Critical path scheduling: an overview and a practical alternative*** (***Civil Engineering***, ASCE, July 1980). This article explains a simple procedure for scheduling either contract or day labor construction projects by using the time-scale arrow diagram method of Critical Path Method (CPM) scheduling. The three basic steps in preparing a CPM schedule are (a) planning or diagramming the activities in sequence, (b) estimating activity durations, and (c) scheduling or computing the critical path or the shortest time to complete a series of activities, each of which is dependent on the prior completion of all previous activities. The first two steps must be done manually, and the third step, by using the technique described

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por computadora. Describe luego la preparación manual de un diagrama de flechas tiempo-escala y compara el esfuerzo y los resultados, con los obtenidos por el sistema convencional CPM.

Se pueden actualizar los diagramas de flechas tiempo-escala durante la fase de construcción de un proyecto utilizando una línea vertical de posición relativa. Esta línea empieza en la fecha de la revisión, desciende verticalmente hasta la primera actividad, se desplaza luego horizontalmente hasta el porcentaje completo de la flecha que corresponde a dicha actividad, y continúa de esa manera a través de cada flecha de actividad programada corrientemente, hasta llegar al final de la página. Este procedimiento es preferible a tener que dibujar nuevamente la red debido a que no oculta el plan original ni las desviaciones previas del plan mostradas en las revisiones anteriores.

Bibliografía

Los textos seleccionados son seguidos por una breve bibliografía que contiene datos de referencia y abstractos de 19 publicaciones. Los primeros 12 describen los textos seleccionados, los otros 7 describen publicaciones que se asocian íntimamente con los textos seleccionados. Aunque hay muchos artículos, informes y libros que podrían haber sido nombrados en la bibliografía, no es el propósito de ésta contener todas las referencias posibles sobre el tema. La bibliografía contiene únicamente aquellas publicaciones de las cuales se seleccionó texto o publicaciones básicas que hubieran sido seleccionadas si no hubiera un límite al número de páginas en este compendio.

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ble et une alternative pratique) publié dans ***Civil Engineering***, ASCE, Juillet 1980. On explique un procédé simple pour programmer la construction de projets de construction soit à l'entreprise, soit en régie, en utilisant les schémas fléchés-échelle de temps de la méthode du chemin critique (CPM). Les trois opérations de base pour préparer un programme CPM sont: (a) planification ou schématisation des activités en série, (b) estimation de la durée de chaque activité, et (c) programmation ou calcul du chemin critique ou le temps le moins long pour compléter une série d'activités, chacune de ces activités etant dépendante de l'achèvement au préalable de toutes les activités précédentes. Les deux premières opérations doivent être faites manuellement, la dernière en utilisant les techniques décrites dans le texte, peut facilement être faite à la main aussi.

On décrit la détermination classique du chemin critique soit à la main soit en utilisant l'ordinateur. On décrit ensuite la préparation manuelle d'un schéma fléché-échelle de temps et on compare ensuite l'effort et le résultat avec ceux obtenus en utilisant la méthode classique du CPM.

Les schémas fléchés-échelle de temps peuvent être mis à jour pendant la phase de construction d'un projet, en utilisant une ligne verticale de position relative. Cette ligne commence à la date de révision, descend à la verticlale jusqu'à la première activité, se déplace ensuite horizontalement jusqu'au pourcentage complété de la flèche qui représente cette activité, et continue de cette manière à travers chaque activité courante programmée, jusqu'au bas de la page. Il est préferable du suivre ce procédé plutôt que de redessiner le réseau, car ainsi ni le

in the text, can easily be done manually.

The text describes the conventional determination of the critical path both manually and by computer. It then describes the manual preparation of a time-scale arrow diagram and compares the effort and results to those of the conventional CPM approach.

Time-scale arrow diagrams can be updated during the construction phase of a project by using a vertical status line. This line starts at the revision date, drops vertically to the first activity, jogs horizontally to the percentage complete of that activity arrow, and continues in like manner through each currently scheduled activity arrow to the bottom of the page. This procedure is preferable to redrafting the network because it does not obscure the original plan and previous deviatons from the plan shown for earlier revision dates.

Bibliography

The selected texts are followed by a brief bibliography containing reference data and abstracts for 19 publications. The first 12 describe the selected texts. The other seven describe publications related to the selected texts. Although there are many articles, reports, and books that could be listed, it is not the purpose of this bibliography to contain all possible references related to the subject of this compendium. The bibliography contains only those publications from which a text has been selected or basic publications that would have been selected had there been no page limit for this compendium.

plan original ni les déviations préalables du plan montrées en des révisions antérieures ne sont obsurcis.

Bibliographie

Les textes choisis sont suivis d'une courte bibliographie contenant les références et résumés de 19 publications. Les douze premiers décrivent les textes choisis. Les autres sept décrivent des textes apparentés au sujet des textes choisis. Bien qu'il existe beaucoup d'articles, rapports et livres que nous pourrions énumérer, l'objectif de cette bibliographie n'est pas d'inclure toute a littérature publié sur le sujet de ce recueil. Cette bibliographie contient seulement les publications dont nous avons extrait un texte, ou des publications de base que nous aurions aimé, mais n'avons pû inclure, pour des raisons évidentes de concision.

Project Correspondent Coronel Mario Flores Theresin, Ministry of Communications, Public Works, and Transportation, Honduras.

Selected Texts

This section of the compendium contains selected pages from each text that is listed in the table of contents. Rectangular frames are used to enclose pages that have been reproduced from the original publication. Some of the original pages have been reduced in size to fit inside the frames. No other changes have been made in the original material except for the insertion of occasional explanatory notes. Thus, any errors that existed in the selected text have been reproduced in the compendium itself.

Page numbers of the original text appear inside the frames. Page numbers for the compendium are outside the frames and appear in the middle left or middle right outside margins of the pages. Page numbers that are given in the table of contents and in the index refer to the compendium page numbers.

Each text begins with one or more pages of introductory material that was contained in the original publication. This material generally includes a title page, or a table of contents, or both. Asterisks that have been added to original tables of contents have the following meanings:

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Chaque texte commence par une ou plusieurs pages d'introduction qui étaient incluses dans le texte original. Ces pages sont généralement le titre, ou la table des matières, ou les deux. Des astériques ont été ajoutés à la table des matières d'origine, pour les raisons suivantes :

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2 Por lo tanto, los textos seleccionados únicamente incluyen aquellas partes de los documentos originales que están precedidas por asteriscos en el índice de las publicaciones respectivas.

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incluses dans les textes choisis, mais d'autres pages (ou portion de pages) de l'édition originale ont été omises

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DIVISION OF ENGINEERING AND INDUSTRIAL RESEARCH
NATIONAL RESEARCH COUNCIL

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PROCEEDINGS
OF THE
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Director, Highway Research Board
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Assistant Director, Highway Research Board

WASHINGTON, D. C.

TABLE OF CONTENTS

	Page
Author Index	v
Organization	viii

Economics

Department of Highway Transportation Economics, R. L. Morrison, Chairman[1]	
Report of Committee for Post-War Planning, C. M. Upham, Chairman	1
** Construction by Contract and by Day Labor, C. N. Conner	3
Wage Earner Employment Resulting from Highway Construction, Alexander C. Findlay	10
Current and Post-War Application of Road Life Data, R. C. Faltinson	15
Current Aspects of Research on Economic Life of Highways, Fred B. Farrell	21
Applications of Highway Economics, R. L. Morrison	26

Design

Department of Design, C. N. Conner, Chairman	
Report of Committee on Rigid Pavement Design, R. D. Bradbury, Chairman	32
Experiments With Continuous Reinforcement in Concrete Pavement—A Five-Year History, H. D. Cashell and S. W. Benham	35
Rigid Type Pavement Joints and Joint Spacing, H. F. Clemmer	45
Transverse Joints in the Design of Heavy Duty Concrete Pavements, H. W. Giffin	56
Uncertainties in Design of Concrete Pavements Due to Differential Settlements and Volumetric Changes, F. M. Baron	75
Report of Committee on Flexible Pavement Design, A. C. Benkelman, Chairman	90
Discussion by: M. D. Catton	99
Results of Accelerated Traffic Tests on Runway Pavements, T. A. Middlebrooks and R. M. Haines	101
Triaxial Testing Methods Usable in Flexible Pavement Design, Herbert E. Worley	109
An Apparatus for Measuring Slab Action in Flexible Type Pavements, John Lowe	117
Discussion by: G. P. Tschebotarioff	123
The Theory of Stresses and Displacements in Layered Systems and Applications to Design of Airport Runways, Donald M. Burmister	126
Discussion by: L. A. Palmer, E. S. Barber, A. Casagrande, T. A. Middlebrooks	144
A Mathematical Analysis of Some Phases of the Flexible Surface Design Problem, H. G. Nevitt	149
Thickness of Surface and Base Courses for Flexible Pavements, Roland Vokac	155
Culvert Design in California, G. A. Tilton, Jr. and R. Robinson Rowe	165
Design of Signs for the Pentagon Road Network, D. W. Loutzenheiser	206
Timber Highway Bridges in Oregon, C. B. McCullough and G. S. Paxson	235
Discussion by: C. C. Marilley, J. S. Seiler	250
Report of Committee on Roadside Development, H. J. Neale, Chairman	255
Report of Subcommittee on Roadside Design, A. R. Nichols, Chairman	258
Report of Subcommittee on Drainage and Drainage Structures—Principles of Highway Drainage, Carl F. Izzard, Chairman	264

Materials and Construction

Department of Materials and Construction, C. H. Scholer, Chairman	
Report of Committee on Traffic Zone Paints, J. E. Myers, Chairman	267
Accelerated Testing of Traffic Zone Paints, D. H. Dawson and A. Skett	267
Temperature Changes and Duration of High and Low Temperatures in a Concrete Pavement, W. J. Arndt	273
Progress Report on California Experience with Cement Treated Bases, T. E. Stanton, F. N. Hveem and J. L. Beatty	279

[1] The report of the Committee on Economic Highway Planning, L. E. Peabody, Chairman, on "Outline for the Initial Report of the State-Wide Highway Planning Survey", which is not printed in this volume is available for distribution on request.

Page

Effect of Calcium Chloride on the Water Requirements, Specific Weights and Compressive Strengths of Concretes Made with Plain and Treated Cements, H. C. Vollmer..... 296

Maintenance

Department of Maintenance, W. H. Root, Chairman
Report of Committee on Maintenance of Concrete Pavements as Related to the Pumping Action of Slabs, Harold Allen, Chairman 301
Pumping of Rigid Pavements in Indiana, K. B. Woods and T. E. Shelburne 301
Discussion by: W. R. Woolley 316
Deflectometer for Measuring Concrete Pavement Deflections Under Moving Loads, R. W. Couch 317
Projective Maintenance, H. D. Metcalf 325

Traffic and Operations

Department of Traffic and Operations, Wilbur S. Smith, Chairman
The Influence of Alinement on Operating Characteristics, O. K. Normann 329
Transverse Placement of Vehicles as Related to Cross Section Design, A. Taragin 342
Current Trends in Volumes and Characteristics of Highway Traffic, John T. Lynch..... 350
Origins and Destinations of Highway Traffic—The Basis for Connecticut Planning, Roy E. Jorgensen 363
Discussion by: J. T. Lynch 382
Indiana Wartime Traffic Speeds, Robert E. Frost 388
Predicting Traffic Death Rates, Earl Allgaier and Kenneth Wood 396
Discussion by: L. E. Peabody, Burton Marsh 401

Soils

Department of Soils Investigations, C. A. Hogentogler, Chairman
Report of Committee on Stress Distribution in Earth Masses, D. P. Krynine, Chairman... 402
Abutments for Small Highway Bridges, Jacob Feld 403
Discussion by: V. T. Boughton, A. W. Bushell, C. N. Conner, R. G. Hennes, W. P. Kimball, L. A. Palmer, G. P. Tschebotarioff 409
Research on Soil Stabilization, Mo Chih Li 413
Factors Involved in Stabilizing Soils with Asphaltic Materials, August Holmes, J. C. Roediger, H. D. Wirsig and R. C. Snyder 422
Discussion by: A. T. Goldbeck, C. N. Conner, A. Holmes 449
The Behavior of Densified Soil-Water Mixtures Under Very Adverse Water Conditions, W. H. Campen and J. R. Smith 450
Discussion by: O. J. Porter, Roy M. Young, W. H. Campen 458
Movement of Calcium Chloride and Sodium Chloride in Soil, Charles Slesser 460
Discussion by: H. G. Nevist, Charles Slesser 468
Large Scale Model Studies of Highway Subdrainage, Bram McClelland 469
Discussion by: W. E. Howland, W. J. Schlick, Bram McClelland 481
Weight-in-Water Methods of Determining the Moisture Content of Soil-Cement Mixtures in the Field, M. D. Catton and E. J. Felt 487
Discussion by: E. E. Bauer, E. J. Felt 494
Effect of Soil and Calcium Admixtures on Soil-Cement Mixtures, M.D. Catton and E. J. Felt 497
Roadway and Runway Soil Mechanics Data, Henry C. Porter 529

Aerial Photography

Use of Stereoscopic Methods in Preparing Topographic Maps from Aerial Photographs, M. J. Harden 552
Aerial Mapping Used in Regional Highway Planning, Robert Kingery 555
Aerial Photographs and the Distribution of Constructional Materials, A. J. Eardley... 557
The Engineering Significance of Soil Patterns, Donald J. Belcher 569
Minutes of Business Meeting 599
Memorials 603
Highway Research Board Award 606
Bartlett Award 606

5

CONSTRUCTION BY CONTRACT AND BY DAY LABOR

CONTRIBUTED BY CARLTON N. CONNER
Public Roads Administration

SYNOPSIS

The relative advantages and disadvantages of public works construction by means of day labor or contract are discussed and data from two surveys are presented.

Under the day labor method a public agency performs the work with employees hired for the purpose. There are five forms of the contract method: cost plus percentage, cost plus fixed fee, negotiated lump sum, competitive lump sum and competitive unit price. Most public road and street construction is done by the unit price contract method.

Prequalification of contractors and the facilities of the Bureau of Contract Information are discussed as factors in successful public work contracting.

Under authorization of the Congress and with the cooperation of the Bureau of Public Roads, now Public Roads Administration, 46 States and one Territory built 53 highway projects by day labor after first taking competitive bids in order to get a basis of comparison of the two methods. The total cost of the 53 projects by day labor was 18 per cent in excess of the bid prices. On 40 of the jobs the day labor cost exceeded the bid prices by 31 per cent and on 13 the cost was less than the bid prices by 10 per cent.

In a survey of county practices conducted in 1941 by *Public Works* by questionnaire 62 per cent of 595 counties replying reported in favor of day labor and 38 per cent in favor of the contract method. Generally, contract work was favored for heavy excavation, large bridges and high type paving, which types of work are relatively infrequent in county operations. Advantages of day labor appeared to be most apparent on small operations.

It is concluded that, except under most favorable conditions, contract work is superior in economy and efficiency to day labor.

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In the expenditure of funds for the accomplishment of public construction projects two principal methods are recognized. One of these is known as the "day labor method" and the other as "contract construction."

The best information available at this time on the relative merits of day labor and contract construction consists of statements by authorities whose chief occupation has been construction and of the results of comparative research on the two systems.

This report relates principally to highway construction and has for its purpose to define the contract and day labor systems, and to compare the advantages and disadvantages of each.

DAY LABOR METHOD

Day labor construction is a procedure whereby a public agency itself undertakes the work with employees hired for the purpose. In this connection the terms day labor and force account may not be used synonymously although common usage makes no distinction between them. Force account is the term used under a contract to designate extra work done by the contractor for which no price was bid in the contract. Whereas, day labor is the term applied to construction that is accomplished by the owner with his own organization.

FIELD OF USE FOR DAY LABOR

Advocates of day labor procedure claim that it saves the contractor's profit, that it readily permits changes in original design or scope of project without cumbersome negotiation, and that it enables the owner to maintain direct control of every feature of the operation at all times. However, day labor has several proved weaknesses which for the most part have limited its application to exceptional situations. In the first place it is

highly vulnerable to political manipulation. In the second place no certain means are provided whereby ultimate cost of the completed structure can be fixed in advance. In the third place a construction organization recruited for day-labor work usually lacks the background of teamwork, experience and driving accomplishment which speedy and economical construction require.

The day-labor method may be used to advantage on public works where much employment must be given quickly and costs may not be an important factor. The day-labor method may be used on new or unusual types of construction, on projects of unprecedented size, experimental undertakings or projects for which a schedule of work items cannot be set up. A number of major projects have been constructed by day-labor after bids were received and rejected including the Panama Canal, the Miami Conservancy District and certain locks and dams along the Ohio River.

Reasons advanced to justify day labor on highway work are better employment of common labor, proximity of supervisors and equipment operators living in the vicinity of the project, better use of local materials and saving in construction costs. It is believed by some that day labor construction can be carried on at a cost equal to that for contract construction provided projects adaptable to day labor are selected and competent supervision is employed. Types of highway work adapted to day labor methods include clearing of right of way, clearing of ditches and culverts, improving shoulders, removal of obstructions to improve sight distance, widening curves, improvement of slopes, minor drainage construction, and resurfacing secondary roads.

In investigating costs of day labor construction all essential and appropriate items must be included if the true cost is desired. Essential items that sometimes are omitted include charges for overhead, depreciation of equipment, equipment rentals and other items of less importance.

Plans and specifications for new highway construction are well standardized. A large number of contractors are well acquainted with the requirements for highway construction. Consequently probable cost can be estimated in advance of the construction. Under the day-labor system, plans, specifications and detailed cost estimates usually are not available at the time of starting the project and the final cost may remain unknown until long after the work is completed.

CONTRACT SYSTEM DEFINED

Under the contract system a single construction agency assumes the full responsibility for the completion of the project. The contractor usually agrees to furnish all labor, materials, equipment, required for the construction and to complete the work according to plans and specifications. The contractor also agrees to protect the owner from all losses due to damage suits, liens or other causes. He provides highly specialized skill, assumes the financial responsibility for the completion of the work, and is usually required to complete the work within a specified time. The owner does not assume any financial responsibility for the completion of the work.

There are several forms of contracts which include the following.

Cost plus percentage contract,
Cost plus fixed fee contract;
Negotiated lump sum contract;
Competitive lump sum contract and
Unit price contract.

COST PLUS PERCENTAGE CONTRACT

Under this form of contract the contractor agrees to complete the project for its actual cost plus a fee for his services. Such fee may be on a direct percentage of the cost, or on a sliding percentage of the cost.

COST PLUS FIXED FEE

The contractor under this form agrees to complete the project for the actual cost plus a stipulated amount.

NEGOTIATED LUMP SUM CONTRACT

Under the provisions of the lump sum form of contract the contractor binds himself to furnish all the materials and labor and to complete the project for a stipulated amount. In this case the owner negotiates with contractors selected by him as competent to handle the work.

COMPETITIVE LUMP SUM CONTRACT

By the lump sum form of contract the contractor agrees to furnish all materials and

7

labor and to provide a completed project for a stipulated amount determined as a result of competitive bidding.

UNIT PRICE CONTRACT

Under the unit price form of contract a price is bid for each unit of construction as set up in a bid schedule.

After an exhaustive study and discussion of contracts "Cost Plus" and other forms, J. A. L. Waddell, the well known consultant and engineer recommended in the 1919-1920 Transactions of A.S.C.E. an Ideal System of Contract-Letting and Profit Sharing which among other desirable features calls for each bidder to submit unit-cost prices.

Substantially all highway construction done by the State Highway Departments with or without federal aid as well as street work done by the larger municipalities is by the unit price form of contract.

FEDERAL AID

Federal aid highway construction is carried out by contract methods using the unit price type of contract. Under the rules and regulations for such construction it is required that no part of the Federal money set aside on account of any project shall be paid until it has been shown that adequate methods, either advertising or other devices appropriate for the purpose were employed prior to the beginning of construction to insure economy and efficiency in the expenditure of such money. An advertising period of two weeks may be accepted provided a suitable mailing list of contractors is maintained by a State highway department to whom notices of new work are mailed, and adequate public advertisement over a specified period is carried out.

8

Substantially all contracts for the construction of Federal aid highways require the contractor to furnish all materials entering into the work.

No procedure or requirement will be approved which is designed or may operate to prevent a submission of a bid or the award of a contract to any responsible contractor whether resident or non-resident of the State wherein the work is to be performed. Federal legislation and regulations are specific with regard to highways constructed with Federal aid and they are recommended for study and use.

PREQUALIFICATION

An important procedure in the administration of public works by contract is the prequalification of contractors. This has been rather widely adopted in one form or another although its greatest peace-time use appears to have been in connection with State highway construction. Nearly all the states, except those in the northeast corner of the country, have laws or regulations dealing with the subject.

During the war emergency, prequalification has been a necessary proceeding in connection with awards of Federal cost-plus-a-fixed-fee and negotiated lump sum contracts and in selection of invitation bidders.

Among the advantages commonly attributed to prequalification are the following:

1. It provides adequate time for determination of the contractor's qualifications before bids are received, thus obviating the necessity for hasty, and frequently incomplete investigation of the low bidder after bids are opened.
2. It eliminates pressure often brought to bear upon the awarding authority to accept the bid of an unsuitable contractor.
3. It prevents the public criticism which sometimes arises when an awarding authority disqualifies the low bidder and makes the award to a higher one.
4. It influences contractors to build up their qualifications to definite standards and thus creates a larger group of qualified competitors.
5. It discourages the activities of shoestring operators, so called, who do not possess the responsibility or resources necessary to surmount unforeseen construction difficulties.

On the other side of the question the following arguments are sometimes advanced:

1. Prequalification opens the way to restriction of competition for political reasons or to favor local contractors.
2. It offers an opportunity for collusive bidding, especially if the qualified bidders are regularly in competition with each other.

3. It retards participation by new organizations which, through process of small beginnings and sound growth, would eventually qualify and replace organizations retiring from the field.
4. It becomes a factor in the establishment of trade barriers between the states, thus restricting interstate commerce and free competition.

Experience covering the past fifteen years appears to have justified the arguments in favor of prequalification. There seems to be little doubt but that the idea is a practical and helpful one, capable of producing beneficial results. In those occasional situations where the procedure has proved relatively ineffective the reason usually may be traced to defects in the laws or regulations governing its operation. During the war contractors have accustomed themselves to Federal prequalification and there is cause to believe that the subject will obtain wider recognition when peace returns.

Standardization of forms and data requirements would perhaps do more than anything else to promote the use of prequalification.

CONTRACT INFORMATION

Information about prospective contractors is important to successful operation by the contract method. Since the first World War facilities have been provided whereby officials and financial interests can obtain needed information regarding the qualifications of contractors. In 1926 committees representing the principal technical, official and trade organisations interested in construction, recommended establishment of an independent agency which would investigate the business reputation and construction ability of contractors. As a result of this recommendation in 1929 construction and surety interests cooperated in the establishment of the Bureau of Contract Information. It is an independent non-profit institution financed principally through subscriptions from nearly all important bonding companies. Its principal function is that of a clearing house which assembles and verifies data regarding the background and capacity of contractors. This information, in factual, unbiased form, is available without cost to those charged with the responsibility for making contract awards.

Each State highway department usually maintains a file of information relating to the performance of contractors within the State and this information is available for exchange between the States.

SUMMARY OF THE ADVANTAGES AND DISADVANTAGES OF THE CONTRACT SYSTEM

Contracts wherein the owner assumes the risk and pays the contractor a fee for services have been proved to be uneconomical for ordinary employment in connection with public works; and this type of contract has been limited principally to emergency use and to unusual projects where the estimation of costs within reasonable limits is impossible.

The negotiated lump sum contract usually involves submission of a proposition by a contractor and subsequent negotiation between him and the owner, using his proposition as a basis. Purpose of the negotiation is to arrive at a lump-sum contract price acceptable to both parties. This form places upon the contractor full responsibility for completion of the work in accordance with plans and specifications and in compliance with all terms of the contract. Its principal disadvantages are that it may not develop the lowest obtainable contract price and that it affords an opportunity for favoritism or for collusion between the negotiators.

The most widely used and most firmly established means of carrying on public construction is that of open competition on a lump sum or unit price basis and award made to the lowest responsible bidder.

Experience has shown that successful routine employment of the competitive contract method requires,

1. Full and clear plans and specifications available in advance.
2. Sufficient notice to prospective bidders.
3. Opening of sealed bids in public, surrounded by safeguards designed to prevent bid manipulation.
4. Prompt award at prices offered by the lowest qualified bidder.
5. Exaction of a binding third party indemnity against loss.

This last requirement, that of third party suretyship, is one of the most important factors in the success of modern contract construction for it brings in a separate outside

resource, distinct from but bound with, the contractor.

RELATIVE ECONOMY OF HIGHWAY CONSTRUCTION BY CONTRACTOR AND BY DAY LABOR

In carrying out the program of Public Works highway construction authorized by the Act of June 16, 1933 it was required that each State undertake to construct one or more sections of highway with forces employed directly by the State. The purpose of the requirement was to determine the relative economy and efficiency of highway construction by contract and by direct employment of labor.

At hearings concerning Emergency Construction of Public Highways, before the Committee on Roads, House of Representatives, January 22 and 23, 1935, the Commissioner of Public Roads, then Chief of Bureau, stated in part regarding the project as follows:

"In order to get a reasonable measure of the relative efficiency of contract and force account work,[1] we required each State to undertake at least one project by the force-account or direct-labor method. These projects were selected after bids had been taken in order to know what the work would cost if let to contract. The States have kept very careful records of the cost of doing the work by force account, and, while we have not the final records, in practically all cases the cost has been higher by force account —some materially higher.

"There is no question about the quality of the work performed, and the increase in cost is not an entirely fair comparison, because the States were not operating this method on a large scale. However, there is no question about the relative economy of contract work versus force-account work under the supervision of the public bodies.

"The principal reason, I think, is that it is very difficult to get the same loyalty and performance from either material suppliers or the employees on the job, to the public, as the contractor can secure."

Forty-six States and one Territory constructed 53 sections of highway that were considered representative of the work generally done. The sections of highway were selected from advertised work after bids had been received and publicly opened and without advance determination.

Construction was executed under the same requirements as for contract work, adhering closely to the original plans. Labor was obtained through the local reemployment agencies when available. The regulations governing wages, hours of employment, and the use of equipment that were applicable to contract work were observed.

As the work progressed the State highway department kept detailed cost records of expenditures classified according to the items upon which bids were received and of general charges to be prorated among the various items. These data were submitted to the Bureau and are the basis of this portion of the report.

Each highway department was considered as a contractor. With two exceptions compensation and liability insurance premiums that would have been paid had the work been performed by contract, were included as a part of the construction cost and no payments of damages were included. In one State neither premiums or payments of claims are included. In another State actual payments of damages exceeded the estimated premium and the actual payments only were included. The cost of a bond for faithful performance was not included.

The 53 projects selected for the test totaled 244 miles in length and were of various types of construction. Substantially all projects were graded and drained and were surfaced with concrete pavement, a granular type surface such as gravel or stone or with a standard type of bituminous construction.

The total cost of construction by the force account method was $3,942,879 an increase of $593,126 or 18 per cent over the total of bid prices of $3,349,753.

On 40 of the jobs aggregating 176 miles or 75.5 per cent of the total projects the cost exceeded the bid price. The cost of these jobs by the force account method was $2,944,773 an increase of $703,384 or 31 per cent over the total of bid prices of $2,241,389. Comments were received on the efficiency of management of 29 of the jobs in this group. They are summarized as follows:

(1) Eighteen reported as inefficiently managed.

[1] In this statement "force account" is the same as "day-labor."

(2) Two reported as inefficiently managed and subjected to outside interference.
(3) Four reported efficiently managed.
(4) Five on which the State claimed contractor's bid did not include ownership expense of equipment.

Thirteen jobs, totaling 68 miles in length or 24.5 per cent of the total were completed at a cost less than the bid price. The cost by force account was $998,107 a decrease of $110,257 or 10 per cent under the bid price of $1,108,364. Six of these jobs were reported as efficiently managed, one was reported as inefficiently managed, and no comment was made for six of the jobs.

may have increased the day labor costs on certain projects.

As a result of the cooperative investigations it is believed that one of the principal advantages of the contract system over the day labor method has its inception in the self interest that is characteristic of human nature. Employed supervision, not having a monetary interest, does not have the same incentive as a contractor who enjoys the financial rewards and to whom losses are a personal penalty. He is spurred on by the knowledge that he must maintain efficiency or be forced out of business.

These tests of the day labor method, with

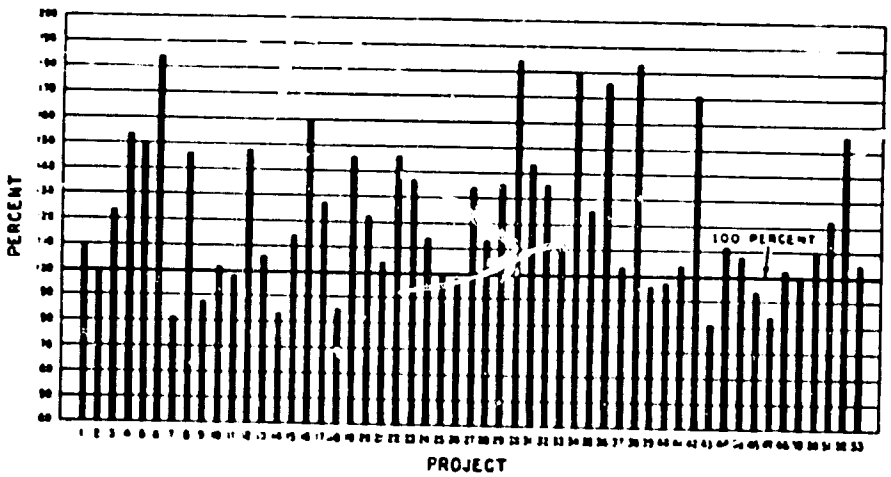


Figure 1. Comparison of Contract and Force Account Costs Based on Contract Cost Being 100 Per cent

Figure 1 shows graphically the comparison of contract with day labor costs, based on contract cost being 100 per cent.

Since the State highway departments had not been constructing highways by day labor on a large scale it was conceded that the day labor costs would have been slightly lower if the States had had more experience and time for preparation.

Some of the States lacked equipment and personnel with which to handle the work.

The regulations required competitive bids for supplying equipment on a rental basis and for supplying materials. A contractor probably would have used his own equipment and could have purchased materials as he chose. It is claimed by some that these requirements

few exceptions and those only where conditions were most favorable, show the advantage in economy and efficiency of construction under the personal supervision of a contractor who has suitable equipment.

DAY LABOR VERSUS CONTRACT IN COUNTY ROAD WORK

In 1941 Public Works Magazine, New York, undertook to determine which was considered more advantageous for county work, construction by contract or by day labor. Of nearly 1,000 counties answering the questionnaire, 595 gave definite replies, 368 or 62 per cent found day labor more advantageous while 227 or 38 per cent reported that contract construction was better.

11

In some States practically every county followed the same system while in others both methods were used. For instance in Iowa, 41 counties reporting, contract construction was almost universally favored; but in Kansas, the 50 counties replying were in favor of day labor.

With regard to efficiency and quality of work 28 counties out of 47 reporting stated that a better job was done and the work was more efficient by contract, while 19 favored day labor for the same reason.

Generally contractor equipment was favored for heavy excavation and for high type paving which, however, were constructed by relatively few counties. Day labor was favored because it employes local men and more money stays in the county and because it made it possible to build up and maintain a force of trained men.

There was general agreement that day labor is more flexible and convenient than contract work and that it permits small jobs to be done without delay.

A majority of those reporting on the subject of control and planning considered the contract method better for estimating costs and for planning in advance as well as for controlling funds.

A relatively small number of engineers favored the contract method because it eliminated "petty graft and politics," while one felt that day labor was preferable for the same reason.

Many of those making a reply felt that there is a place for both the force account and contract methods. In essence these men utilized contract construction for big excavation jobs and large bridges, neither of which most counties were well equipped to do, while day labor was employed on smaller jobs and on the usual work for which the county-owned equipment was adapted.

Necessarily most of the reasons for these beliefs were based on local conditions and local experiences.

SUMMARY AND CONCLUSIONS

The day labor method may be used to advantage on public works where much employment must be given quickly and cost may not be an important factor. Day labor should not be used as an economy measure or to secure better or quicker construction at low cost.

Types of highway work adapted to day labor methods include clearing and grubbing of right of way, clearing ditches and drainage structures, improving shoulders, removing obstructions to improve sight distance, widening curves, flattening slopes, resurfacing low type roads.

The day labor system of highway improvement is quite universally followed by town officials, officials of small cities, county authorities, and by State bodies when the work involved is classified as maintenance work.

Under the day labor system plans, specifications and detailed cost estimates usually are not available at the time of starting the project and the final cost may remain unknown until long after the work is completed.

The most widely used and most firmly established contract form of carrying on public construction is that of open competition on a lump sum or unit price basis and award made to the lowest responsible bidder.

The principle reason for the success of the contract system is that with other systems it is difficult to obtain the same loyalty and performance from material suppliers and employees that the contractor can secure.

Suitable equipment is essential to the success of either contract or day labor procedure.

Substantially all new Federal aid construction is carried out by the contract method using the unit price type of contract.

Substantially all new highway construction done by the State highway departments with or without Federal aid as well as street work done by the larger municipalities is by the unit price form of contract.

Experience covering the past 15 years appears to have justified the practice of prequalifying bidders. The practice is considered to be practical, helpful and capable of producing beneficial results.

The tests made by the Public Roads Administration to determine the relative economy and efficiency of highway construction by contract and by day labor show that construction by contract is more economical and more efficient than when done by day labor under the supervision of public agencies.

Briefly stated it appears that unless working conditions are favorable, supervision compe-

tent and the undertakings free from political and partisan interference, construction of new projects by day-labor is likely to be high in cost and low in quality.

REFERENCES

Federal Legislation and Rules and Regulations Relating to Highway Construction Administered by the Public Road Administration.

Hearings before the Committee on Roads, House of Representatives, Seventy-Fourth Congress, First Session, January 22, 23, 1935.

Transactions of the American Society of Civil Engineers, 1919–1920.

Proceedings, Association of Highway Officials of the North Atlantic States—1934.

American Association of State Highway Officials.

Highway Administration and Finance, Agg and Brindley, 1927.

American Road Builders' Association, Proceedings, 1935–1936.

Estimates and Costs of Construction, Frank Whitworth Stubbs, Jr.—1938.

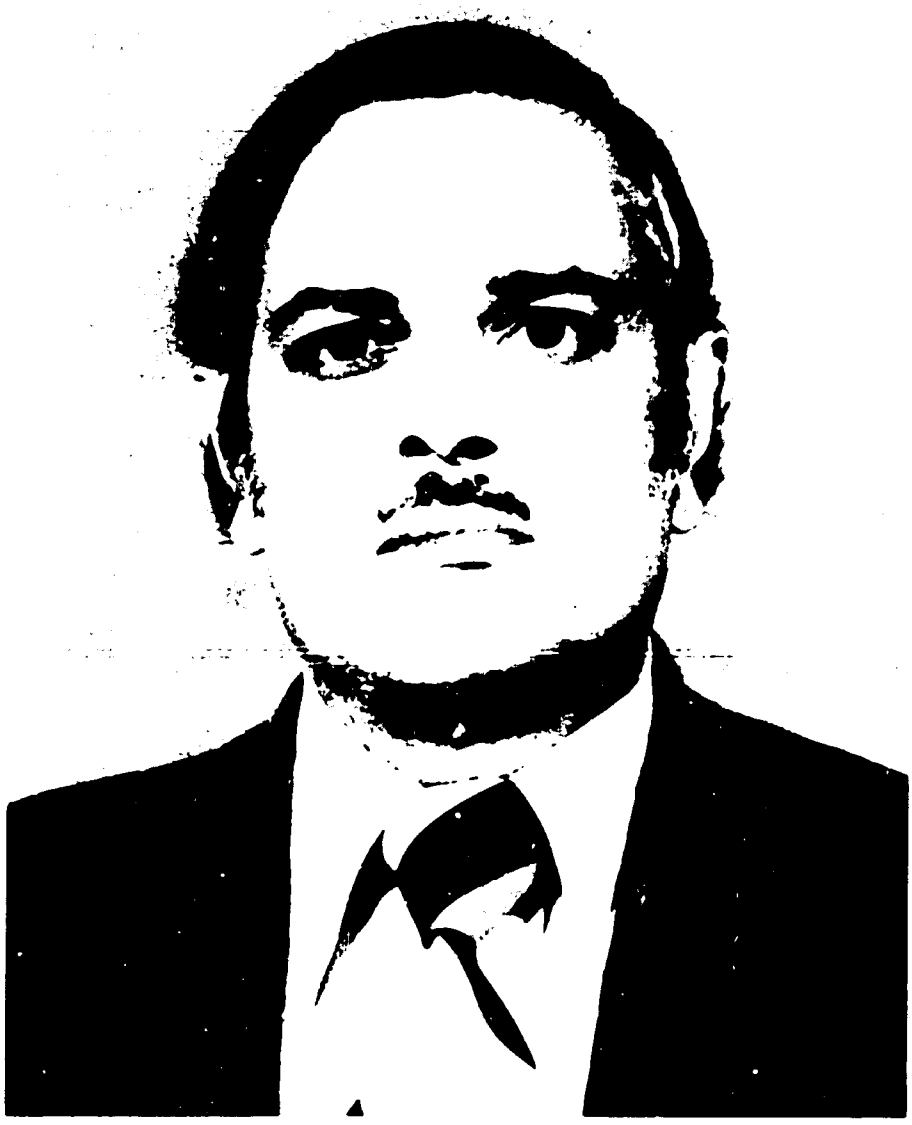
Economics of Construction Management, J. L. Harrison—1932.

Force Account on Unit Price Construction Contract—A Report by the Bureau of Municipal Research of Philadelphia—1928.

The Associated General Contractors of America.

Bureau of Contract Information, Inc.

Public Works Magazine.



Project Correspondent R. P. Sikka, Chief Engineer (Roads), Ministry of Shipping and Transport, Government of India.

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Director

ELMER M. WARD
Assistant Director

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Contents

Highway Research Board Officers and Executive Committee v
Papers and Reports in Other HRB Publications x

General

Highway Research Board:
Member Organizations and Their Representatives xv
Research Departments and Committees xvi
Highway Research Correlation Service Advisory Committee xxi
University and College Contact Men xxii

Economics, Finance, and Administration

Developments in the Western States Relating to Reciprocity Agreements—Harmer E. Davis 1
The Investment Analysis Approach to Estimating Highway Needs—Fred B. Farrell 9
Financial Planning for an Expanded Highway Program—G. P. St. Clair and T. R. Todd 14
Methodology of the Kentucky Incremental Analysis—Virgil L. Christian, Jr. 29
A Comprehensive Method of Scientific Programming—J. Carl McMonagle 33
Improvement Priority Ratings for Local Rural Roads in Indiana—John E. Baerwald 38
The Application of Benefit-Cost Ratios to an Expressway System—Howard W. Bevis 63
Performance Criteria for Local Road Operations—Robert S. Scott 76
Lives of Highway Surfaces—Half Century Trends—Gordon D. Gronberg and Nellie B. Blosser 89
** A Cost Comparison Study of Force Account and Contract Construction on Five Secondary Projects in North Carolina—F. B. Farrell and M. J. Kilpatrick 102

Design

Selection and Design of Semi-Flexible and Conventional Type Pavements—Frederick A. Harris 110
A Model Study of Rigid Pavement Behavior Under Corner and Edge Loadings—Paul F. Carlton and Ruth M. Behrmann 139
Investigation of Load Transfer Characteristics of Dowels—J. R. Keeton 147
Field Tests on a Prestressed Concrete Multi-Beam Bridge—A. Roesh, A. Smislova, C. E. Ekberg, Jr., and W. J. Eney 152
Overload Capacity—Prestressed Compared with Reinforced Concrete—Thomas J. Bezoriska 172
Head Losses in Storm Drain Junction Boxes—Horace W. Wood 177
Discussion by Herbert G. Bossy 191

Hydraulics of Box Culverts with Fish-Ladder Baffles—Roy H. Shoemaker, Jr. 196
Discussions by W. R. McKinley; Roy H. Shoemaker 208
Simplified Design Method for Reinforced Concrete Pipe Under Earth Fills—Dudley P. Babcock 210
Discussions by C. M. Adams; E. F. Bespalow; M. G. Spangler; R. E. Bald; John G. Hendrickson, Jr.; D. N. Brown; Howard F. Peckworth, Dudley P. Babcock 221
Dynamics of Highway Guardrails: Laboratory Experiments (II)—Robert S. Ayre and Milton A. Hilger 237
Full Scale Tests of Concrete Bridge Rails Subjected to Automobile Impacts—J. L. Beaton 251
Discussions by Robert S. Ayre; John L. Beaton 267
The Use of Multiple Regression and Correlation in Test Road Data—P. E. Irick, R. C. Leathers, R. A. Lill, and W. L. Mertz 268

Materials and Construction

Procuring Traffic Paint on the Basis of Performance Tests—C. C. Rhodes 299
Improved Methods of Estimating Stripped Area in Asphalt Stripping Tests—L. L. Lortscher, M. J. Snyder, and R. B. Filbert, Jr. 314
Determination of Asphalt Content of Bituminous Mixtures by Means of Radioactive Isotopes—Donald R. Lamb and J. Harold Zoller 322
Relationships Between Density, Bitumen Content, and Voids Properties of Compacted Bituminous Paving Mixtures—Norman W. McLeod 327
The Strength of Bituminous Mixtures and Their Behavior Under Repeated Loads—L. E. Wood and W. H. Goetz 405
A New Soniscope—"The Elastiscope"—Donald R. Lamb 418
Illinois Develops High Pressure Air Meter for Determining Air-Content of Hardened Concrete—J. D. Lindsay 424
Discussions by Thomas B. Kennedy; J. D. Lindsay 434
Prediction of Creep Behavior in Concrete from Sonic Properties—Tien S. Chang and Clyde E. Kesler 436

Maintenance

Resurfacing and Patching Concrete Pavements with Bonded Concrete—Earl J. Felt 444
Analytical Appraisal of the Effect of Bituminous Surfacing on the Stresses in Portland Cement Concrete Pavement—Ole Larsen 470
Bridge Maintenance Problems—John F. McGovern and Richard D. Murphy 481
California's Bridge Expansion Problems—Raymond J. Ivy 485

Traffic and Operations

Relation of Highway Accidents to Shoulder Width on Two-Lane Rural Highways in New York State—Walter R. Stohner 500
Field Measurement of Delay at Signalized Intersections—Donald S. Berry 505
Effect of Type of Control on Intersection Delay—Wayne N. Volk 523
Scheduling of Traffic Signals by Linear Programming—R. S. LaVallee 534

17

Simulation of Freeway Traffic by an Electronic Computer—D. L. Gerlough . . 543
The Use of a Digital Computer to Model a Signalized Intersection—Harry H. Goode, Carl H. Pollmar, and Jesse B. Wright 548
The Relationship Between Accident Data and the Width of Gravel Shoulders in Oregon—J. A. Head and Noel F. Kaestner 558
Effect of Governors on Passenger Car Performance—K. A. Stonex 577
The Role of Television in Traffic Control—Alger F. Malo and Roy S. Head . . 585
The Effect of Letter Width and Spacing on Night Legibility of Highway Signs—David Solomon . . 600
A Study of Ingress and Egress at Gasoline Service Stations on Rural State Highways Without Control of Access—C. E. Billion and Irving Scheinbart 618

Soils, Geology, and Foundations

Composition and Engineering Properties of Soil (IV)—T. William Lambe and R. Torrence Martin 661
The Importance of Colloid Science for Highway Construction and Research—Ernst A. Hauser 678
The Development of Non-Homogeneous Flow Condition During Electro-Osmosis in a Saturated Clay Mineral—Ralph L. Rollins 686
The Fabric of Natural Clays and Its Relation to Engineering Properties—James K. Mitchell 693
Experiments on Vibratory Cutting of Soils—Robert S. Ayre 714
Soils Exploration and Design Considerations for the Greater New Orleans Expressway. I—James. H. Schaub 725
Soils Exploration and Design Considerations for the Greater New Orleans Expressway. II—John R. Bayliss 736
Field Observations on Sand Drain Construction on Two Highway Projects in Illinois—T. H. Wu and R. B. Peck 747
Interrelationship of Load, Volume Change, and Layer Thickness of Soils to the Behavior of Engineering Structures—Chester McDowell 754
Discussions by Raymond C. Herner; F. L. D. Wooltorton 770
Stress and Displacement Characteristics of a Two-Layer Rigid Base Soil System: Influence Diagrams and Practical Applications—Donald M. Burmister. 773

General

Awards 815
Minutes of 1956 Annual Business Meeting 820
Author Index 833

A Cost Comparison Study of Force Account and Contract Construction on Five Secondary Projects in North Carolina

F. B. FARRELL and
M. J. KILPATRICK
Department of Commerce, Bureau of Public Roads, Washington, D. C.

This report presents the results of comprehensive job cost studies made on three contract and two force account secondary road projects in North Carolina during 1952 and 1953. A complete study of the relative merits of contract and force account methods would require a much wider coverage of kinds and conditions of highway work. Additionally, it would be necessary that social and economic benefits of the two methods be analyzed, that inherent managerial and operational advantages of each method be carefully weighed, and that policy considerations be reviewed. These broader phases of the problem are not part of this report. It is essential that this fact be recognized in appraising the findings presented herein.

● BOTH the contract and force account methods of doing highway construction and maintenance work have their place in the pattern of highway development. In general, the contract method prevails in construction where standards of materials and performance are specified and controlled and items of work are planned for construction and measurement. Maintenance work is generally done by the force account but there is a definite trend to do a greater percentage by the contract method.

Even though there may be general acceptance of the traditional policy of doing construction by contract, it does not preclude an occasional examination of doing work by the force account method. When judiciously managed, the latter method can be a stabilizing influence in situations where the contract mechanism falls short of meeting its full obligations. Such a situation could be brought about by a rapid increase in volume of highway work accompanied by a shortage of contractors, lack of competition, and rising prices. These were among the factors that concerned the North Carolina State Highway and Public Works Commission after the state undertook its expanded program of secondary road construction in 1949.

This secondary construction program involved the expenditure of $200 million over a 4-year period. The North Carolina State Highway and Public Works Commission, which has jurisdiction over all rural roads, elected to do a substantial portion of the construction program with its own forces and proceeded to purchase about $5 million of additional road equipment. Legal steps were taken by outside parties, without success, to block such purchases and require all construction to be done by contract.

Still later, use of federal-aid secondary funds in constructing some of the secondary projects with state forces was requested. Subsequent arrangements provided that several of these projects would be set up and constructed by either contract or state force methods. It was further agreed that the Bureau of Public Roads would make cost studies on these projects. The number of projects involved was eventually reduced to five by contract and three by state forces. Of these, three contract and two force account projects were selected for detailed unit cost studies during 1952 and 1953 by the Bureau of Public Roads. The projects were situated in central North Carolina. They totaled about 41 miles in length and involved a total cost of about $735,000.

The purpose of these studies was to develop facts on the comparative costs of the two methods of doing work. It was generally

19

accepted that the usefulness of the study results would be principally in furnishing certain factual background on each method, in minimizing unsubstantiated claims as to excessive economies of one method over the other, and in keeping the main issues involved from being complicated by minor unresolved details.

The results presented relate only to the five projects studied. They should not be viewed as being specifically applicable to all contract and force account construction. The following items are pertinent:

1. Construction work on each job appeared to reflect normal patterns of operation. There was no evidence of special efforts to make a "good showing."
2. Quality of completed work seemed to be about the same on all jobs.
3. Contractors obtained their aggregates from commercial sources; the state produced most aggregates in their own local quarries. The cost comparison reflects these conditions as they existed. No adjustment was made on the basis of assuming common sources of aggregates or other materials.
4. The several jobs studied were reasonably typical with respect to terrain and general nature of the work.
5. Identical cost keeping procedures were employed on each of the five jobs. All field data were obtained by Bureau of Public Roads personnel. They kept a daily record of the time spent by each employee and each unit of equipment on each work item. The contractors and the state made all of their records available to study personnel.
6. For purposes of this cost comparison, a uniform schedule of depreciation rates was applied to each job, contract and force account. Separate rates were established for each major class of equipment. These rates were then applied to the original purchase price for the period that the equipment was on the job. The depreciation, thus computed, was distributed according to working time spent on each operation performed.
7. In the case of contractors, time and one-half was paid any hourly personnel for work in excess of 40 hours per week. State hourly employees did not work any hours over the scheduled 55 per week and no overtime was paid for hours worked in excess of 40 per week. The retroactive pay increase granted state employees near the close of this study has not been included in the cost data developed in this report.
8. Any expense on a unit of equipment during its retention on the job was handled as a project cost.
9. Final costs which were developed for both the state and the contractors include an allowance for interest on invested capital. They do not include an allowance for any profit on the contract. They do, of course, contain each job's on-project overhead and a pro rata share of off-project overhead expense, including salaries and expenses of management personnel. (A $7500 annual salary rate was allowed for the owners of unincorporated contractor organizations in determining management expense.)

20

BID ITEMS AND WORK ACCOUNTS

The principal items involved in the estimates, bids, and payments on the cost study projects were as follows:

Bid Item	Unit
Grading on a mileage basis	Lump sum cost per mile
Drainage ditch excavation	Cubic yards (outside of the typical roadway section)
Excavation borrow	Cubic yards
Base course	Cubic yards in place
Bituminous surface treatment	Square yards
Culvert pipe	Lineal feet (by individual size of each type)

At the outset of the cost study, it was determined that additional breakdown would be needed for several of the bid items, particularly in those cases where an item was bid as a lump sum or where certain variables, such as haul distance, might account for measurable differences in costs between jobs. Each bid item was therefore subdivided to the extent necessary to show these differences. These breakdowns are called "work accounts."

For example, one of the bid items on each of the jobs was "grading on a mileage basis." This particular item was, in effect, a lump sum cost per mile, and included clearing and grubbing. There was also some clearing and grub-

bing for borrow pits, material pits, drainage ditches, and other areas outside the typical cross section which was handled by separate bid items. For the purpose of the cost study, therefore, this lump sum grading item was broken down into several work accounts as shown in Table 1.

Table 1 is not complete; it simply illustrates the manner in which the work accounts were set up. The upper half of Table 1 shows typical entries for the labor expense elements. These entries were processed from the daily time records kept by study personnel for each man who worked on the grading item at any time during the course of the job. The lower half of Table 1 shows the working time, by classes of equipment, summarized from daily time records kept on each individual unit of equipment. Similar breakdowns were made showing charges to each work account for materials, supplies, services, taxes, depreciation, and so on.

Study personnel also made field measurements of the quantities of work performed on each work account. In the case of grading on a mileage basis, measurements were made of clearing and grubbing, cubic yards of common excavation, and cubic yards of rock excavation involved in this one item. By such means, the costs and corresponding quantities for any work account could be segregated or grouped in various ways to show the principal cost differences between jobs.

To determine the relative costs of doing work by either of the two construction methods, contract or force account, a common base of reference was established. This was done by setting up a hypothetical composite job consisting of typical quantities for the principal work accounts. The relative costs of construction were then determined by applying average unit costs for the two methods to the quantities in the composite job.

COST OF THE COMPOSITE JOB, UNADJUSTED

The assumed quantities for the principal work accounts of the composite job are as follows:

Work Account	Quantity
Clearing and grubbing	20 acres
Excavation	85,000 cubic yards
Base course:	
Material	15,000 cubic yards
Hauling	300,000 ton-miles
Manipulation	80,000 square yards
Bituminous surface treatment	80,000 square yards
15" plain concrete pipe	1000 lineal feet
18" plain concrete pipe	1500 lineal feet
24" plain concrete pipe	300 lineal feet

21

TABLE 1
EXAMPLE FOR A SINGLE BID ITEM (GRADING ON A MILEAGE BASIS) SHOWING TYPICAL MANNER IN WHICH LABOR EXPENSE AND EQUIPMENT TIME WERE KEPT BY WORK ACCOUNTS

Cost Element	Work Accounts							Total
	Grading on a mileage basis, undistributed	Clearing and grubbing within right-of-way	Common excavation	Rock excavation	Drilling and blasting	Building fill	Maintenance for traffic	
Labor expense								
Direct wages	$2492.23	$4254.19	$1053.40	—	$673.38	$616.10	$163.11	$9252.41
Equipment operation	67.64	561.96	5608.91	$442.29	156.15	227.24	259.37	7323.56
Equipment maintenance and repair wages	27.90	99.83	1553.60	91.83	88.10	37.86	58.89	1948.01
Liability and compensation insurance	104.69	305.60	311.16	17.97	46.74	48.59	19.23	853.98
Social security payments	64.8[illegible]	122.85	205.73	13.38	22.98	22.07	12.05	463.86
Leave and holiday charges	72.72	137.86	230.87	15.01	25.79	24.76	13.53	520.54
Total—labor expense	$2829.98	$5472.29	$8963.67	$580.48	$1013.14	$976.62	$526.18	$20,362.36
Equipment time—net working hours								
Crawler tractors	—	74.1	573.9	161.1	29.3	67.1	7.1	913.6
Scraper, self-propelled	9.8	—	557.7	20.0	5.5	—	3.3	596.3
Motor graders	—	—	992.3	—	11.6	12.4	96.6	1112.9
Shovels, draglines, and backhoes	1.3	67.3	166.9	—	—	—	—	235.5
Dump trucks	9.5	191.9	141.0	—	13.2	—	—	365.6
Industrial rubber-tired tractor	—	—	—	—	4.7	10.0	—	14.7
Rollers	—	—	—	—	—	13.3	—	13.3
Compressors	—	—	7.7	—	121.8	13.7	—	143.2
Loaders	—	—	12.5	—	—	—	—	12.5

The above rounded quantities will account for over 90 percent of the work on a typical secondary road project of the types studied. Arithmetic averages of the final unit costs for each work account, shown separately for the state jobs and the contract jobs, are given in Table 2.

Application of these unit costs to the quantities for the composite job gives the following totals:

Total cost of composite job, using state's average unit costs	$139,905
Total cost of composite job, using contractor's average unit costs, and excluding profit	$134,572

Because of the differing unit costs on the individual jobs, the above difference of about 4 percent in favor of contract work is not wholly conclusive. For example, when the separate unit costs for each of the five study projects are applied to the quantities for the composite job, it is found that the total cost of the state force jobs was $128,400 and $151,700, and the contract jobs ranged between $131,600 and $137,800.

22

COSTS OF THE COMPOSITE JOB, ADJUSTED

The unit costs listed in Table 2 represent actual study results, unadjusted for differing job conditions and unadjusted for certain items of expense, such as taxes, which are borne in varying amounts on force account and contract work. Certain of these conditions and items of expense can be readily evaluated, whereas others can only be approximated. For example, the tax on gasoline can be precisely determined as can the amount of the wage differential between the jobs. In the latter case, however, there is no direct method of measuring the effect of the wage differential on labor productivity.

There is the problem, too, of the compounding effect of a series of adjustments. An adjustment in dollar amounts of one account, such as that involved in equalizing haul distances, will affect dollar amounts of such cost elements as tax payments and interest on the investment. No attempt has been made in this report to analyze these interrelationships. Rather, each adjustment has been computed separately so as to show its particular total dollar amount that is included in the original unadjusted total cost of the composite job.

TABLE 2
AVERAGE UNIT COSTS FOR STATE AND CONTRACT WORK FOR WORK ACCOUNTS INCLUDED IN THE COMPOSITE JOB

Work Account	Unit	Unit Cost Arithmetic Averages	
		State jobs	Contract jobs
Clearing and grubbing	Acre	$567.00	$521.00
Excavation	Cu yd	0.366	0.360
Base course			
Materials*	Cu yd	2.13	1.87
Hauling	Ton mile	0.074	0.069
Manipulation	Sq yd	0.095	0.105
Bituminous surface treatment	Sq yd	0.292	0.367
15" plain concrete pipe	Lin ft	2.20	2.11
18" plain concrete pipe	Lin ft	4.05	3.78
24" plain concrete pipe	Lin ft	5.00	5.94

* On trucks at loading site

Included in the costs of the composite job are certain taxes, fees, assessments, and contributions which are incurred as direct and indirect expenses to varying degrees on state force and contract work. Theoretically these items may be viewed as costs which are borne, directly or indirectly, regardless of how the work is performed, whether by state forces or by contract. Hence, it is appropriate to make a comparison with all such determinable costs excluded. For this purpose, the cost elements involved are divided into two groups.

Group I Items

In Group I are those items of direct expense involving compulsory payments in the form of taxes, fees, and assessments. The rates and amounts of the payments will vary depending upon whether they are applicable to force account work or to contract work. Group I covers the following items:

- Taxes:
  - Sales
  - Use
  - Gasoline, state and federal
  - Lubricating oil
  - Tires and tubes
  - Automotive equipment and parts
  - Property
  - Communications
  - Corporation franchise
  - Intangibles
  - Project
  - Transportation
  - Income
- Licenses, Fees, Payments:
  - Labor liability and compensation
  - Social security

Performance surety bond
Project plans
Licensing board fee
Bidding license
Motor vehicle license

In the evaluation of these items the various job costs were analyzed to the extent necessary to depict the actual differences involved. For example, the state crushed most of its aggregate with benefit of tax exemption. On the contract jobs, therefore, a study was made of all payments to commercial producers of aggregate to determine the amounts of taxes and fees therein. Likewise, hauling of base course and other materials was performed by the state with the benefit of certain tax exemptions. Accordingly, investigations were made of all payments by the state and the contractor to hired haulers, except railroads, to determine the amount of taxes and fees involved. Rental payments for equipment were similarly checked.

The amount of the Group I items ranged from 0.2 to 0.9 percent of the total cost on the two state jobs and from 7.9 to 11.3 percent on the three contract jobs. Table 3 shows the percentages applicable to the individual work accounts which comprise the composite job.

Total costs of the Group I items, obtained by application of the respective percentages shown in Table 3 to the cost of each work account are as follows:

Group I Items in Composite Job:

Using state's costs	$908
Using contractor's costs	12,885

TABLE 3
GROUP I ITEMS (TAXES, FEES, AND ASSESSMENTS) EXPRESSED AS A PERCENTAGE OF THE TOTAL COST OF INDIVIDUAL WORK ACCOUNTS IN THE COMPOSITE JOB

Work Account	Group I Items, Expressed as Percentage of Total Cost of Each Work Account (Arithmetic Averages)	
	State jobs	Contract jobs
	Percent	*Percent*
Clearing and grubbing	0.35	7.43
Excavation	0.43	5.53
Base course		
Materials	0.17	11.07
Hauling	1.41	14.63
Manipulation	1.61	8.44
Bituminous surface treatment	0.56	11.19
15" plain concrete pipe	0.28	4.42
18" plain concrete pipe	1.34	5.27
24" plain concrete pipe	1.34	4.79

With Group I items excluded, the apparent cost advantage is substantially in favor of the contractors' operations. On an individual job basis, each of the three contract jobs shows a lower cost than for either of the two state jobs.

Group II Items

Included in Group II are those items of expense involving optional or discretionary payments in the form of insurance and labor benefits. These differ from the items in Group I in that they fall, to some extent, within the purview of the state or contractor as a matter of management policy. Following are the items included in Group II:

1. Public liability payments or insurance premiums.
2. Contributions to employee retirement funds.
3. Compensation for annual leave, sick leave, and holidays.

The state does not carry public liability insurance, but expenses are nevertheless incurred through cash payments for liability claims. There is a statutory limit of litigious liability in the case of the state of $8000 per claim. The contractor, on the other hand, has no such protection and is rarely in a position to be self-insured. Thus, he usually elects to obtain sufficient protection from insurance companies.

Expenses to the contractors for items 2 and 3 above vary to a marked degree between different organizations and the amounts involved are usually determined by the respective managements. Expenses by the state for items 2 and 3 are established by enabling provisions of current civil service regulations. Thus, in the case of the state, they might not be viewed as optional or discretionary. However, they are so considered herein to enable uniformity of treatment with comparable items by the contractor.

Group II items amount to about 2.2 percent of the total project cost on the state jobs and 1.5 percent on the contract jobs. Much of the difference is due to the lower employer contributions and labor benefits on the contractors' jobs. This, however, is more than offset by the higher wages paid on the contractors' jobs. Effects of wage differentials will be discussed later.

The percentages of the total cost of particular work accounts in the composite job represented by Group II items are shown in Table 4.

Total costs of the Group II items, obtained by application of these percentages to the cost of each work account, are as follows:

Group II Items in Composite Job:

Using state's costs	$3535
Using contractors' costs	2087

In this instance, the deduction of Group II items from the costs of the composite job would reduce the margin in favor of the contractors.

Wage Rate Differential

The average hourly wage rate on the contract jobs was about $1.23. This compares with an average of $0.975 on the state jobs. Since about 21 percent of the cost of the composite job, using contractors' costs, represented wages paid directly by the contractor, the contractors' job costs would have been reduced by about $5860 by paying at the hourly rate prevailing on the state jobs.

Included in this $5860 is approximately $1200 representing personal income taxes (state and federal) that would have been paid out of this wage-earning increment.

Certain employer contributions and other benefits to labor are associated with wage earnings. Had the wages been reduced on contractors' work in the amount of the aforementioned $5860, the corresponding benefits would have been reduced by about $580. This amount is in addition to the $5860.

In summary, the additional costs borne by the contractors on the composite job which are attributable to the wage rate differential are as follows:

"Take-home" pay	$4660
Personal income taxes	1200
Labor benefits	580
Total	6440

This is a substantial amount the deletion of which favors the contractor. However, the extent to which labor productivity or other job factors might be affected by this hypothetical adjustment for wage rate differential was not determined.

TABLE 4
GROUP II ITEMS (INSURANCE AND LABOR BENEFITS) EXPRESSED AS A PERCENTAGE OF THE TOTAL COST OF INDIVIDUAL WORK ACCOUNTS IN THE COMPOSITE JOB

Work Account	Group II Items, Expressed as a Percentage of the Total Cost of Each Work Account (Arithmetic Averages)	
	State jobs	Contract jobs
	Percent	*Percent*
Clearing and grubbing	2.51	2.17
Excavation	4.18	1.37
Base course:		
Materials	1.87	1.09
Hauling	2.21	2.27
Manipulation	3.93	2.05
Bituminous surface treatment	1.37	1.43
15" plain concrete pipe	1.54	1.18
18" plain concrete pipe	1.96	1.44
24" plain concrete pipe	1.81	1.25

Lengths of Haul

There were certain differences in lengths of haul among the several jobs. On excavation it was determined that actual haul distances averaged about 90 feet more on the contract jobs than on the state jobs. To compensate for this difference, an amount of $0.005 per cubic yard was deducted from the cost of contract work on the composite job. The dollar amount is $425.

For the base course, the average haul by the state and the contractor varied by such a minor distance that no adjustment for this reason was warranted.

In the case of bituminous surface treatment, the surface aggregate was hauled by truck from state-owned local quarries to the state jobs; by truck from local commercial sources on two of the contract jobs; and by a combination of rail and truck on the remaining contract job. The longer hauls prevailed on the contract jobs. The cost of hauling this additional distance amounted to about $0.023 per square yard of bituminous surface treatment. The dollar amount of this reduction on the contractors' cost of the composite job is $1840.

The effect of the foregoing adjustments for haul lengths is to reduce the contractors' cost in each instance. The total reduction in the cost of the composite job, using contractors' costs, is $2265. This consists of $425 for excavation, and $1840 for surface aggregate.

Base Course Materials

There were wide differences in practices for procuring base course materials that warrant consideration. On the state jobs, base course materials were obtained from state-owned and operated quarries and pits in the vicinity of the projects. For the contract jobs, crushed rock was obtained from commercial sources on one project and hauled by truck, commercially produced soil was shipped in by rail on another; and on the last contract job, soil was obtained by the contractor in local pits adjacent to the project.

There are several alternatives that would have materially affected the cost comparison. For example, the state could have elected to furnish materials to the contractor; on the other hand, the state could have elected to purchase either rock or soil from commercial sources. Any attempt to equalize the varying practices by computing probable costs for any one or a combination of these alternatives would require many assumptions that could not be supported by actual field data.

In view of these variables with respect to the base course item, it is likely that the most valid comparison would be that in which the cost of base course materials is eliminated. For the composite job, the cost of these materials was $31,950 using state's prices and $28,050 using contractors' prices. Elimination of these costs would tend to reduce the margin in favor of the contractors.

TABLE 5
EFFECT OF CERTAIN COST VARIABLES ON TOTAL COST OF COMPOSITE JOB

Nature of Variable	Amount of Variable in Composite Job*		Total Cost of Composite Job, After Deducting the Amount of the Variable		
	State	Contract	State	Contract	Difference, in favor of contractors†
Group I items	$908	$12,845	$138,997	$121,687	$17,310
Group II items	1535	2047	136,170	132,445	1985
Wage rate differential	—	6440	139,905	128,132	11,773
Haul distance differential	—	2255	139,905	132,307	7598
Base course materials	31,950	28,050	107,955	106,522	1433
Interest on State's investment	2385	—	137,520	134,572	2948

* Amounts are not additive. See text.
† Includes the initially computed cost differential of $8333 in favor of the contractors.

Interest on Investment in Equipment

Whereas depreciation of equipment is an expense that must be met regardless of how the work is done, the matter of interest in the investment in equipment is a point on which opinion may differ. For purposes of uniformity, interest charges were computed in similar fashion on both state and contract jobs during the course of the studies. The total costs of interest tended to be somewhat higher on the contract jobs. This was due, in part, to the contractors' practice of keeping equipment on the job for somewhat longer periods of time. (On the state jobs, it was common practice to move idle or standby equipment off the job and put it to use on other nearby construction and maintenance work in the District.) Expressed as a percentage of the total costs of the composite job, interest costs were 1.6 percent on state work and 1.8 percent on contract work. By applying these percentages to the costs of the composite job on state work ($139,905) and on contract work ($134,572) the following amounts are derived:

Interest on Investment in Equipment in Composite Job:

Using state's costs	$2385
Using contractors' costs	2422

It is generally recognized that interest on the investment is a proper cost of contractors' work. From the standpoint of comparative economic cost, it is also a proper cost of state force work. However, it is a cost for which a public agency seeks no return and one which would not be met by actual cash transactions in case of state work. Hence, there is some basis for excluding this item of expense from the state's total costs.

Other Variables

There were other variables. Some were of minor importance with respect to their effect on costs; others could not be readily evaluated. A few are as follows:

1. *Maintenance of Public Traffic:* For the composite job, this expense amounted to $384 on state work and $320 on contract work.
2. *Moving In and Moving Out:* For the composite job, this expense amounted to

25

$1088 on state work and $1469 on contract work. Ordinarily it might be expected that this difference would be much greater. However, two of the contractors had permanent headquarters in the immediate vicinity of the projects. The other was about 100 miles distant. The state's expense was increased somewhat by the practice of frequently moving its equipment on and off the job to meet fluctuating requirements on other construction and maintenance work in the District. The contractors did not move their equipment quite so often.

3. *Age of Equipment:* The average age of trucks, for example, was about the same on three of the five jobs studied, one contract and two state jobs. It was about twice as great on one of the other contract jobs. On the third contract job, age data for trucks were not available.
4. *Size of Equipment:* The size of comparable units was about the same on all jobs. There were certain exceptions, such as scrapers on the contract jobs which averaged about 30 percent larger than those used by the state.
5. *Major Delays:* These delays of 15 minutes or more in duration with weather excluded were about the same on both the state and the contract jobs.
6. *Minor Delays:* These delays of less than 15 minutes each in duration were slightly greater on the state jobs.

26

SUMMARY OF COST COMPARISON OF COMPOSITE JOB

As previously stated, the initial computation of total costs of the composite job shows the following:

Total cost of composite job, using state's average unit costs	$139,905
Total cost of composite job, using contractors' average unit costs, and excluding profit	134,572
Initially computed cost differential, in favor of contractors	5333

The total costs and the differential will vary depending on the adjustments that may be made to show the effect of individual cost elements. The principal adjustments are listed in Table 5. In the cases of the Group I items, the wage rate differential, and the haul distance differential, the adjustments result in increases in the original spread of $5333 between the costs of the composite jobs. In the other three instances, listed in Table 5, the adjustments decrease the original spread but in no case is any one adjustment sufficient to overcome it completely.

With the exception of Group I and II items and interest, the variables listed in Table 5 are not wholly additive. Each has been separately computed on the basis of its amount in the initially developed total cost of the composite job. There are, for example, Group I and Group II items involved in adjustments for wage differential, and all three together with interest are involved to a certain extent in the haul distance differential and base course materials.

A more refined analysis could be developed to show the net and cumulative effects of each of these variables and also give an indication of the amount of other cost variables which are not herein itemized or evaluated. Such computations would not, however, be sufficiently weighted in favor of state work as to alter the finding that, exclusive of profit, contract work was performed at a lower construction cost than state force work on the five jobs studied. This finding is limited solely to the circumstances herein reported. No attempt was made in this particular study to determine whether or to what extent contract or state force work was the more economic in all phases.

Indian Roads Congress
Special Publication 20

MANUAL ON ROUTE LOCATION, DESIGN, CONSTRUCTION AND MAINTENANCE OF RURAL ROADS

(OTHER DISTRICT ROADS AND VILLAGE ROADS)

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CONTENTS

		Page
1.	Introduction ...	1
2.	Route Selection and Surveys for Road Location ...	7
3.	Soil and Material Surveys, and Laboratory Investigations ...	11
4.	Geometric Design Standards ...	17
5.	Pavement Materials, Properties and Specifications ...	41
6.	Pavement Thickness and Composition ...	53
7.	Drainage ...	61
8.	Cross-Drainage Structures, Retaining Walls and Breast Walls ...	65
* 9.	Preparation and Presentation of Project Documents ...	73
10.	Tools, Plant and Equipment ...	79
11.	Construction Procedures and Quality Control ...	83
12.	Maintenance ...	93

Appendices

Appendix 1	Guiding Principles of Route Selection and Location ...	101
Appendix 2	Laboratory Investigations required for the Various Stabilised Soil Specifications ...	104

9

PREPARATION AND PRESENTATION OF PROJECT DOCUMENTS

9.1. General

9.1.1. The project data collected during the investigations together with the proposals worked out on that basis should be presented in a proper form for full appreciation by the appropriate authority. These should be prepared in the following three parts:

(i) Report
(ii) Estimate
(iii) Drawings

9.1.2 Details to be presented in each part are brought out in subsequent paragraphs for guidance. It should, however, be understood that the extent of detailing an individual aspect will depend upon the size of the concerned project, the amount of pre-investigations that have gone into its preparation, and the scope of the work viz. whether new construction or improvement to an existing road. No doubt, rural road projects being small might have constraints for pre-investigations; nevertheless the guidelines of project presentation below should be kept in view for adoption as far as possible.

9.2. Project Report

9.2.1. The Project Report should give a precise account of the different features for easy understanding and appreciation of the proposals and should cover the following aspects:

(i) Preliminary details such as name of work and its broad scope, climatic factors etc;
(ii) Necessity and nature of work involved,
(iii) Route selection;
(iv) Condition of existing road (for projects involving improvements to existing roads);
(v) Traffic data;
(vi) Soil investigations and pavement design;
(vii) Design standards and specifications;

(viii) Hydraulic investigations and design of cross drainage structures;
(ix) Materials, labour and equipment;
(x) Rates;
(xi) Construction scheduling;
(xii) Miscellaneous.

9.3. Estimate

9.3.1. The project estimate should give a clear picture of the financial commitments involved and should be realistic. This can be possible only if items of work are carefully listed, quantities are determined to a reasonable degree of accuracy and the rates provided are workable.

9.3.2. The estimate should consist of a general abstract of cost and detailed estimates for each major head as described below:

(i) General abstract of cost

This should give the total cost of the scheme with a general break-up under major heads, e.g. land acquisition, site clearance, earthwork, sub-bases and bases, surfacing, cross-drainage and other structures, miscellaneous items, percentage charges for contingencies, work-charged establishment, quality control, etc.

30

(ii) Detailed estimates for each major head

These should consist of

(a) Abstract of cost
(b) Estimate of quantities
(c) Analysis of rates for items not covered by relevant Schedule of Rates.
(d) Quarry/material source charts.

9.4. Drawings

9.4.1. **General**: Project drawings should depict the proposed works in relation to the existing features, besides other information necessary for easy and accurate translation of the proposals in the field. For convenience of interpretation, it is desirable that the drawings should follow a uniform practice with regard to size, scales and the details to be incorporated.

9.4.2. **Drawing size**: Drawings should be of adequate size to accommodate a reasonable length of the road, or an independent structure such as a culvert, in full detail. At the same time these

should not be inconveniently large to necessitate several folds. From this angle it is recommended that preferably the size may be 594 × 420 mm, corresponding to size A2 of IS: 696-1960. With this size, the drawings can be conveniently stitched in a folio for storage on shelves in the office, or rolled for taking to the construction site. They can also be folded compactly to the standard size of 297 × 210 mm. On one sheet of this size, it will be possible to accommodate plan and longitudinal section of one km length of the road, with sufficient overlap on either side, if drawn to the horizontal scale of 1:2500. A wider margin of 40 mm should be kept on the left hand side of the drawing to facilitate stitching into a folio.

9.4.3. **Component parts of project drawings**: The drawings usually required for a rural road project include the following:

(i) **Locality map-cum-site plan**

This is combination of a key map and index map, usually drawn on a single sheet. This will be the first sheet in folio of drawings for a project. However, where the length of the road is substantial, it may become necessary to separate out the locality map and the site plan, the former being accommodated in one sheet and the latter on a series of sheets.

The locality map (also sometime called "key map") should give a bird's eyeview of the proposed work with respect to the road network serving the area, important town centres, other means of communication, etc. The map may be to a scale of 1:2,500,000 which is one of the common scales used in Survey of India maps.

The site plan (also sometime called "index map") should show the project road and its immediate neighbourhood covering the important physical features such as hills, rivers, tracks, railway lines, etc. It may be to a scale of 1:50,000 and should show the kilometrage.

The sheet containing the locality map-cum-site plan should have a legend to explain the abbreviations and symbols used in subsequent drawing sheets. Alternatively, the legend could be shown on a separate sheet in the beginning.

One typical example of locality map-cum-site plan is given in Plate III.

(ii) Land acquisition plans

These should be prepared on available village maps or settlement maps to a scale of 1:2000 to 1:8000 showing the relevant details.

(iii) Plan and longitudinal section

Plan and longitudinal section for about one km length of the road should be shown on a single sheet with plan at the top and L-section at the bottom. Common scales adopted are 1:2500 for horizontal, and 1:250 for vertical, but these may be changed suitably for hilly stretches.

The manner of presenting the details on the plan and longitudinal section drawings is illustrated in Plate IV.

(iv) Typical cross-section sheet

In a rural road project, cross-section elements like width of the carriageway and roadway, side slopes and pavement crossfall, will generally remain constant for most of the road length. Instead of repeating the details on every cross-section, it would be desirable to show these on a typical cross-section sheet, like the sample in Plate V.

32

(v) Detailed cross-sections

The cross-sections should be presented serially according to continuous chainage. The recommended method of presenting the cross-sections is illustrated in Plate VI.

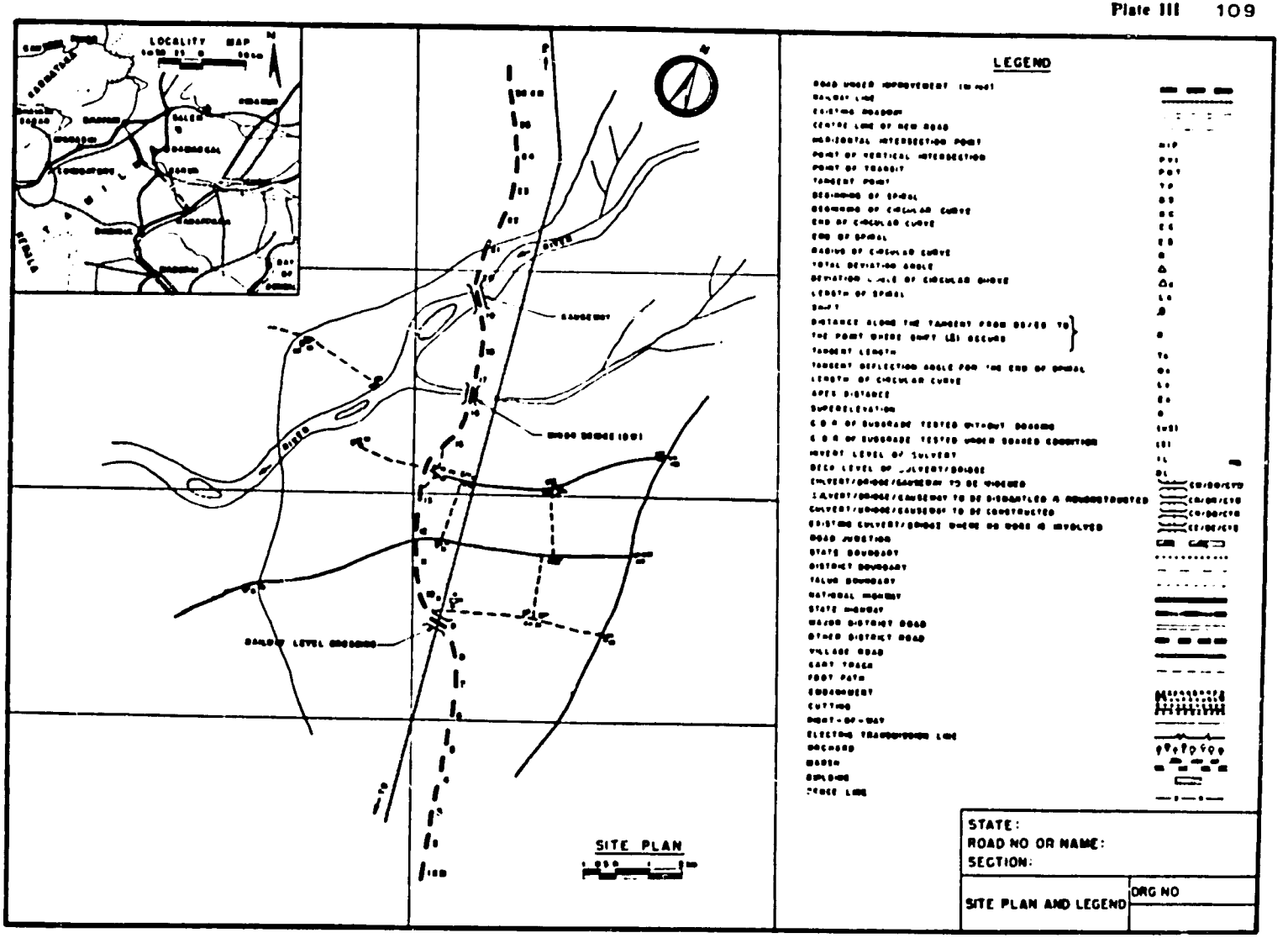
(vi) Drawings for cross-drainage structures

On rural roads cross drainage structures will generally consist of slab/pipe culverts for minor crossings and causeways/submersible bridges for larger waterways (see also Section 8). It will be advantageous to use standard designs for these structures so that the need for individual designs/drawings is obviated. In such cases, a reference to these can be given instead of enclosing drawings.

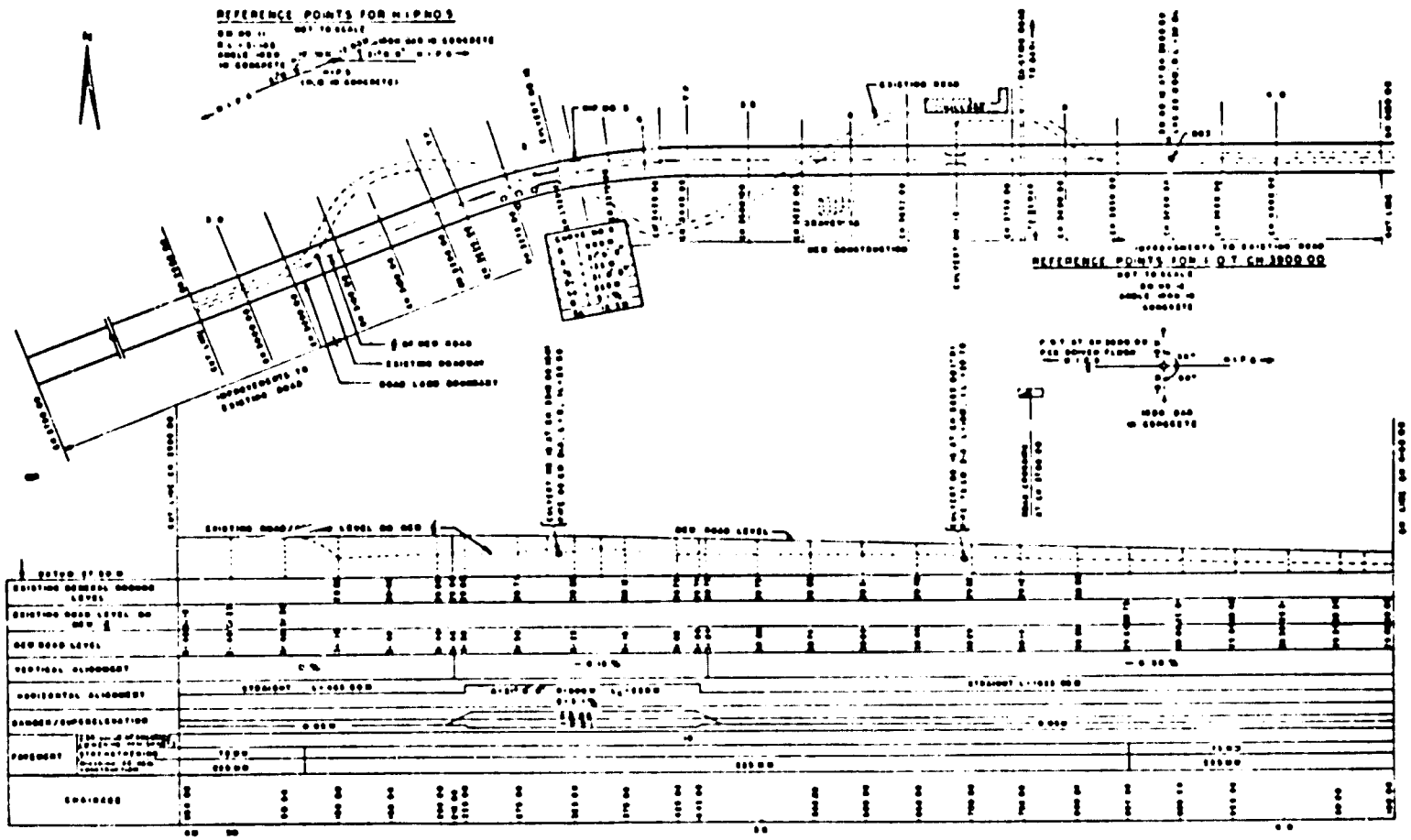
(vii) Drawings for retaining walls, breast walls and other structures

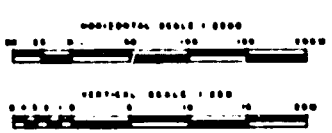
These drawings should clearly show the foundation and structural details as also the materials proposed to be used. The scale chosen should be large enough to show all the details comprehensively.

BEST AVAILABLE DOCUMENT



110 Plate IV





STATE:	
ROAD NO. OR NAME:	
SECTION:	
PLAN AND LONGITUDINAL SECTION	DRG NO

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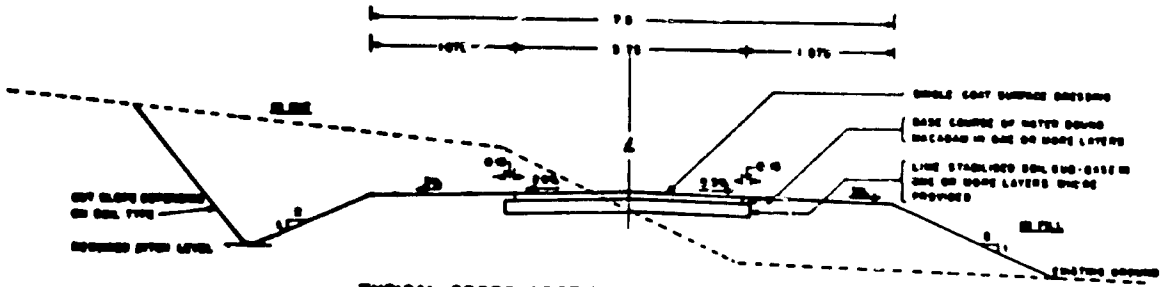
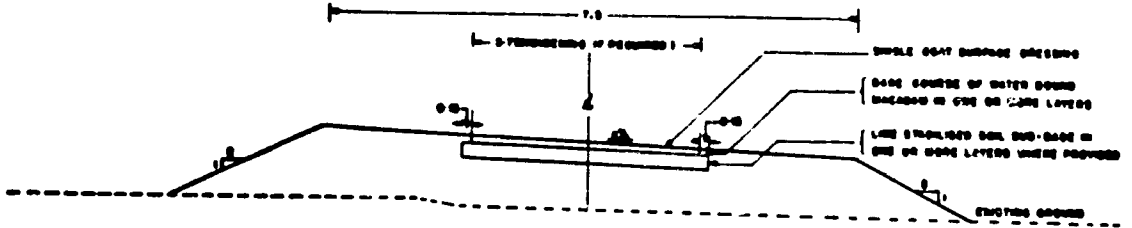
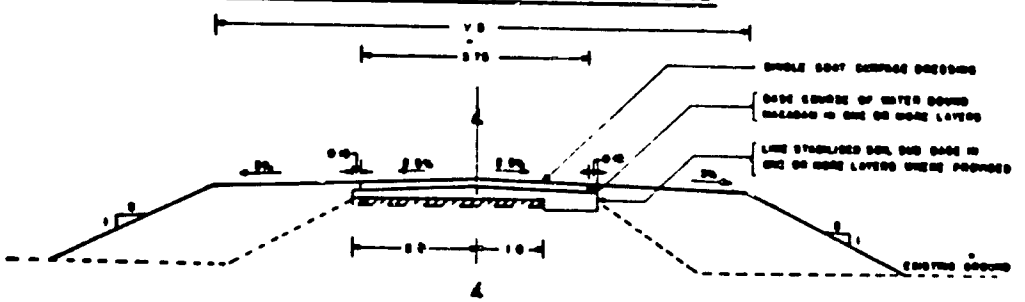


TYPICAL CROSS-SECTION OF NEW ROAD IN STRAIGHT



TYPICAL CROSS-SECTION OF NEW ROAD IN CURVE



TYPICAL CROSS-SECTION FOR WIDENING & STRENGTHENING OF EXISTING ROAD IN STRAIGHT

LEGEND FOR SYMBOLS

APPEARING ON PLATES V & VI

SINGLE COAT SURFACE DRESSING	SDS
WATER BOUND MACADAM	WB
LIME STABILISED SOIL	LS
EXISTING ROAD / GROUND	
PROPOSED ROAD	
EXISTING PAVEMENT	
PAVEMENT COMPOSITION	
THICKNESS OF COURSE (mm) FOR STRENGTHENING	
THICKNESS OF COURSE (mm) FOR WIDENING / NEW CONSTRUCTION	

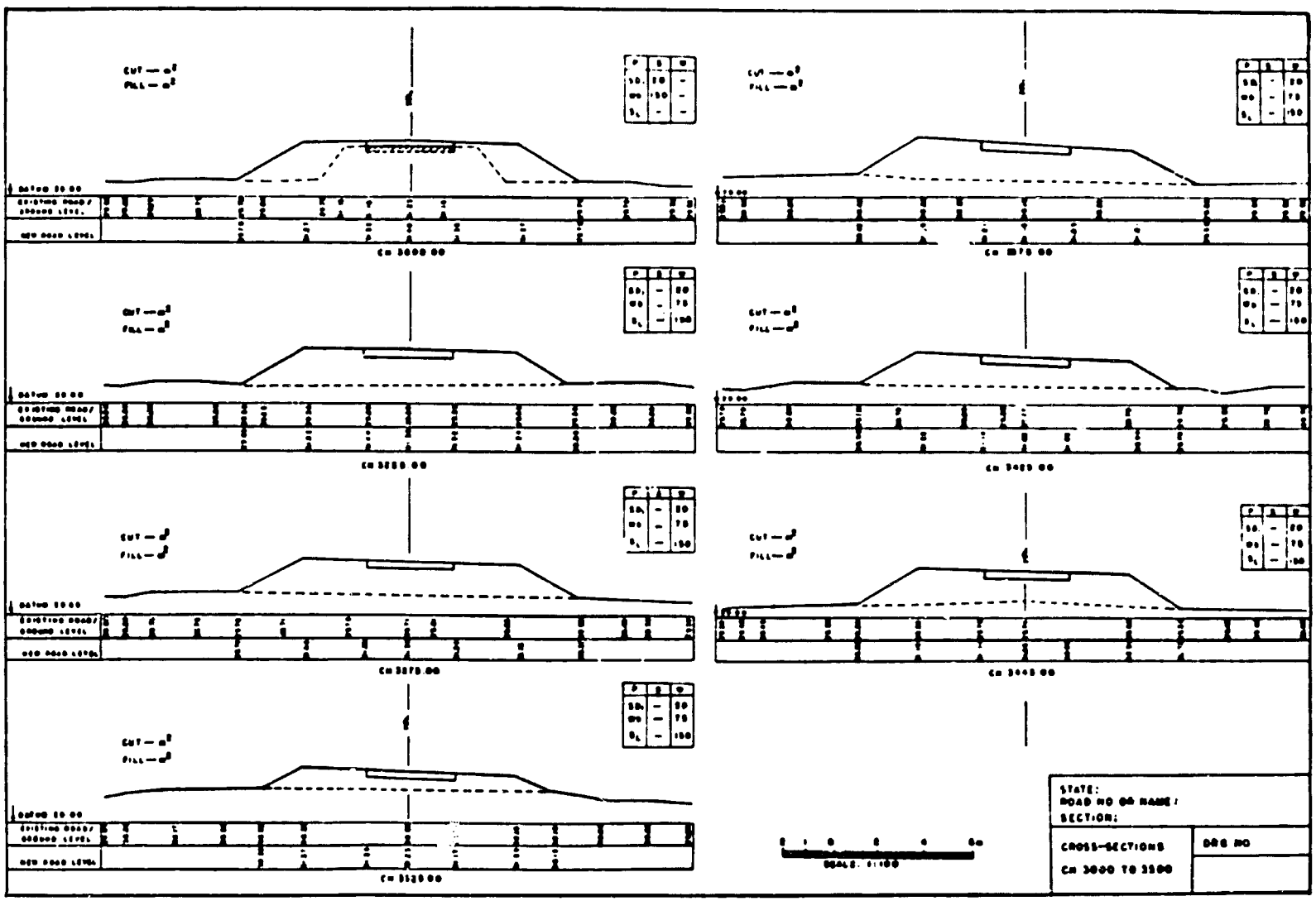
NOTES:-

1. ALL DIMENSIONS UNLESS OTHERWISE SPECIFIED ARE IN METRES
2. THICKNESS OF PAVEMENT COURSES NOT TO SCALE

STATE:	
ROAD NO. OR NAME:	
SECTION:	
TYPICAL CROSS-SECTIONS	DRG. No.

WORKING DOCUMENT

112 Plate VI



Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects

FP-69

1969

U.S. Department of Transportation

FEDERAL HIGHWAY ADMINISTRATION

Bureau of Public Roads

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CONTENTS

Title	Page
Preface	iii
** Section 100—General Provisions	1
Section 101—Definitions and Terms	1
102—Bidding Requirements and Conditions	7
103—Award and Execution of Contract	14
104—Scope of Work	16
105—Control of Work	20
106—Control of Material	30
107—Legal Relations and Responsibility to Public	39
108—Prosecution and Progress	49
109—Measurement and Payment	56
CONSTRUCTION DETAILS	
Section 200—Earthwork	75
Section 201—Clearing and Grubbing	75
Construction Requirements	75
Section 202—Removal of Structures and Obstructions	79
203—Excavation and Embankment	82
Construction Requirements	83
Section 204—Haul	93
205—Overhaul	94
206—Structure Excavation	95
207—Finishing Roadbed	102
208—Sheathing	104
209—Obliteration of Old Roadways	106
210—Roadside Cleanup	107
Section 211 through 299 Reserved	
Section 300—Bases	109
Section 301—Plant Mix Bituminous Base Course	109
Materials	109
Construction Requirements	110
Section 302—Reserved.	
Section 303—Reserved.	
Section 304—Aggregate Base Course	111
Materials	111
Construction Requirements	111
Section 305—Subgrade Modification	114
Materials	114
Construction Requirements	115
Section 306—Reconditioning Roadbed	117
Section 307—Reserved.	

Title	Page
Section 308—Portland Cement Treated Base	119
Materials	119
Construction Requirements	120
Section 309—Portland Cement Concrete Base	122
Materials	122
Construction Requirements	123
Sections 310 through 399 Reserved.	
Section 400—Bituminous Pavements	125
Section 401—Plant Mix Bituminous Pavements—General	125
Materials	125
Construction Requirements	127
Section 402—Reserved.	
Section 403—Hot Bituminous Pavement	138
Materials	139
Construction Requirements	139
Section 404—Cold Bituminous Pavement	140
Materials	140
Construction Requirements	140
Section 405—Road Mix Bituminous Pavement	143
Materials	143
Construction Requirements	144
Section 406—Penetration Macadam Pavement	148
Materials	149
Section 407—Tack Coat	153
Materials	153
Section 408—Prime Coat	155
Materials	155
Construction Requirements	156
Section 409—Seal Coat	158
Materials	158
Construction Requirements	157
Section 410—Bituminous Surface Treatment	162
Materials	164
Construction Requirements	165
Section 411—Bituminous Preservative Treatment	168
Materials	168
Construction Requirements	168
Section 412—Aggregate Surface Course	172
Materials	172
Construction Requirements	172
Section 413—Stockpiled Aggregates	174
Materials	174
Construction Requirements	174
Sections 414 through 499 Reserved.	
Section 500—Rigid Pavement	177
Section 501—Portland Cement Concrete Pavement	177
Construction Requirements	178

Title	Page
Section 600—Incidental Construction	207
Section 600A—Piling	207
Materials	211
Construction Requirements	212
Section 601—Structural Concrete	221
Materials	225
Construction Requirements	225
Section 601A—Prestressed Concrete Structures	242
Materials	243
Construction Requirements	244
Section 602—Reinforcing Steel	249
Materials	249
Construction Requirements	249
Section 603—Pipe Culverts and Storm Drains	250
Materials	251
Construction Requirements	251
Section 604—Manholes, Inlets and Catch Basins	258
Materials	258
Construction Requirements	259
Section 605—Underdrains	260
Materials	260
Construction Requirements	261
Section 606—Guard Rail	263
Materials	264
Construction Requirements	264
Section 607—Fences, Gates and Cattle Guards	266
Materials	266
Construction Requirements	267
Section 608—Sidewalks	268
Materials	268
Construction Requirements	269
Section 609—Curbing	271
Materials	271
Construction Requirements	272
Section 610—Stone Masonry Structures	276
Materials	277
Construction Requirements	279
Section 611—Steel Structures	285
Materials	286
Construction Requirements	286
Section 612—Bridge Railing	336
Materials	336
Construction Requirements	337
Section 613—Timber Structures	339
Materials	340
Construction Requirements	340
Section 614—Damp-Proofing	345
Materials	345
Construction Requirements	346

Title	Page
Section 615—Waterproofing	346
Materials	347
Construction Requirements	347
Section 616—Water Stops	350
Materials	350
Construction Requirements	351
Section 617—Structural-Plate Pipe, Pipe-arches, and Arches	352
Materials	353
Construction Requirements	353
Section 618—Cleaning and Reconditioning Existing Drainage Structures	356
Materials	356
Construction Requirements	356
Section 619—Loose Riprap	358
Materials	358
Construction Requirements	358
Section 620—Special Rock Embankment	359
Materials	359
Construction Requirements	359
Section 621—Corrugated Metal Spillways	360
Materials	361
Construction Requirements	361
Section 622—Paved Waterways	362
Materials	363
Construction Requirements	363
Section 623—Monuments, Markers, and Guide Posts	366
Materials	366
Construction Requirements	366
Section 624—Topsoiling	367
Section 625—Turf Establishment	369
Section 626—Furnish and Plant Trees, Shrubs, Vines and Groundcovers	371
Section 627—Lawn Irrigation System	377
Section 628—Sprigging	382
Section 629—Sodding	385
Sections 630 through 699 Reserved.	
Section 700—Materials Details	389
Section 701—Hydraulic Cement	389
Section 702—Bituminous Materials	389
Section 703—Aggregates	392
Section 704—Masonry Units	400
Section 705—Joint Materials	400
Section 706—Concrete, Clay and Fiber Pipe	404
Section 707—Metal Pipe	405
Section 708—Paints	408
Section 709—Reinforcing Steel and Wire Rope	415

Title Page
Section 710—Fence and Guard Rail 417
Section 711—Concrete Curing Materials and Admixtures 419
Section 712—Miscellaneous 420
Section 713—Roadside Improvement Materials 424
Section 714—Irrigation System Materials 430
Section 715—Piling 434
Section 716—Material for Timber Structures 436
Section 717—Structural Metal 437

Index 447

Section 100

GENERAL PROVISIONS

Section 101.—DEFINITIONS AND TERMS

101.01 Abbreviations. Wherever the following abbreviations are used in these specifications or on the plans, they are to be construed the same as the respective expressions represented:

AAN—American Association of Nurserymen.
AAR—Association of American Railroads.
AASHO—American Association of State Highway Officials.
AGC—Associated General Contractors of America.
AIA—American Institute of Architects.
ARA—American Railway Association.
AREA—American Railway Engineering Association.
ASCE—American Society of Civil Engineers.
ASLA—American Society of Landscape Architects.
ASME—American Society of Mechanical Engineers.
ASTM—American Society for Testing and Materials.
AWPA—American Wood-Preserver's Association.
AWWA—American Water Works Association.
AWS—American Welding Society.
BPR—Bureau of Public Roads,The Federal Highway Administration, Department of Transportation.
FHWA—The Federal Highway Administration.
FPR—Federal Procurement Regulations System.
FSS—Federal Specifications and Standards.
GSA—General Services Administration.
SAE—Society of Automotive Engineers.
USASI—United States of America Standards Institute.

101.02 Definitions. Wherever in these specifications or in other contract documents the following terms or pronouns in place of them are used, the intent and meaning shall be interpreted as follows:

Administrator.—The Federal Highway Administrator, The Federal Highway Administration, U.S. Department of Transportation.

Advertisement.—The public announcement, as required by law, inviting bids for work to be performed or materials to be furnished.

Award.—The written acceptance by the Government of a bid.

Bid.—The offer of a bidder, on prescribed forms to perform the work and to furnish the labor and materials at the price quoted.

Bid forms.—The approved forms on which the Government requires bids to be prepared and submitted for the work.

Bid guarantee.—The security furnished with a bid to guarantee that the bidder will enter into the contract if his bid is accepted.

Bid schedule.—The prepared schedule included with the bid forms, containing the estimated quantities of pay items for which unit bid prices are invited.

Bidder.—An individual, partnership, joint venture, or corporation submitting a bid for the advertised work.

Bridge.—A structure, including supports, erected over a depression or an obstruction, as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads and having a length measured along the center of roadway of more than 20 feet between undercopings of abutments or extreme ends of openings for multiple boxes.

Bridge length.—The length of a bridge structure is the over-all length measured along the line of survey stationing back to back of backwalls of abutments, if present, otherwise end to end of the bridge floor; but in no case less than the total clear opening of the structure.

Bridge roadway width.—The clear width measured at right angles to the longitudinal centerline of the bridge between the bottom of curbs or, if curbs are not used, between the inner faces of bridge parapet or railing.

Calendar day.—Every day shown on the calendar.

Change order.—A written order issued by the Engineer to the Contractor, covering changes within the scope of the contract and establishing the basis of payment and time adjustments for the work affected by the changes.

Contract.—The written agreement between the Government and the Contractor setting forth the obligations of the parties thereunder, including, but not limited to, the performance of the work, the furnishing of labor and materials, and the basis of payment.

The contract includes all documents and Standard Forms included or referred to in the Invitation for Bids; also other documents issued subsequently to provide for completion of the work in an acceptable manner.

Contract item (pay item).—A specifically described unit of work for which a price is provided in the contract.

Contract payment bond.—The security furnished by the Contractor and his surety to guarantee payment of the debts covered by the bond.

Contract performance bond.—The security furnished by the Contractor and his surety to guarantee performance of the work in accordance with the contract.

Contract time.—The number of work days or calendar days allowed for completion of the contract, including authorized time extensions. In case a calendar date of completion is shown in the proposal in lieu of the number of working or calendar days, the contract shall be completed by that date.

Contracting officer.—The following clause of SF 23A applies and shall prevail in event of any conflict in contract provision:

1. DEFINITIONS

(a) *The term "head of the agency" or "Secretary" as used herein means the Secretary, the Under Secretary, any Assistant Secretary, or any other head or assistant head of the executive or military department or other Federal agency; and the term "his duly authorized representative" means any person or persons or board (other than the Contracting Officer) authorized to act for the head of the agency or the Secretary.*

(b) *The term "Contracting Officer" as used herein means the person executing this contract on behalf of the Government and includes a duly appointed successor or authorized representative.*

For contracts executed by the U.S. Bureau of Public Roads, the Contracting Officer is the Director of the Bureau of Public Roads or his duly authorized representative.

Contractor.—The individual, partnership, joint venture, or corporation contracting with the Government for performance of prescribed work.

County.—The county, borough, or parish in which the work herein specified is to be done.

Culvert.—Any structure not classified as a bridge which provides an opening under the roadway.

Directive.—A written order issued by the Engineer to the Contractor requiring the work to be performed in accordance with the contract including all changes that do not involve any adjustment in the basis of payment. Directives will include orders to start, stop, and resume work and orders to perform work under any contingent item in the contract.

Director.—The Director of Public Roads, Bureau of Public

Roads, Federal Highway Administration, U.S. Department of Transportation.

Engineer.—The duly authorized representative of the Contracting Officer who is delegated the responsibility for engineering supervision of the construction.

Equipment.—All machinery and equipment, together with the necessary supplies for upkeep and maintenance, and also tools and apparatus necessary for the proper construction and acceptable completion of the work.

Federal procurements regulations.—The provisions of Chapter I, Title 41, Code of Federal Regulations.

General provisions.—The contract provisions contained in Standard Form 23A—General Provisions (Construction Contract)—and/or Section 100 in these specifications.

Government.—The Government of the United States of America.

Inspector.—The Engineer's authorized representative assigned to make detailed inspections of contract performance.

Invitation for bids. The complete assembly of related documents (whether attached or incorporated by reference) furnished prospective bidders for the purpose of bidding.

Laboratory. A testing laboratory of the Government or any other testing laboratory which may be designated by the Engineer.

Major and minor contract items. Major contract items are listed as such in the bid schedule or in the special provisions; all other contract items will be considered as minor items.

Materials. Any substances specified for use in the construction of the project and its appurtenances.

Nominal dimensions or weights.—The numerical values shown on the plans or in the specifications as measurements for work to be constructed at the site. Work completed in reasonably close conformity with such values, including any tolerances shown, will be considered for acceptance in accordance with Subsection 105.03.

Notice to proceed.—Written notice to the Contractor to proceed with the contract work including, when applicable, the date of beginning of contract time.

Pavement structure. The combinations of subbase, base course, and surface course placed on a subgrade to support the traffic load and distribute it to the roadbed.

Plans. The approved drawings, or exact reproductions thereof, furnished by the Government, which show the location, character, dimensions, and details of the work to be done.

Profile grade. The trace of a vertical plane intersecting the top surface of the proposed road construction, usually along

the longitudinal centerline of the roadbed. Profile grade means either elevation or gradient of such trace according to the context.

Questionnaire. The specified form on which a bidder shall furnish required information as to his ability to perform and finance the work.

Reasonably close conformity. Reasonably close conformity means compliance with reasonable and customary manufacturing and construction tolerances where working tolerances are not specified. Where working tolerances are specified, reasonably close conformity means compliance with such working tolerances. Without detracting from the complete and absolute discretion of the Engineer to insist upon such tolerances as establishing reasonably close conformity, the Engineer may accept variations beyond such tolerances as reasonably close conformity where they will not materially effect the value or utility of the work and the interests of the Government.

Right-of-way.—A general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to a highway.

Road (highway or street).—A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

Roadbed.—The graded portion of a highway within top and side slopes, prepared as a foundation for the pavement structure and shoulders.

Roadside.—A general term denoting the area adjoining the outer edge of the roadway. Extensive areas between the roadways of a divided highway may also be considered roadside.

Roadside development.—Those items necessary to the complete highway which provide for the preservation of landscape materials and features; the rehabilitation and protection against erosion of all areas disturbed by construction through seeding, sodding, mulching and the placing of other ground covers; such suitable planting and other improvements as may increase the effectiveness and enhance the appearance of the highway.

Roadway.—The portion of a highway within limits of construction.

Safety manual.—Latest edition and approved amendments of "Construction Safety Requirements" for Federal Highway Projects.

Shoulder.—The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses.

Sidewalk.—That portion of the roadway primarily constructed for the use of pedestrians.

Skew or skew angle.—The complement of the acute angle between two centerlines which cross.

Special provisions.—Additions and revisions to the standard and supplemental specifications covering conditions peculiar to an individual project.

Specialty items.—Pay items designated in the bid schedule as specialty items; usually minor items requiring equipment and crafts not ordinarily associated with the major types of work covered by the contract.

Specifications.—A general term applied to all directions, provisions and requirements pertaining to performance of the work.

Specified completion date.—The date on which the contract work is specified to be completed.

Standard forms.—Numbered forms issued by the General Services Administration for use as contract documents, abbreviated as SF.

Standard specifications.—The specifications in this book.

State.—The State or Commonwealth in which the work to be done is located.

Structures.—Bridges, culverts, catch basins, drop inlets, retaining walls, cribbing, manholes, endwalls, buildings, sewers, service pipes, underdrains, foundation drain and other features which may be involved in the work and not otherwise classed herein.

Subcontractor.—An individual, partnership, joint venture, or corporation to whom the Contractor subcontracts part of the work under the contract.

Subgrade.—The top surface of a roadbed upon which the pavement structure and shoulders are constructed.

Substructure.—All of that part of the structure below the bearings of simple and continuous spans, skewbacks of arches and tops of footings of rigid frames, together with the backwalls, wingwalls and wing protection railings.

Superintendent.—The Contractor's authorized representative in responsible charge of the work.

Superstructure.—The entire structure except the substructure.

Supplemental agreement.—A written agreement between the Contracting Officer and the Contractor, constituting a modification of the contract originally executed and covering the performance of work beyond the general scope thereof, including any change in the project length of more than 25 percent.

Supplemental specifications.—Additions and revisions to the

standard specifications that are adopted as standard subsequent to issuance of the printed book.

Surety.—The corporation, partnership or individual, other than the Contractor, executing a bond furnished by the Contractor.

City, township, town or district.—A subdivision of the county used to designate or identify the location of the proposed work.

Traveled way.—The portion of the roadway for the movement of vehicles, exclusive of shoulders.

Work.—The furnishing of all labor, materials, equipment, and other incidentals necessary or convenient to the successful completion of the project and the carrying out of all the duties and obligations imposed by the contract upon the Contractor.

Working day.—A calendar day, exclusive of Saturdays, Sundays and national holidays, on which weather and other conditions not under control of the Contractor will permit construction operations to proceed for the major part of the day with the normal working force engaged in performing the controlling item or items of work which would be in progress at that time.

Working drawings.—Stress sheets, shop drawings, erection plans, falsework plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel, or any other supplementary plans or similar data which the contractor is required to furnish and to submit to the Engineer.

Section 102.—BIDDING REQUIREMENTS AND CONDITIONS

102.01 Qualification of Bidders. The following clause of SF22 applies and shall prevail in event of any conflict in the contract provisions:

3. Bidder's Qualifications. *Before a bid is considered for award, the bidder may be requested by the Government to submit a statement regarding his previous experience in performing comparable work, his business and technical organization, financial resources, and plant available to be used in performing the work.*

When specified in the contract documents, a certified statement setting forth such qualification shall be submitted at the time specified in the Invitation for Bids.

102.02 Contents of Bid Forms. Upon request, the Government will furnish the prospective bidder with an Invitation for Bids. This assembly will state the location and descrip-

tion of the contemplated construction and will show the estimate of the various quantities and kinds of work to be performed or materials to be furnished and will have a schedule of items for which unit bid prices are invited. The Bid Forms will state the time in which the work must be completed, the amount of the bid guarantee, and the date, time and place of the opening of bids. The Bid Forms will also include any special provisions or requirements which vary from or are not contained in the standard specifications.

All papers bound with or attached to the Bid Forms are considered a part thereof and must not be detached or altered when the bid is submitted.

The plans, specifications and other documents designated in the Bid Forms will be considered a part of the Invitation for Bids whether attached or not.

102.03 Reserved

102.04 Interpretation of Quantities in Bid Schedule. The quantities appearing in the bid schedule are approximate only and are prepared for the comparison of bids. Payment to the Contractor will be made only for the actual quantities of work performed and accepted or materials furnished in accordance with the contract. The scheduled quantities of work to be done and materials to be furnished may each be increased, decreased, or omitted as hereinafter provided. Bid schedule quantities will be considered the original contract quantities.

102.05 Examination of Plans, Specifications, Special Provisions, and Site of Work. The Government will prepare plans and specifications giving directions to be carried out by the Contractor.

When subsurface investigations have been made, the Invitation for Bids (Standard Form 20) will indicate where bidders may inspect the investigation records.

The records of subsurface investigations are not a part of the contract and are made available to bidders for informational purposes only.

While subsurface investigations will have been performed with reasonable care, there is no warranty or guaranty, either expressed or implied, that they will disclose the actual conditions which will be encountered during the progress of the work.

When a log of test borings is included in the subsurface investigation record, the data shown in the individual log of each test boring apply only to that particular boring and are not intended to be conclusive as to the character of any material between or around test borings.

Any interpretation of the Government's subsurface investigation record made by the bidder as to the types, characteristics, quantity and quality of any subsurface material or condition shall be at the sole risk of the bidder.

The following clause of SF23-A also applies and shall prevail in event of any conflict in the contract provisions:

13. CONDITIONS AFFECTING THE WORK

The Contractor shall be responsible for having taken steps reasonably necessary to ascertain the nature and location of the work, and the general and local conditions which can affect the work or cost thereof. Any failure by the Contractor to do so will not relieve him from responsibility for successfully performing the work without additional expense to the Government. The Government assumes no responsibility for any understanding or representations concerning conditions made by any of its officers or agents prior to the execution of this contract, unless such understanding or representations by the Government are expressly stated in the contract.

102.06 Preparation of Bid Forms. The following clause of SF22 applies and shall prevail in event of any conflict in the contract provisions:

5. Preparation of Bids. (a) *Bids shall be submitted on the forms furnished, or copies thereof, and must be manually signed. If erasures or other changes appear on the forms, each erasure or change must be initialed by the person signing the bid. Unless specifically authorized in the invitation for bids, telegraphic bids will not be considered.*

(b) *The bid forms may provide for submission of a price or prices for one or more items, which may be lump sum bids, alternate prices, scheduled items resulting in a bid on a unit of construction or a combination thereof, etc. Where the bid forms explicitly requires that the bidder bid on all items, failure to do so will disqualify the bid. When submission of a price on all items is not required, bidders should insert the words "no bid" in the space provided for any item on which no price is submitted.*

(c) *Unless called for, alternate bids will not be considered.*

(d) *Modifications of bids already submitted will be considered if received at the office designated in the invitation for bids by the time set for opening of bids. Telegraphic modifications will be considered, but should not reveal the amount of the original or revised bid.*

The bidder shall specify a unit price in words and figures, for each pay item for which a quantity is given and shall also show the products of the respective unit prices and quantities written in figures in the column provided for that purpose and the total amount of the bid obtained by adding

the amounts of the several items. All the words and figures shall be in ink or typed. In case of a discrepancy between the prices written in words and those written in figures, the prices written in words will govern.

When an item in the bid schedule contains a choice to be made by the bidder, the bidder shall indicate his choice in accordance with the specifications for that particular item, and thereafter no further choice will be permitted.

The bidder's bid must be signed with ink by the individual, by one or more members of the partnership, by one or more members or officers of each firm representing a joint venture, or by one or more officers of a corporation, or by an agent of the Contractor legally qualified and acceptable to the Government.

102.07 Irregular Bids. Bids will be considered irregular and may be rejected for the following reasons or as otherwise set forth in the standard forms contained in the Invitation for Bids:

(a) If the bid is on a form other than that furnished by the Government or if forms are altered or any parts thereof are detached.

(b) If there are unauthorized additions, conditional or alternative bids, or irregularities of any kind which may tend to make the bid incomplete, indefinite, or ambiguous as to its meaning.

(c) If the bidder adds any provisions reserving the right to accept or reject an award, or to enter into a contract pursuant to an award. This does not exclude a bid limiting the maximum gross amount of awards acceptable to any one bidder at any one bid letting, provided that any selection of awards will be made by the Government.

(d) If the bid does not contain a unit price for each pay item listed except in the case of authorized alternative pay items.

102.08 Bid Guarantee. The following clause of SF22 applies and shall prevail in event of any conflict in the contract provisions:

4. Bid Guarantee. *Where a bid guarantee is required by the invitation for bids, failure to furnish a bid guarantee in the proper form and amount, by the time set for opening of bids, may be cause for rejection of the bid.*

A bid guarantee shall be in the form of a firm commitment, such as a bid bond, postal money order, certified check, cashier's check, irrevocable letter of credit or, in accordance with Treasury Department regulations, certain bonds or notes of the United States. Bid guarantees, other than bid bonds, will be returned (a) to unsuccessful bidders as soon as practicable after the opening of bids, and

(b) to the successful bidder upon execution of such further contractual documents and bonds as may be required by the bid as accepted.

If the successful bidder, upon acceptance of his bid by the Government within the period specified therein for acceptance (sixty days if no period is specified) fails to execute such further contractual documents, if any, and give such bond(s) as may be required by the terms of the bid as accepted within the time specified (ten days if no period is specified) after receipt of the forms by him, his contract may be terminated for default. In such event he shall be liable for any cost of procuring the work which exceeds the amount of his bid, and the bid guarantee shall be available toward offsetting such difference.

See subsection 103.04 for specific instructions on return of bid guarantees.

Checks or money orders submitted as a bid guarantee shall be made payable to the Bureau of Public Roads, The Federal Highway Administration, U.S. Department of Transportation.

102.09 Submission of Bids. The following clause of SF-22 applies and shall prevail in event of any conflict in the contract provisions:

6. Submission of Bids. *Bids must be sealed, marked, and addressed as directed in the invitation for bids. Failure to do so may result in a premature opening of, or a failure to open, such bid.*

102.10 Late Bids and Modifications or Withdrawals. The following clauses of SF22 apply and shall prevail in event of any conflict in the contract provisions:

7. Late Bids and Modifications or Withdrawals. *(a) Bids and modifications or withdrawals thereof received at the office designated in the Invitation for Bids after the exact time set for opening of bids will not be considered unless: (1) They are received before award is made; and either (2) they are sent by registered mail or by certified mail for which an official dated post office stamp (postmark) on the original Receipt for Certified Mail has been obtained, or by telegraph if authorized, and it is determined by the Government that the late receipt was due solely to delay in the mails, or delay by the telegraph company, for which the bidder was not responsible; or (3) if submitted by mail (or by telegram if authorized), it is determined by the Government that the late receipt was due solely to mishandling by the Government after receipt at the Government installation:* Provided, *That timely receipt at such installation is established upon examination of an appropriate date or time stamp (if any)*

of such installation, or of other documentary evidence of receipt (if readily available) within the control of such installation or of the post office serving it. However, a modification which makes the terms of the otherwise successful bid more favorable to the Government will be considered at any time it is received and may thereafter be accepted.

(b) Bidders using certified mail are cautioned to obtain a Receipt for Certified Mail showing a legible, dated postmark and to retain such receipt against the chance that it will be required as evidence that a late bid was timely mailed.

(c) The time of mailing of late bids submitted by registered or certified mail shall be deemed to be the last minute of the date shown in the postmark on the registered mail receipt or registered mail wrapper or on the Receipt for Certified Mail unless the bidder furnishes evidence from the post office station of mailing which establishes an earlier time. In the case of certified mail, the only acceptable evidence is as follows: (1) where the Receipt for Certified Mail identifies the post office station of mailing, evidence furnished by the bidder which establishes that the business day of that station ended at an earlier time, in which case the time of mailing shall be deemed to be the last minute of the business day of that station; or (2) an entry in ink on the Receipt for Certified Mail showing the time of mailing and the initials of the postal employee receiving the item and making the entry, with appropriate written verification of such entry from the post office station of mailing, in which case the time of mailing shall be the time shown in the entry. If the postmark on the original Receipt for Certified Mail does not show a date, the bid shall not be considered.

8. Withdrawal of Bids. *Bids may be withdrawn by written or telegraphic request received from bidders prior to the time set for opening of bids.*

102.11 Combination or Conditional Bids. No combination bids, other than those specifically provided for in the Bid Forms by the Government will be considered. Conditional bids will be considered when so stated in the special provisions.

102.12 Public Opening of Bids. The following clause of SF22 applies and shall prevail in event of any conflict in the contract provisions:

9. Public Opening of Bids. *Bids will be publicly opened at the time set for opening in the Invitation for Bids. Their content will be made public for the information of*

bidders and others interested, who may be present either in person or by representative.

102.13 Disqualification of Bidders. The Government reserves the right to disqualify a bidder for any of the following reasons, or as otherwise set forth in the standard forms contained in the Invitation for Bids:

(a) Lack of competency as revealed by the financial statement and experience questionnaires required under subsection 102.01.

(b) Uncompleted work which, in the judgment of the Government might hinder or prevent the prompt completion of additional work if awarded.

(c) Failure to pay or satisfactorily settle all bills due for labor and material on former contracts in force at the time of advertisement for bids.

(d) Failure to comply with any qualification regulations of the Government.

(e) Default under previous contracts.

(f) More than one bid for the same work from a bidder under the same or different name.

(g) Evidence of collusion among bidders. Participants in such collusion will receive no recognition as bidders for any future work of the Government until any such participant shall have been reinstated as a qualified bidder.

(h) Otherwise not responsible.

102.14 Material Guarantee. The following clause of SF23—A applies and shall prevail in event of any conflict in the contract provisions:

9. MATERIAL AND WORKMANSHIP

(a) Unless otherwise specifically provided in this contract, all equipment, material, and articles incorporated in the work covered by this contract are to be new and of the most suitable grade for the purpose intended. Unless otherwise specifically provided in this contract, reference to any equipment, material, article, or patented process, by trade name, make, or catalog number, shall be regarded as establishing a standard of quality and shall not be construed as limiting competition, and the Contractor may, at his option, use any equipment, material, article, or process which, in the judgment of the Contracting Officer, is equal to that named. The Contractor shall furnish to the Contracting Officer for his approval the name of the manufacturer, the model number, and other identifying data and information respecting the performance, capacity, nature, and rating of the machinery and mechanical and other equipment which the Contractor contemplates incorporating in the work. When required by this contract or when called for by the Contracting Officer, the Contractor

shall furnish the Contracting Officer for approval full information concerning the material or articles which he contemplates incorporating in the work. When so directed, samples shall be submitted for approval at the Contractor's expense, with all shipping charges repaid. Machinery, equipment, material, and articles installed or used without required approval shall be at the risk of subsequent rejection.

(b) All work under this contract shall be performed in a skillful and workmanlike manner. The Contracting Officer may, in writing, require the Contractor to remove from the work any employee the Contracting Officer deems incompetent, careless, or otherwise objectionable.

Section 103.—AWARD AND EXECUTION OF CONTRACT

103.01 Consideration of Bids. After the bids are opened and read, they will be compared on the basis of the summation of the products of the approximate quantities shown in the bid schedule by the unit bid prices. The results of such comparisons will be immediately available to the public. In the event of a discrepancy between unit bid prices and extensions, the unit bid price will govern.

103.02 Award of Contract. The following clause of SF22 applies and shall prevail in event of any conflict in the contract provisions:

10. Award of Contract. (a) *Award of contract will be made to that responsible bidder whose bid, conforming to the invitation for bids, is most advantageous to the Government, price and other factors considered.*

(b) The Government may, when in its interest, reject any or all bids or waive any informality in bids received.

(c) The Government may accept any item or combination of items of a bid, unless precluded by the invitation for bids or the bidder includes in his bid a restrictive limitation.

The award will be made by written acceptance to the successful bidder within the period specified in the Bid Forms.

103.03 Reserved.

103.04 Return of Bid Guarantee. All bid guarantees other than bid bonds, except those of the two lowest bidders, may be returned immediately following the opening and checking of the bids. The retained bid guarantee of the

unsuccessful of the two lowest bidders will be returned within 10 days following the award of contract and that of the successful bidder will be returned after satisfactory bonds have been furnished and the contract has been executed.

See subsection 102.08 for general instructions on bid guarantees.

103.05 Contract and Bonds. The following clause of SF22 applies and shall prevail in event of any conflict in the contract provisions:

11. Contract and Bonds. *The bidder whose bid is accepted will, within the time established in the bid, enter into a written contract with the Government and, if required, furnish performance and payment bonds on Government standard forms in the amount indicated in the invitation for bids or the specifications.* (See below).

(a) A performance bond in the penal amount of 100 percent of the contract price at the time of award.

(b) A payment bond as follows:

(1) When the contract price is not more than $1,000,000, the penal amount shall be 50 percent of the contract price;

(2) When the contract price is more than $1,000,000, but not more than $5,000,000, the penal amount shall be 40 percent of the contract price; and

(3) When the contract price is more than $5,000,000, the penal amount shall be $2,500,000.

(c) Additional Bond Security. The following clause of SF23-A also applies and shall prevail in event of any conflict in the contract provisions:

16. Additional Bond Security.

If any surety upon any bond furnished in connection with this contract becomes unacceptable to the Government, or if any such surety fails to furnish reports as to his financial condition from time to time as requested by the Government, the Contractor shall promptly furnish such additional security as may be required from time to time to protect the interests of the Government and of persons supplying labor or materials in the prosecution of the work contemplated by the contract.

103.06 Reserved

103.07 Failure to Execute Contract. If the successful bidder does not execute the contract and furnish bonds in accordance with the provisions contained in the Bid Forms, the Government will retain an amount from the bid guarantee equal to the difference between the bid amount and the cost to the Government of procuring the required work, if the latter amount be in excess of the former.

Section 104.—SCOPE OF WORK

104.01 Intent of Contract. The intent of the contract is to provide for the construction and completion in every detail of the work described. The Contractor shall furnish all labor, materials, equipment, tools, transportation and supplies required to complete the work in accordance with the plans, specifications and terms of the contract.

104.02 Alteration of Plans or Character of Work. The following clauses of SF23-A apply and shall prevail in event of any conflict in the contract provisions:

CHANGES

(a) The Contracting Officer may, at any time, without notice to the sureties, by written order designated or indicated to be a change order, make any change in the work within the general scope of the contract, including but not limited to changes:

(i) in the specifications (including drawings and designs);

(ii) in the method or manner of performance of the work;

(iii) in the Government-furnished facilities, equipment, materials, services, or site; or

(iv) directing acceleration in the performance of the work.

(b) Any other written order or an oral order (which terms as used in this paragraph (b) shall include direction, instruction, interpretation, or determination) from the Contracting Officer, which causes any such change, shall be treated as a change order under this clause, provided that the Contractor gives the Contracting Officer written notice stating the date, circumstances, and source of the order and that the Contractor regards the order as a change order.

(c) Except as herein provided, no order, statement, or conduct of the Contracting Officer shall be treated as a change under this clause or entitle the Contractor to an equitable adjustment hereunder.

(d) If any change under this clause causes an increase or decrease in the Contractor's cost of, or the time required for, the performance of any part of the work under this contract, whether or not changed by any order, an equitable adjustment shall be made and the contract modified in writing accordingly: PROVIDED, HOWEVER, That except for claims based on defective specifications, no claim for any change under (b) above shall be allowed for any costs incurred more than 20 days before the

Contractor gives written notice as therein required: AND PROVIDED FURTHER, That in the case of defective specifications for which the Government is responsible, the equitable adjustment shall include any increased cost reasonably incurred by the Contractor in attempting to comply with such defective specifications.

(e) If the Contractor intends to assert a claim for an equitable adjustment under this clause, he must, within 30 days after receipt of a written change order under (a) above or the furnishing of a written notice under (b) above, submit to the Contracting Officer a written statement setting forth the general nature and monetary extent of such claim, unless this period is extended by the Government. The statement of claim hereunder may be included in the notice under (b) above.

(f) No claim by the Contractor for an equitable adjustment hereunder shall be allowed if asserted after final payment under this contract.

DIFFERING SITE CONDITIONS

(a) The Contractor shall promptly, and before such conditions are disturbed, notify the Contracting Officer in writing of: (1) Subsurface or latent physical conditions at the site differing materially from those indicated in this contract, or (2) unknown physical conditions at the site, of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inhering in work of the character provided for in this contract. The contracting Officer shall promptly investigate the conditions, and if he finds that such conditions do materially so differ and cause an increase of decrease in the Contractor's cost of, or the time required for, performance of any part of the work under this contract, whether or not changed as a result of such conditions, an equitable adjustment shall be made and the contract modified in writing accordingly.

(b) No claim of the Contractor under this clause shall be allowed unless the Contractor has given the notice required in (a) above; provided, however, the time prescribed therefor may be extended by the Government.

(c) No claim by the Contractor for an equitable adjustment hereunder shall be allowed if asserted after final payment under this contract.

It is mutually agreed that it is inherent in the nature of highway construction that some changes in the plans and specifications may be necessary during the course of construction to adjust them to field conditions and that it is of the essence of the contract to recognize a normal and ex-

pected margin of change within the meaning of the clauses "Changes" and "Differing Site Conditions" in the "General Provisions" of the contract as not requiring or permitting any adjustment of contract prices:

(a) When the quantity of work to be done or material to be furnished under any major item of the contract is increased to more than 125 percent of the quantity stated in the bid schedule then either party to the contract, upon demand, shall be entitled to an equitable price adjustment on that portion of the work above 125 percent of the quantity stated in the bid schedule.

(b) When the quantity of work to be done or material to be furnished under any major item of the contract is reduced to less than 75 percent of the quantity stated in the bid schedule then either party to the contract, upon demand, shall be entitled to an equitable price adjustment for the work quantity actually performed, limited to a total payment not more than 75 percent of the amount originally bid for the item.

Payment for work occasioned by changes or alterations will be made in accordance with the provisions set forth under subsection 109.03. If the work is of sufficient magnitude as to require additional time in which to complete the project, such time adjustment may be made in accordance with the provisions of subsection 108.06.

104.03 Reserved

104.04 Maintenance of Traffic. Unless otherwise provided, the existing road while undergoing improvements shall be kept open to all traffic by the Contractor. Where so provided on the plans or in the special provisions, the Contractor may bypass traffic over an approved detour route or by approved part-width construction.

The Contractor shall keep the portion of the project being used by public traffic, whether it be through or local traffic, in such condition that traffic will be adequately accommodated. He shall also provide and maintain in a safe condition temporary approaches or crossings and intersections with trails, roads, streets, businesses, parking lots, residences, garages and farms; provided, however, that snow removal will not be required of the Contractor. He shall furnish and apply water or use other satisfactory means for dust control.

The Contractor shall bear all expense of maintaining traffic over the section of existing road undergoing improvement and of constructing and maintaining such approaches, crossings, intersections, and other features as may be necessary, without direct compensation, except as provided in (*a*), (*b*), and (*c*) below.

(a) Special Detours.—When the bid schedule contains an item for "Maintenance of Detours" or "Removing Existing Structures and Maintaining Traffic", then the payment for such item will cover all cost of constructing and maintaining such detour or detours, including the construction of any and all temporary bridges and accessory features and the removal of the same, and obliteration of the detour road. Right-of-way for temporary highways or bridges called for under this paragraph will be furnished by the Government.

(b) Maintenance of Traffic During Suspension of Work.—During any suspension, the Contractor shall make passable and shall open to traffic such portions of the project and temporary roadways or portions thereof as may be directed by the Engineer for the temporary accommodation of necessary traffic during the anticipated period of suspension. Thereafter, and until an issuance of an order for the resumption of construction operations, the maintenance of such a temporary route or line of travel, if done by the Contractor will be as directed, and will be paid for in accordance with subsection 109.04.

When work is resumed, the Contractor shall replace or renew any work or materials lost or damaged because of such temporary use of the project; shall remove to the extent directed by the Engineer any work or materials used in the temporary maintenance thereof by the Government and shall complete the project in every respect as though its prosecution had been continuous and without interferences. All work performed as directed during such suspensions, will be paid for by the Government at contract prices, agreed prices, or force account.

(c) Flagmen and Pilot Car Operators.- If the special provisions permit payment to be made in full or in part for the labor costs of flagmen and pilot car operators furnished with the prior approval of the Engineer, such payment will be made in accordance with subsection 109.04(a), excluding payment for foremen.

104.05 Rights in and Use of Materials Found on the Work. The Contractor, with the approval of the Engineer, may use on the project such stone, gravel, sand, or other material determined suitable by the Engineer, as may be found in the excavation and will be paid both for the excavation of such materials at the corresponding contract unit price and for the pay items for which the excavated material is used. He shall replace at his own expense with other acceptable material all of that portion of the excavation material so removed and used which was needed for use in the embankments, backfills, approaches, or otherwise. No charge for the materials so used will be made against the

Contractor. The Contractor shall not excavate or remove any material from within the highway location which is not within the grading limits, as indicated by the slope and grade lines, without written authorization from the Engineer.

In the event the Contractor has produced or processed materials from lands of the Government in excess of the quantities required for performance of this contract, the Government may take possession of such excess materials, including any waste material produced as a byproduct, without obligation to reimburse the Contractor for the cost of production, or may require the Contractor to remove such materials and restore the premises to a satisfactory condition at the Contractor's expense. This provision will not preclude the Government from arranging with the Contractor to produce material over and above the contract needs, payment for which will be by mutual agreement between the Government and the Contractor.

Unless otherwise provided, the material from any existing abandoned structure may be used temporarily by the Contractor in the erection of the replacement structure. Such material shall not be cut or otherwise damaged except with the approval of the Engineer.

104.06 Final Cleaning Up. Before final acceptance, the highway, borrow pits, and all ground occupied by the Contractor in connection with the work shall be cleaned by him of all rubbish, excess materials, temporary structures, and equipment; and all parts of the work shall be left in an acceptable condition. This work will be considered necessary work auxiliary to the accomplishment of the contract and no direct payment will be made therefor.

Section 105.—CONTROL OF WORK

105.01 Authority of the Engineer; Suspension of Work. The Engineer will decide all questions which may arise as to the quality and acceptability of materials furnished and work performed and as to the rate of progress of the work; all questions which may arise as to the interpretation of the plans and specifications; all questions as to the acceptable fulfillment of the contract on the part of the Contractor.

The Engineer's decision will be based on engineering judgment, taking into consideration all facts, the inherent variations in the processing and testing of highway materials, past experiences, research findings, and other factors bearing on

the issue, including all regulations, instructions, and guidelines established by the Government for administration of contract work. Such tests as the Engineer deems necessary may be taken to ascertain the degree of conformance of the material or work in question with the plans and specifications.

The Engineer will have the authority to suspend the work wholly or in part due to the failure of the Contractor to correct conditions unsafe for the workmen or the general public; for failure to carry out provisions of the contract; for failure to carry out orders; for such periods as he may deem necessary due to unsuitable weather; for conditions considered unsuitable for the prosecution of the work or for any other condition or reason deemed to be in the public interest. Suspension of work on some but not all items will be considered "partial suspension". Suspension of work on all items will be considered "total suspension". Work of an emergency nature ordered by the Engineer for the convenience of public traffic, and minor operations not affected by nor connected with the cause of suspension, if permitted by the Engineer, may be performed during a period of total suspension.

Any adjustment of contract time for suspension of work will be made as provided in subsection 108.06 and 108.09.

105.02 Plans and Working Drawings. Plans furnished by the Government will show lines, grades, typical cross sections of the roadway, location and construction details of all structures and a summary of items appearing on the bid schedule. Only general features will be shown for steel bridges. The Contractor shall keep one set of plans available at the work site at all times.

The plans shall be supplemented by such working drawings as are necessary to adequately control the work. Working drawings for structures shall be furnished by the Contractor and shall consist of such detailed plans as may be required to adequately control the work and are not included in the plans furnished by the Government. They shall include stress sheets, shop drawings, erection plans, falsework plans, cofferdam plans, bending diagrams for reinforcing steel or any other supplementary plans or similar data required of the Contractor. All working drawings must be approved by the Engineer, but it is mutually agreed that the Contractor shall be responsible for accuracy of dimensions and details and for agreement and conformity of his working drawings with the contract plans and specifications. This approval shall not operate to relieve the Contractor of any of his responsibility under the contract for the successful completion of the work.

Shop detail drawings and other working drawings shall not exceed 22 inches by 36 inches in size. Three sets of blue prints or other acceptable type copies shall be submitted to the Engineer for his purposes, one set of which will be returned to the Contractor with desired revisions noted thereon. After correction and approval, five additional sets of prints or copies shall be given to the Government. Upon completion of fabrication, the original tracings, or one set of reproducible prints or tracings, shall be furnished to the Government.

The contract price shall include the cost of furnishing all working drawings.

105.03 Conformity with Plans and Specifications. All work performed and all materials furnished shall be in reasonably close conformity (see definition) with the lines, grades, cross sections, dimensions and material requirements shown on the plans or indicated in the specifications.

Plan dimensions and contract specification values are to be considered as the target value to be strived for and complied with as the design value for which any deviations are allowed. It is the intent of the specifications that the materials and workmanship shall be uniform in character and shall conform as nearly as realistically possible to the prescribed target value or to the middle portion of the tolerance range. The purpose of the tolerance range is to accommodate occasional minor variations from the median zone that are unavoidable for practical reasons. When a maximum or minimum value is specified, the production and processing of the material and the performance of the work shall be so controlled that material or work will not be preponderately of borderline quality or dimension.

In the event the Engineer finds the materials or the finished product in which the materials are used not within reasonably close conformity with the plans and specifications but that reasonably acceptable work has been produced, he will then make a determination whether the work will be accepted and remain in place. In this event, the Engineer will issue a change order which will provide for an appropriate adjustment in the contract price for such work or materials as he deems necessary to conform to his determination based on engineering judgment.

In the event the Engineer finds the materials or the finished product in which the materials are used or the work performed are not in reasonably close conformity with the plans and specifications and have resulted in an inferior or unsatisfactory product such work or materials shall be removed and replaced or otherwise corrected by and at the expense of the Contractor.

See also subsection 105.11.

105.04 Coordination or Plans, Specifications, and General Provisions. These specifications, the supplemental specifications, the plans, special provisions, General Provisions and all supplementary documents are essential parts of the Contract, and a requirement occurring in one is as binding as though occurring in all. They are intended to be complementary and to describe and provide for a complete work. In case of discrepancy, calculated dimensions will govern over scaled dimensions; plans will govern over standard and supplemental specifications; supplemental specifications will govern over standard specifications; special provisions will govern over both standard and supplemental specifications and plans; and the "General Provisions" of the contract will prevail over the plans, supplemental and standard specifications, and special provisions.

Standard Forms used as contract documents will prevail over conflicting requirements in the specifications.

In subsection 105.05 below and in Clause 2, SF23A of the General Provisions, the term "specifications" is interpreted to mean job specifications of a nature corresponding to "special provisions", as defined in subsection 101.02 and not the standard specifications that are of general application.

The Contractor shall take no advantage of any apparent error or omission in the plans or specifications. In the event the Contractor discovers such an error or omission, he shall immediately notify the Engineer. The Engineer will then make such corrections and interpretations as may be deemed necessary for fulfilling the intent of the plans and specifications.

105.05 Cooperation by Contractor. The Contractor will be supplied with a minimum of two sets of approved plans and contract assemblies including special provisions.

The following clause of SF23-A also applies and shall prevail in event of any conflict in the contract provisions:

2. Specifications and Drawings

The Contractor shall keep on the work a copy of the drawings and specifications and shall at all times give the Contracting Officer access thereto. Anything mentioned in the specifications and not shown on the drawings, or shown on the drawings and not mentioned in the specifications, shall be of like effect as if shown or mentioned in both. In case of difference between drawings and specifications, the specifications shall govern. In case of discrepancy either in the figures, in the drawings, or in the specifications, the matter shall be promptly submitted

to the Contracting Officer, who shall promptly make a determination in writing. Any adjustment by the Contractor without such a determination shall be at his own risk and expense. The Contracting Officer shall furnish from time to time such detail drawings and other information as he may consider necessary, unless otherwise provided.

105.06 Cooperation with Utilities. The Government will notify all utility companies, all pipe line owners or other parties affected, and endeavor to have all necessary adjustments of the public or private utility fixtures, pipe lines, and other appurtenances within or adjacent to the limits of construction, made as soon as practicable.

Water lines, gas lines, wire lines, service connections, water and gas meter boxes, water and gas valve boxes, light standards, cableways, signals, and all other utility appurtenances within the limits of the proposed construction which are to be relocated or adjusted are to be moved by others at their expense, except as otherwise provided for in the special provisions or as noted on the plans.

It is understood and agreed that the Contractor has considered in his bid all of the permanent and temporary utility appurtenances in their present or relocated positions as shown on the plans and that no additional compensation will be allowed for any delays, inconvenience, or damage sustained by him due to any interference from the said utility appurtenances or the operation of moving them.

In general, the contract will indicate various utility items, certain of which are to be relocated or adjusted by the utility owner and others which are to be relocated or adjusted by the Contractor. The special provisions will indicate the means of adjudication, if any, in case of failure by the utility owners to comply with their responsibility in relocating or adjusting their facility.

105.07 Cooperation Between Contractors. The following clause of SF23-A applies and shall prevail in event of any conflict in the contract provisions:

14. Other Contracts

The Government may undertake or award other contracts for additional work and the Contractor shall fully cooperate with such other contractors and Government employees and carefully fit his own work to such additional work as may be directed by the Contracting Officer. The Contractor shall not commit or permit any act which will interfere with the performance of work by any other contractor or by Government employees.

The Contractor shall arrange his work and shall place and dispose of the materials being used so as not to interfere with the operations of the other contractors within the

limits of the same project. He shall join his work with that of the others in an acceptable manner and shall perform it in proper sequence to that of the others.

105.08 Construction Stakes, Lines and Grades. The Engineer will set such initial construction stakes establishing lines, slopes, and continuous profile-grade in road work, and reference lines and bench marks for bridge work, culvert work, protective and accessory structures and appurtenances as he may deem necessary, and will furnish the Contractor with all necessary information relating to lines, slopes and grades. These stakes and marks will constitute the field control by and in accordance with which the Contractor shall establish other necessary controls and perform the work.

The Contractor will be held responsible for the preservation of all stakes and marks, and if any of the construction stakes or marks have been carelessly or willfully destroyed or disturbed by the Contractor, the cost to the Government of replacing them may be charged against him and may be deducted from the payment for the work.

The Contractor shall notify the Engineer of apparent errors discovered in initial stakeout before the affected work is begun. Should work be performed in accordance with inaccurate initial stakeout made by the Engineer and not discovered by the Contractor, payment for such work and any directed correction thereof will be made at applicable unit prices of the contract unless such work differs substantially from that described on the plans or in the specifications, in which case the provisions of subsection 109.04 will apply.

105.09 Designation of Engineer. Each project will have an Engineer designated as a representative of the Contracting Officer, with authority in accordance with subsection 105.01. The Contractor will be notified of the identity of this Engineer before work has begun.

105.10 Duties of the Inspector. Inspectors employed by the Government are authorized to inspect all work done and materials furnished. Such inspection may extend to all or any part of the work and to the preparation, fabrication or manufacture of the materials to be used. The inspectors are not authorized to alter or waive the provisions of the contract. The inspectors are not authorized to issue instructions contrary to the plans and specifications, or to act as foreman for the Contractor. He (Inspector) shall have the authority to reject materials or suspend the work until any questions at issue can be referred to and decided by the Engineer.

105.11 Inspection of Work. The following clause of SF23-A applies and shall prevail in event of any conflict in contract provisions:

10. Inspection and Acceptance

(a) Except as otherwise provided in this contract, inspection and test by the Government of material and workmanship required by this contract shall be made at reasonable times and at the site of the work, unless the Contracting Officer determines that such inspection or test of material which is to be incorporated in the work shall be made at the place of production, manufacture, or shipment of such material. To the extent specified by the Contracting Officer at the time of determining to make off-site inspection or test, such inspection or test shall be conclusive as to whether the material involved conforms to the contract requirements. Such off-site inspection or test shal not relieve the Contractor of responsibility for damage to or loss of the material prior to acceptance, nor in any way affect the continuing rights of the Government after acceptance of the completed work under the terms of paragraph (f) of this clause, except as hereinabove provided.

(b) The Contractor shall, without charge, replace any material or correct any workmanship found by the Government not to conform to the contract requirements, unless in the public interest the Government consents to accept such material or workmanship with an appropriate adjustment in contract price. The Contractor shall promptly segregate and remove rejected material from the premises.

(c) If the Contractor does not promptly replace rejected material or correct rejected workmanship, the Government (1) may, by contract or otherwise, replace such material or correct such workmanship and charge the cost thereof to the Contractor or (2) may terminate the Contractor's right to proceed in accordance with Clause 5 of these General Provisions.

(d) The Contractor shall furnish promptly, without additional charge, all facilities, labor, and material reasonably needed for performing such safe and convenient inspection and test as may be required by the Contracting Officer. All inspection and test by the Government shall be performed in such manner as not unnecessarily to delay the work. Special, full size, and performance tests shall be performed as described in this contract. The Contractor shall be charged with any additional cost of inspection when material and workmanship are not ready at the time specified by the Contractor for its inspection.

(e) Should it be considered necessary or advisable by the Government at any time before acceptance of the entire work to make an examination of work already completed, by removing or tearing out same, the Contractor shall, on request, promptly furnish all necessary facilities, labor, and material. If such work is found to be defective or nonconforming in any material respect, due to the fault of the Contractor or his subcontractors, he shall defray all the expenses of such examination and of satisfactory reconstruction. If, however, such work is found to meet the requirements of the contract, an equitable adjustment shall be made in the contract price to compensate the Contractor for the additional services involved in such examination and reconstruction and, if completion of the work has been delayed thereby, he shall, in addition, be granted a suitable extension of time.

(f) Unless otherwise provided in this contract, acceptance by the Government shall be made as promptly as practicable after completion and inspection of all work required by this contract. Acceptance shall be final and conclusive except as regards latent defects, fraud, or such gross mistakes as may amount to fraud, or as regards the Government's rights under any warranty or guarantee.

See also subsections 105.03 and 105.16.

When any unit of government or political subdivision or any railroad corporation is to pay a portion of the cost of the work covered by the contract, its respective representatives will have the right to inspect the work. Such inspection will in no sense make such unit of government or political subdivision or such railroad corporation a party to the contract, and will in no way interfere with the rights of either party hereunder.

105.12 Removal of Unacceptable and Unauthorized Work. Work determined to be unacceptable, in accordance with subsection 105.03, shall be removed immediately and replaced in an acceptable manner. No work shall be done without lines and grades having been given by the Engineer in accordance with subsection 105.08.

Work done contrary to the instructions of the Engineer, work done beyond the lines shown on the plans, or as given, except as herein specified, or any work done without authority, will be considered as unauthorized and will not be paid for under the provisions of the contract. Work so done may be ordered removed or replaced at the Contractor's expense.

See also subsection 105.11.

105.13 Load Restrictions. The Contractor shall comply with all legal load restrictions in the hauling of materials on public roads beyond the limits of the project. A special permit will not relieve the Contractor of liability for damage which may result from the moving of equipment.

The operation of equipment of such weight or so loaded as to cause damage to structures or the roadway or to any

other type of construction will not be permitted. Hauling of materials over the base course or surface course under construction shall be limited as directed. No loads will be permitted on a concrete pavement, base or structure before the expiration of the curing period. In no case shall legal load limits be exceeded unless permitted in writing. The Contractor shall be liable for all damage done by his hauling equipment.

105.14 Maintenance of the Work During Construction. The Contractor shall maintain the work during construction and until the project is accepted. This maintenance shall be prosecuted as required with adequate equipment and forces to the end that the roadway or structures are kept in satisfactory condition at all times.

In the case of a contract for the placing of a course upon a course or subgrade previously constructed, the Contractor shall maintain or restore the previous course or subgrade to the specified condition before the succeeding course is placed.

All cost of maintenance work during construction and before the project is accepted shall be included in the unit prices bid on the contract pay items and the Contractor will not be paid an additional amount for such work except as provided in subsection 104.04.

105.15 Failure to Maintain Roadway or Structure. If the Contractor, at any time, fails to comply with the provisions of subsection 105.14, the Engineer will immediately notify the Contractor of such noncompliance. If the Contractor fails to remedy unsatisfactory maintenance within 24 hours after receipt of such notice the Engineer may immediately proceed to maintain the project, and the entire cost of this maintenance will be deducted from monies due or to become due the Contractor on his contract.

105.16 Acceptance.

(a) *Partial Acceptance.*—If at any time during the prosecution of the project the Contractor substantially completes a unit or portion of the project, such as a structure, an interchange, or a section of road or pavement, he may request the Engineer to make final inspection of that unit. If the Engineer finds upon inspection that the unit has been substantially completed in compliance with the contract he may accept that unit as being completed and the Contractor may be relieved of further responsibility for that unit. Such partial acceptance shall in no way void or alter any of the terms of the contract.

(b) *Final Acceptance.*—Upon due notice from the Contractor of presumptive completion of the entire project, the Engineer will make an inspection. If all construction provided for and contemplated by the contract is found completed in reasonably close conformity with the contract requirements, that inspection will constitute the final inspection and the Engineer will make the final acceptance—and notify the Contractor in writing of this acceptance and of the date after which no further time will be charged.

If, however, the inspection discloses any work, in whole or in part, as being unsatisfactory, the Engineer will give the Contractor the necessary instructions for correction of such work, and the Contractor shall immediately comply with and execute such instructions.

Upon correction of the work, another inspection will be made which will constitute the final inspection provided the work has been satisfactorily completed. In such event, the Engineer will make the final acceptance and notify the Contractor in writing of this acceptance as provided above. See also subsection 105.11.

105.17 Claims for Adjustment and Disputes. If, in any case, the Contractor deems that additional compensation is due him for work or material not clearly covered in the contract or not ordered by the Engineer, the Contractor shall notify the Engineer in writing of his intention to make claim for such additional compensation before he begins the work on which he bases the claim. If such notification is not given, and the Engineer is not afforded proper facilities by the Contractor for keeping strict account of actual cost as required, then the Contractor hereby agrees to waive any claim for such additional compensation. Such notice by the Contractor, and the fact that the Engineer has kept account of the cost as aforesaid, will not in any way be construed as proving or substantiating the validity of the claim.

Nothing in this subsection shall be construed as establishing any claim contrary to the terms of subsection 104.02.

The following clause of SF-23A also applies and shall prevail in event of any conflict in contract provisions:

6. Disputes

(a) *Except as otherwise provided in this contract, any dispute concerning a question of fact arising under this contract which is not disposed of by agreement shall be decided by the Contracting Officer, who shall reduce his decision to writing and mail or otherwise furnish a copy thereof to the Contractor. The decision of the Contracting Officer shall be final and conclusive unless within 30 days from the date of receipt of such copy, the Contractor mails or otherwise furnishes to the Contracting Officer a written appeal addressed to the head of the agency involved. The decision of the head of the agency or his duly authorized representative for the determination of such appeals shall*

be final and conclusive. This provision shall not be pleaded in any suit involving a question of fact arising under this contract as limiting judicial review of any such decision to cases where fraud by such official or his representative or board is alleged: Provided, however, *that any such decision shall be final and conclusive unless the same is fraudulent or capricious or arbitrary or so grossly erroneous as necessarily to imply bad faith or is not supported by substantial evidence. In connection with any appeal proceeding under this clause, the Contractor shall be afforded an opportunity to be heard and to offer evidence in support of his appeal. Pending final decision of a dispute hereunder, the Contractor shall proceed diligently with the performance of the contract and in accordance with the Contracting Officer's decision.*

(b) This Disputes clause does not preclude consideration of questions of law in connection with decisions provided for in paragraph (a) above. Nothing in this contract, however, shall be construed as making final the decision of any administrative official, representative, or board on a question of law.

Section 106.—CONTROL OF MATERIAL

106.01 Source of Supply and Quality Requirements.

Unless otherwise provided, all materials used on the work shall be furnished by the Contractor in reasonably close conformity to all quality requirements of the contract. In order to expedite the inspection and testing of materials, the Contractor shall notify the Engineer of his proposed sources of materials so that the materials may be approved at the source of supply before delivery is started, subject to the provisions of subsection 106.03. If it is found after trial that sources of supply for previously approved materials do not produce uniform and satisfactory products or if the product from any source proves unacceptable at any time, the Contractor shall furnish materials from other sources.

See also subsection 102.14.

106.02 Local Material Sources

(a) *Designated Sources.*—Possible sources of local materials may be designated on the plans and described in the special provisions. The quality of material in such deposits will be acceptable in general, but the Contractor shall determine for himself the amount of equipment and work required

to produce a material meeting the specifications. It shall be understood that it is not feasible to ascertain from samples the limit for an entire deposit, and that variations shall be considered as usual and are to be expected. The Engineer may order procurement of material from any portion of a deposit and may reject portions of the deposit as unacceptable.

If crushed aggregate is produced from designated gravel pits, all oversize material encountered therein with diameters of 12 inches or less shall be crushed and used if suitable.

The Government may acquire and make available to the Contractor the right to take materials from the sources designated on the plans and described under special provisions, together with the right to use such property as may be specified, for plant site, stockpiles and hauling roads.

Except for Case 1, Borrow, designated sources will be identified as either type A sources, for which the Government assumes responsibility for the adequacy of acceptable materials in accordance with paragraph 1 hereinafter or type B sources for which the Contractor shall satisfy himself as to the quantity of acceptable material that may be produced in accordance with paragraph 2 hereinafter. The Contractor will be relieved of any obligation to obtain the right to remove material from type A or type B sources except that if any royalty charges are involved, they will be set forth in the special provisions and shall be paid by the Contractor. If the Contractor elects to furnish material from other than type A or type B sources, he shall assume all responsibility and expense in connection with obtaining the right to remove material therefrom including the payment of any royalty charges.

(1) *Type A sources.*—Should the Contractor elect to obtain material from a type A source and it is subsequently determined by the Engineer that due to causes beyond control of the Contractor the source contains insufficient available acceptable material to meet the contract needs, the Government will provide another source. In this event an equitable adjustment in payment and contract time will be made in accordance with subsection 104.02. Should the Contractor choose, for some other reason, to change the source of material from a type A source at which he has installed a plant, no adjustment in payment or contract time will be made.

(2) *Type B sources.*—Should the Contractor elect to obtain material from a type B source and it is subsequently determined by the Engineer that the source contains insufficient acceptable material to meet the contract needs and it becomes necessary for the Contractor to select a new source, or if the

Contractor chooses, for some other reason, to change the source of material, no adjustment in payment or contract time will be made, regardless of the conditions which caused such insufficiency of acceptable material or of the fact that the Contractor has installed a plant at a type B source.

(b) *Contractor Furnished Sources.*—When material deposits are not designated in the special provisions, the Contractor shall provide sources of material acceptable to the Engineer.

When sources of material or material deposits are provided by the Contractor, the Government will assume the cost of processing samples to determine the suitability of the material.

(c) *General.*—When work areas, gravel pits or other than commercially operated borrow pits are located in or adjacent to live streams or other bodies of water, operations at the sites shall be so controlled, both during and after completion of the work, that erosion will be minimized and sediment will not enter streams or other bodies of water. This may require segregating such areas by a dike or other barrier, treatment of pollutants by filtration, a settling basin or other means sufficient to reduce the sediment content to not more than that of the body of water into which it is discharged.

Waste or disposal areas and construction roads shall be located and constructed in a manner that will keep sediment from entering streams or other bodies of water.

Where practicable, borrow pits, gravel pits, quarry sites and waste or disposal areas shall be located so that they will not be visible from the highway and shall be so excavated that water will not collect and stand therein, unless otherwise provided. Final restoration of borrow or waste disposal areas shall include grading, establishment of vegetative cover, or other necessary treatments that will blend the area into the surrounding area.

106.03 Samples, Tests, Cited Specifications. All materials for which tests are specified will be inspected, and tested for acceptability by the Engineer before incorporation in the work.

Any work in which untested and unaccepted materials are used without approval or written permission of the Engineer will be performed at the Contractor's risk and may be considered as unacceptable and unauthorized and may not be paid for. Unless otherwise designated, when a reference is made in the contract to a specification, standard, or test method adopted by AASHO, ASTM, GSA, or other recognized national technical association, it shall mean the specification, standard, or test method (including interim or tentative issues) which is in effect on the date of advertisement for bids. Samples will be taken by a qualified representative of the Government.

All materials being used are subject to inspection, test or retest and rejection at any time prior to incorporation into the work.

Copies of all tests will be furnished to the Contractor's representative at his request.

Acceptance Sampling and Testing of Bituminous Materials

A. Draining Transports at Point of Discharge

The contractor shall provide a suitable unloading area at the project plant site for use by transport trucks that will assure complete drainage of the tanks while the material is still fluid.

B. Bituminous Material not Conforming with Specification Requirements

Bituminous materials which do not meet the specification requirements in any respect shall not be accepted and shall be removed from the work, including all portions of the work in which such nonconforming bituminous material has been incorporated, unless, (1) there is a written request by the contractor for acceptance of the material under Clause 10(b) of Standard Form 23-A of the contract at a reduced price, and (2) there is a determination by the engineer that the nonconforming material may be accepted and permitted to be used or to remain in the completed work. If the engineer accepts the nonconforming material, payment for the actual quantity of the said material accepted and used in the work will be made at a reduction from the contract unit price for conforming bituminous material; 85 percent of the contract unit price when nonconformances are few in number, or in importance; 80 percent of the contract unit price when nonconformances are intermediate in number, or in importance, and 75 percent of the contract unit price when the nonconformances are at or near the maximum acceptable in number, or importance. Under the provisions of (2) above, the engineer's decisions shall be final and conclusive.

C. Sampling Procedure

In lieu of AASHO T-40, Sampling Bituminous Materials, all bituminous materials called for in the bid schedule and

used in the work shall be sampled by the Bureau in accordance with the following procedure:

1. **Notice of Shipments.**

The contractor, or the supplier as his agent, shall notify the project engineer or his representative sufficiently in advance of arrival of shipments of bituminous materials on the project that the latter may be present at such time of arrival, as necessary.

2. **Certification with Shipments.**

(a) The contractor, or the supplier as his agent, shall deliver to the project engineer or his representative for, and along with, each tank car, truck tank, trailer tank, or other individual conveyance of bituminous material shipped or hauled to the project, two copies of the covering bill of lading upon which (or upon a separate card firmly attached thereto) is stamped and fully executed a Certificate of Compliance conforming to the following; except that the designated format of the Certificate of Compliance will not be required when the standard bill of lading in use by the supplier contains within itself the essential information required by the Certificate:

Consignee ..... Destination .....
Project Number ..... Date .....
Identification (Truck No., Car No., etc.) .....
Type and Grade . With Additive (% and brand) ..... Specific Gravity at 60 F ...
Loading Temp. ..... Net Weight .....
Net Gallons .....

The shipment of bituminous material identified above and covered by this bill of lading complies with Bureau of Public Roads standard specifications as modified by special provisions applicable to this project.

Producer .....
Signed .....
Producer's Representative

(b) On the basis of presentation of the foregoing bill of lading bearing properly executed certificate of compliance or incorporating therein the essential elements of the certificate, the project engineer will permit use of the bituminous material in the contract work, pending receipt of laboratory test results on samples taken as hereinafter set forth. It is expressly understood and agreed that the contractor proceeds with such use of the material at his own risk, and permission by the engineer for such use shall not be construed as acceptance of the material or any implied responsibility therefor, by the Bureau. Final acceptance or rejection of the material, in accordance with the terms of the contract, will

be based upon the laboratory test results on samples taken under Government supervision as hereinafter specified.

3. **Liquid and Penetration Grade Bituminous Material used in direct application on the road (not initially discharged into storage tanks on project).**

(a) All truck tanks, trailer tanks, or other conveyances containing above bituminous materials shall be equipped with a suitable spigot in the transport tank or the contractor shall provide, a suitable spigot or gate valve in the discharge line for the purpose of conveniently obtaining samples during discharge at point of delivery. The diameter of the spigot or valve shall be not less than ⅜" or more than ¾". The contractor shall be responsible at all times for the availability and cleanliness of the sampling devices to insure against contamination of the samples taken.

(b) The project engineer or his representative shall supervise the actual taking of samples by a representative of the contractor in the following manner:

(1) A minimum of two (duplicate) one quart samples shall be taken in new, clean containers furnished by the Bureau, of each separate tank load of bituminous material delivered, at the time of discharge into distributors or other conveyance on the project. Second-hand containers or any containers washed or rinsed with solvents shall not be used.

(2) The samples shall be taken when the tank load has been approximately one-half discharged, and while the discharge line is running full.

(3) Just prior to taking the samples, not less than one gallon of the material shall be drawn through the valve and discarded in order to clear the valve and insure the taking of a uniform sample.

(4) The two samples shall be taken consecutively with a minimum lapse of time. Any samples desired by the contractor at that time may be taken before or after the taking of the Bureau samples.

(5) The two samples shall be considered as representing no more than the amount of asphaltic material in the tank from which taken.

4. **Liquid and Penetration Grade Bituminous Material, initially discharged into storage tanks on project.**

(a) Liquid grade bituminous material to be discharged from storage tank into distributors, and penetration grade bituminous material to be used in hot plant mixed pavement or base shall be sampled from the line between the storage tank and the distributor or the bituminous mixing plant, as the case may be, utilizing a spigot or gate valve furnished and installed therein for such purpose by the contractor, and having a diameter not less than ⅜" nor more than ¾". The

installation shall be in a location as free as possible from plant dust or any other possibility of contamination. If deemed necessary to avoid contamination of the sample, the engineer may require the contractor to construct and maintain in a clean condition a suitable covering for the valve and sampling area.

(b) The project engineer or his representative shall supervise the actual taking of the sample by a representative of the contractor in the following manner:

(1) A minimum of two (duplicate) one quart samples shall be taken, in new clean containers furnished by the Bureau, after each delivery and discharge of any bituminous material into the storage tank. Second-hand containers or any containers washed or rinsed with solvents shall not be used.

(2) The samples shall be taken after a sufficient period of circulation of such bituminous material has taken place to insure a sample representative of the total material then in the storage tank. No sample shall be taken from the spigot or valve until several times the storage capacity of the line has been drawn from the tank.

(3), (4), and (5) Same procedure as set forth under Section 3b hereinbefore.

(6) The contractor shall provide a convenient and accurate means of determining the gallonage of the asphalt in the storage tank represented by the sample taken.

5. **Asphaltic Emulsion.**

(a) Asphaltic emulsions used in direct application on the road shall be sampled in the same manner as set forth under Section 3 hereinbefore except that one gallon samples shall be taken.

(b) Asphaltic emulsions used in pugmill mixed aggregate involving storage tank on the project shall be sampled in the same manner as set forth under Section 4 hereinbefore except that one gallon samples shall be taken.

6. **All Bituminous Materials.**

(a) As soon after sampling as practicable, one of the duplicate samples, but both duplicate samples in the case of asphaltic emulsions, shall be delivered by the engineer to the nearest authorized laboratory for tests to determine compliance.

(b) The remaining duplicate sample shall be retained by the engineer on the project for later check test, in the event results on the first duplicate sample indicates noncompliance.

7. **Special Requirements for Bituminous Materials containing Antistripping Additives.**

(a) All the foregoing requirements apply for the type of bituminous material involved.

(b) Additionally, the contractor, or the supplier as his agent, shall furnish the engineer or his representative along with and at the time of delivery of the initial shipment of fortified bituminous material to the project, and thereafter with the subsequent shipments when ordered by the engineer, a one quart sealed sample of the bituminous material taken at time of loading at the refinery and prior to introduction of the additive, along with a separate one pint sample of the antistripping additive involved.

8. **Asphalt Cement.**

The asphalt furnished under this contract shall be prepared by the distillation of asphaltic petroleum. It shall be homogeneous and free from water. It shall not have been distilled at a temperature high enough to injure by burning or high enough to produce flecks of carbonaceous matter. It shall meet the requirements of AASHO M 20.

106.04 Inspection at the Plant. The Engineer may undertake the inspection of materials at the source. In the event inspection is undertaken at the plant, the following conditions shall be met:

(a) The Engineer shall have the cooperation and assistance of the Contractor and the producer with whom he has contracted for materials.

(b) The Engineer shall have full entry at all times to such parts of the plant as may concern the manufacture or production of the materials being furnished.

(c) If required by the special provisions the Contractor shall arrange for an approved building for the use of the inspector; such building to be located conveniently near the plant, independent of any building used by the material producer, and conforming to the requirements of subsection 106.05.

106.05. Weighing Devices; Field Laboratory; Bulletin-Board. When the method of measurement requires determination of pay quantities by weighing, the Contractor shall furnish a weigh house and acceptable scales or other weighing devices. Scale platforms shall be of sufficient length to permit simultaneous weighing of all axle loads of each hauling vehicle. Each weighing device shall be accurate within 0.5 percent throughout the range of use, and shall be inspected, tested, and sealed as often as the Engineer may deem necessary to assure continued accuracy. The Engineer may permit the use of weighing devices for a reasonable period prior to sealing, provided field testing indicates consistent compliance with the limits of accuracy specified herein. The Contractor shall have on hand not less than 10 fifty-pound standard weights and shall assist the Engineer

in testing the scales. Public weighing facilities may be used if tested and sealed by the local authority, subject to approval by the Engineer of the weighing procedures.

If provided herein or in the special provisions, the Contractor shall provide a weatherproof building or trailer for use as a field laboratory by the Engineer. The structure shall have adequate work space for required testing operations and be provided with necessary heat, water supply, lighting and any other utilities shown in the special provisions.

The Contractor shall provide and maintain a substantial weatherproof bulletin board at a conspicuous accessible location on the project site until final acceptance of the work. The size and construction shall be suitable for the continuous display and protection from the elements and vandalism of posters and other information as required by the contract.

All devices and structures furnished by the Contractor under this subsection shall remain his property and be removed by him when no longer needed by the Engineer. No direct payment will be made for structures or utilities furnished, but the costs thereof will be considered to be included in pay items of the contract.

106.06 Storage of Materials. Materials shall be so stored as to assure the preservation of their quality and fitness for the work. The equipment and methods used for stockpiling aggregates and for removing the aggregates from the stockpiles shall be such that no detrimental degradation or segregation of the aggregate will result and that no appreciable amount of foreign material will be incorporated into the aggregate and that there will be no intermingling of stockpiled materials. Stockpiles shall be built up in layers of one to five feet in thickness. Stored materials, even though approved before storage, may again be inspected prior to their use in the work. Stored materials shall be located so as to facilitate their prompt inspection. Approved portions of the right-of-way may be used for storage purposes and for the placing of the Contractor's plant and equipment, but any additional space required therefor must be provided by the Contractor at his expense. Private property shall not be used for storage purposes without written permission of the owner or lessee, and if requested by the Engineer copies of such written permission shall be furnished him. All storage sites from which the stored material has been removed shall be restored to their original condition by the Contractor at his expense.

106.07 Handling Materials. All materials shall be handled in such manner as to preserve their quality and fitness for the work. Aggregates shall be transported from the storage site to the work in tight vehicles so constructed as to

prevent loss or segregation of materials after loading and measuring in order that there shall be no inconsistencies in the quantities as actually received at the place of operations.

106.08 Unacceptable Materials. All materials not within reasonably close conformity to the requirements of the specifications at the time tested for acceptance will be considered as unacceptable and all such materials will be rejected in accordance with subsection 105.03 and shall be removed immediately from the site of the work unless the defects are corrected and the material subsequently approved by the Engineer. No rejected material, the defects of which have been corrected, anall be used until approval has been given. See also subsection 105.11.

106.09 Material Furnished by the Government. Any material furnished by the Government will be delivered or made available to the Contractor at the points specified in the special provisions or shown on the plans. The cost of handling and placing all such materials after they are delivered to the Contractor will be considered as included in the contract price for the item in connection with which they are used. The Contractor will be held responsible for all material delivered to him by the Government and deductions will be made from any monies due him to make good any shortages and deficiencies, from any cause whatsoever, and for any damage which may occur after such deliver, and for any demurrage charges.

Section 107.—LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC

107.01 Laws to be Observed. The Contractor shall keep fully informed of all Federal and State laws, all local laws, ordinances, safety codes, regulations and all orders and decrees of bodies or tribunals having any jurisdiction or authority, which in any manner affect those engaged or employed on the work, or which in any way affect the conduct of the work. He shall at all times observe and comply with all such laws, ordinances, safety codes, regulations, orders, and decrees; and shall protect and indemnify the Government and its representatives against any claim or liability arising from or based on the violation of any such law, ordinance safety code, regulation, order, or decree, whether by himself or his employees.

The Contractor shall obtain workmen's compensation insurance in accordance with the benefit amount requirements of the laws of the State in which the work is to be performed.

107.02 Permits and Responsibilities. The following clause of SF23-A applies and shall prevail in event of any conflict in contract provisions:

12. Permits and Responsibilities

The Contractor shall, without additional expense to the government, be responsible for obtaining any necessary licenses and permits, and for complying with any applicable Federal, State, and municipal laws, codes, and regulations, in connection with the prosecution of the work. He shall be similarly responsible for all damages to persons or property that occur as a result of his fault or negligence. He shall take proper safety and health precautions to protect the work, the workers, the public, and the property of others. He shall also be responsible for all materials delivered and work performed until completion and acceptance of the entire construction work, except for any completed unit of construction thereof which theretofore may have been accepted.

107.03 Patented Devices; Materials, and Processes. The following clause of SF23-A applies and shall prevail in event of any conflict in contract provisions:

15. Patent Indemnity

Except as otherwise provided, the Contractor agrees to indemnify the Government and its officers, agents, and employees against liability, including costs and expenses, for infringement upon any Letters Patent of the United States (except Letters Patent issued upon an application which is now or may hereafter be, for reasons of national security, ordered by the Government to be kept secret or otherwise withheld from issue) arising out of the performance of this contract or out of the use or disposal by or for the account of the Government of supplies furnished or construction work performed hereunder.

107.04 Surfaces Opened by Permit. The right to construct or reconstruct any utility service in the highway or street or to grant permits for same, at any time, is hereby expressly reserved by the Government for the proper authorities of the locality in which the work is done and the Contractor will not be entitled to claim any damages, other than time adjustment, for delay due to such permitted work.

Any eligible individual, firm, or corporation wishing to make an opening in the highway must secure a permit from the Government. The Contractor shall allow parties bearing such permits, and only those parties, to make openings in the

highway. When directed by the Engineer, the Contractor shall make in an acceptable manner all necessary repairs due to such openings and such necessary work will be paid for in accordance with subsection 109.04 or as provided in the specifications, and will be subject to the same conditions as original work performed.

107.05 Federal Procurement Regulations. All construction contracts supervised directly by the Bureau of Public Roads are awarded under the Federal Procurement Regulations promulgated by the U.S. General Services Administration.

107.06 Sanitary Provisions. The Contractor shall provide and maintain in a neat, sanitary condition such accommodations for the use of his employees and for the use of government employees when the special provisions do not contain other provisions, to comply with the requirements of the State and local Boards of Health, or of other bodies or tribunals having jurisdiction. No direct payment will be made for the work required by this subsection, but the costs thereof will be considered to be included in bid prices of the contract.

107.07 Public Convenience and Safety. The Contractor shall at all times so conduct his work as to assure the least possible obstruction to traffic. The safety and convenience of the general public and the residents along the highway and the protection of persons and property shall be provided for by the Contractor as specified under subsection 104.04.

Care shall be taken at all times to regulate the operations so as to protect visitors and campers in the National Forest or Park or other Government reservation involved. No road shall be closed by the Contractor to the public except by written permission of the Engineer.

107.08 Railway-Highway Provisions. If the plans require that materials be hauled across the tracks of any railway, the Government will make arrangement with the railway for any new crossings required or for the use of any existing crossings. If the Contractor elects to use crossings other than those shown on the plans, he shall make his own arrangements for the use of such crossings.

All work to be performed by the Contractor in construction on the railroad right-of-way shall be performed at such times and in such manner as not to unnecessarily interfere with the movement of trains or traffic upon the track of the railway company. The Contractor shall use all care and precaution in order to avoid accidents, damage, or unnecessary delay or interference with the railway company's trains or other property.

Railroad liability insurance shall be obtained by the Contractor as provided in the special provisions.

107.09 Bridges over Navigable Waters. All work on navigable waters shall be so conducted that free navigation of the waterways will not be interfered with and that the existing navigable depths will not be impaired except as provided in the special provisions.

107.10 Barricades, Warning Signs and Other Devices. The Contractor shall provide, erect, and maintain all necessary barricades, suitable and sufficient lights, danger signals, signs and other traffic control devices, and shall take all necessary precautions for the protection of the work and safety of the public. Highways closed to traffic shall be protected by effective barricades, and obstructions shall be illuminated during the hours of darkness. Suitable warning signs shall be provided to properly control and direct traffic.

The Contractor shall erect warning signs in advance of any place on the project where operations may interfere with the use of the road by traffic, and at all intermediate points where the new work crosses or coincides with an existing road. All barricades, warning signs, lights, temporary signals, flagmen and pilotcar operators and equipment, and other protective devices except for special devices, whenever required under subsection 107.09, shall conform with Part V of the Manual on Uniform Traffic Control Devices for Streets and Highways, published by the Bureau of Public Roads.

The Contractor shall furnish, erect, maintain, and remove, when directed, any informational identification signs shown on the plans.

Warning signs shall be posted, wherever directed, during blasting operations.

No direct payment will be made for the work required by this subsection, but the costs thereof will be considered to be included in bid prices of the contract, except as provided in 104.04(c).

107.11 Use of Explosives. When the use of explosives is necessary for the prosecution of the work, the Contractor shall exercise the utmost care not to endanger life or property, including new work. The Contractor shall be liable for all damage resulting from the use of explosives.

Excavation of rock by use of explosives shall be done in such a manner as will result in a minimum of breakage outside the neat lines of the typical cross section as staked by the Engineer.

When specified in the special provisions, all materials to be excavated by blasting shall be line drilled or presplit on the slope line the full depth of the cut or as directed by the Engineer.

107.12 Protection and Restoration of Property and Landscape. The Contractor shall be responsible for the preservation of all public and private property and shall protect carefully from disturbance or damage all land monuments and property marks until the Engineer has witnessed or otherwise referenced their location and shall not move them until directed.

When the Contractor's operations encounter remains of prehistoric people's dwelling sites or artifacts of historical or archeological significance, the operations shall be temporarily discontinued. The Engineer will determine the disposition thereof. When directed by the Engineer, the Contractor shall excavate the site in such a manner as to preserve the artifacts encountered and shall remove them for delivery to the custody of the proper authorities. Such excavation will be considered and paid for by agreed prices or force account.

The Contractor shall take every precaution to prevent damage and shall be liable for all damage or injury to property of any character, during the prosecution of the work, resulting from any act, omission, neglect, or misconduct in his manner or method of executing the work, or at any time due to defective work or materials, and said liability will not be released until the project shall have been completed and accepted.

The Contractor shall schedule and conduct his operations to minimize erosion of soils and to prevent silting and muddying of streams, rivers, irrigation systems and impoundments (lakes, reservoirs, etc.). Construction of drainage facilities and performance of other contract work which will contribute to the control of erosion and sedimentation shall be carried out in conjunction with earthwork operations or as soon thereafter as practicable. The area of bare soil exposed at any one time by construction operations shall be kept to a minimum.

Prior to suspension of construction operations for appreciable lengths of time the Contractor shall shape the earthwork in a manner that will permit storm runoff with a minimum of erosion. Temporary erosion and sediment control measures such as berms, dikes, slope drains, or sedimentation basins deemed necessary by the engineer shall be provided and maintained until permanent drainage facilities and erosion control features are completed and operative. Unless otherwise provided for in the contract, temporary erosion control measures will not be paid for directly, but will be considered as a subsidiary obligation of the contractor covered under the various contract items of work.

Pollutants such as fuels, lubricants, bitumens, raw sewage

and other harmful materials shall not be discharged into or near rivers, streams, and impoundments or into natural or manmade channels leading thereto. Wash water or waste from concrete mixing operations shall not be allowed to enter live streams.

When or where any direct or indirect damage or injury is done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the work, or in consequence of the nonexecution thereof by the Contractor, he shall restore, at his own expense, such property to a condition similar or equal to that existing before such damage or injury was done, by repairing, rebuilding, or otherwise restoring as may be directed, or he shall make good such damage or injury in an acceptable manner.

107.13 Forest, Park, and Public Lands Protection. In carrying out work within or adjacent to State or National Forests or Parks or other Public Lands the Contractor shall comply with all regulations of the State Fire Marshal, Conservation Commission, Forest Service, National Park Service, or other authority having jurisdiction, governing the protection of Forests, or Parks and the carrying out of work within Forests or Parks and shall observe all sanitary laws and regulations with respect to the performance of work in such reservations. He shall keep the areas in an orderly condition, dispose of all refuse, obtain permits for the construction and maintenance of all construction camps, stores, warehouses, residences, latrines, cesspools, septic tanks, and other structures in accordance with the requirements of the Forest, or Park Supervisor.

Fire protection shall be given particular attention, as follows:

(a) *Fire regulations.*—The Contractor shall abide by such rules and instructions as to fire prevention and control and as to the time and place for burning as the Forest Service, National Park Service, State, or other public agency having jurisdiction may prescribe. The Contractor shall take all necessary steps to prevent his employees from setting fires not required in the construction of the project, shall be responsible for preventing the escape of fires set in connection with the construction of the project, and shall extinguish any and all fires that may escape.

The Contractor shall at all times during the period of contract operations maintain satisfactory spark arresters on all steam engines, internal combustion engines, and on all flues used in his operations and in construction camps and shall maintain a fire patrol in the vicinity of operations creating a fire hazard.

(b) *Fire guard.*—When required by the special provisions,

the Contractor shall employ a trained fire guard who is acceptable to the Engineer. Such fire guard shall carry out all instructions received from the Engineer and shall be charged with the responsibility of enforcing regulations and stipulations of the Forest Service, National Park Services, or other public agency concerned. The fire guard shall obtain such regulations and stipulations directly from the Engineer. He shall be charged with the responsibility of protecting from fires the area affected by the operations of the Contractor and shall see that the Contractor and his employees comply with all regulations and stipulations dealing with fire protection.

The fire guard shall be provided with suitable transportation for his exclusive use.

(c) *Fire-fighting equipment required.* The Contractor shall, at his expense, furnish and maintain at the site of work at all times such fire-fighting equipment and tools as are required by the agency having jurisdiction.

(d) *Regulations for burning.* Before starting any burning operations, the Contractor shall notify the agency having jurisdiction. During burning operations, special care shall be taken to prevent scorching or causing any damage to adjacent trees and shrubbery. Piles of material to be burned shall be of such size and so placed that during burning no damage shall result to adjacent objects. The decision as to the maximum safe size of such piles will rest with the appropriate officer of the agency having jurisdiction, and instructions regarding same will be given to the Contractor through the Engineer.

Burning shall be suspended when so ordered by the agency having jurisdiction and burning embers shall not be left unattended.

(e) *Contractor's responsibility in fighting own fires*—The Contractor, under the direction of the appropriate Federal agency, or, in the absence of an officer from any such agency, acting independently, shall extinguish without expense to the Government all fires on or in the vicinity of the project set or caused by him or his employees whether set directly or indirectly as a result of construction operations. The Contractor may be held liable for all damages resulting from fires set or caused by his employees or resulting from his construction operations.

Where the Contractor is obligated to suppress any fire without expense to the Government under the provisions of this section, if the amount and character of labor, subsistence supplies, and transportation which the Contractor is in a position to furnish promptly for fire suppression prove inadequate for that purpose, in the judgment of the Federal

agency or other person or body responsible for fire suppression in the area, then the appropriate officer of such agency is authorized to procure and to charge to the Contractor such additional labor, subsistence supplies, and use of transportation facilities as he may deem necessary for the suppression of the fire.

(f) *Contractor's forces used to fight other fires.* When requested by the Federal agency having local authority, the Contractor shall make his forces temporarily available for fighting fires, in the vicinity of the project, other than those described in subsection 107.13(e). It is understood that payment for such services will be made by the Federal agency making the request, at rates not less than those established by that agency for the area concerned. Firefighting will be directed by the requesting agency. All claims for injury not covered by workmen's compensation insurance, or other damages in connection with such firefighting shall be directed to the Federal agency which made the request for assistance.

107.14 Responsibility for Damage Claims. The Contractor shall indemnify and save harmless the Government, its officers and employees, from all suits, actions, or claims of any character brought because of any injuries or damage received or sustained by any person, persons, or property on account of the operations of the said Contractor; or on account of or in consequence of any neglect in safeguarding the work; or through the use of unacceptable materials in constructing the work; or because of any act or omission, neglect, or misconduct of said Contractor; or because of any claims or amounts recovered from any infringements of patent, trademark, or copyright; or from any claims or amounts arising or recovered under the "Workmen's Compensation Act", or any other law, ordinance, order, or decree. So much of the money due the said Contractor under and by virtue of his contract as may be considered necessary by the Government for such purpose may be retained for the use of the Government. In c[illegible] no money is due, his surety may be held until such suit or suits, action or actions, claim or claims for injuries or damages as aforesaid shall have been settled and suitable evidence to that effect furnished to the Government except that money due the Contractor will not be withheld when the Contractor produces satisfactory evidence that he is adequately protected by public liability and property damage insurance.

107.15 Opening Sections of Project to Traffic. Opening of sections of the work to traffic prior to completion of the entire contract may be desirable from a traffic service standpoint, or may be necessary due to conditions inherent in the

work, or by changes in the contractor's work schedule, and may be necessary due to conditions or events unforeseen at the time of the contract. Such openings as may be necessary due to any of the foregoing conditions shall be made when so ordered by the Engineer. Under no condition shall such openings constitute acceptance of the work or a part thereof, or a waiver of any provisions of the contract.

Special Provisions shall state, insofar as possible, which sections shall be opened prior to completion of the contract. On any section opened by order of the Engineer, whether covered in the Special Provisions or not, the contractor shall not be required to assume any expense entailed in maintaining the road for traffic. Such expense shall be borne by the Department, or compensated for in a manner provided hereinafter in Subsection 109.04. On such portions of the project which are ordered by the Engineer to be opened for traffic, in the case of unforeseen necessity which is not the fault of the contractor, compensation for additional expense, if any, to the contractor and allowance of additional time, if any, for completion of any other items of work on the portions of the project ordered by the Engineer to be opened in the event of such unforeseen necessity, shall be as set forth in a change order mutually agreed on by the Engineer and the contractor as set forth hereinafter.

If the contractor is dilatory in completing shoulders, drainage structures, or other features of the work, the Engineer may so notify him in writing and establish therein a reasonable period of time in which the work should be completed. If the contractor is dilatory, or fails to make a reasonable effort toward completion in this period of time, the Engineer may then order all or a portion of the project opened to traffic. On such sections which are so ordered to be opened, the contractor shall conduct the remainder of his construction operations so as to cause the least obstruction to traffic and shall not receive any added compensation due to the added cost of the work by reason of opening such section to traffic.

On any section opened to traffic under any of the above conditions, whether stated in the Special Provisions or opened by necessity of contractor's operations, or unforeseen necessity, any damage to the highway not attributable to traffic which might occur on such section (except slides) shall be repaired by the contractor at his expense. The removal of slides shall be done by the contractor on a basis agreed to prior to the removal of such slides. The removal of unavoidable slides shall be done by the Contractor as provided in subsection 109.04.

107.16 Contractor's Responsibility for Work. Until final written acceptance of the project by the Engineer except as provided in subsections 105.16 and 107.15, the Contractor shall have the charge and care thereof and shall take every precaution against injury or damage to any part thereof by the action of the elements or from any other cause, whether arising from the execution or from the nonexecution of the work. The Contractor shall rebuild, repair, restore, and make good all injuries or damages to any portion of the work occasioned by any of the above causes before final acceptance and shall bear the expense thereof except damage to the work due to unforeseeable causes beyond the control of and without the fault or negligence of the Contractor including but not restricted to acts of God of the public enemy or governmental authorities.

In case of suspension of work from any cause whatever, the Contractor shall be responsible for the project and shall take such precautions as may be necessary to prevent damage to the project, provide for normal drainage and shall erect any necessary temporary structures, signs, or other facilities at his expense. During such period of suspension of work, the Contractor shall properly and continuously maintain in an acceptable growing condition all living material in newly established plantings, seedings, and soddings furnished under his contract and shall take adequate precautions to protect new tree growth and other vegetative growth against injury. See also subsection 107.02.

107.17 Contractor's Responsibility for Utilities. At points where the Contractor's operations are adjacent to properties of railway, telegraph, telephone, and power companies, or are adjacent to other property, damage to which might result in considerable expense, loss, or inconvenience, work shall not be commenced until all arrangements necessary for the protection thereof have been made.

The Contractor shall cooperate with the owners of any underground or overhead utility lines in their removal and rearrangement operations in order that these operations may progress in a reasonable manner, that duplication of rearrangement work may be reduced to a minimum, and that services rendered by those parties will not be unnecessarily interrupted.

In the event of interruption to water or utility services as a result of accidental breakage or as a result of being exposed or unsupported, the Contractor shall promptly notify the proper authority and shall cooperate with the said authority in the restoration of service. If water service is interrupted repair work shall be continuous until the service is restored. No work shall be undertaken around fire

hydrants until provisions for continued service have been approved by the local fire authority.

Any unavoidable damage caused without negligence by the Contractor to underground utilities not shown on the plans shall be repaired, if so directed by the Engineer, and payment will be made in accordance with subsection 109.04.

107.18 Furnishing Right-Of-Way. The Government will be responsible for obtaining all necessary rights-of-way in advance of construction. Any exceptions will be indicated in the contract.

107.19 Personal Liability of Public Officials. In carrying out any of the provisions of these specifications, or in exercising any power or authority granted to them by or within the scope of the contract, there shall be no liability upon the Contracting Officer, Engineer, or their authorized representatives, either personally or as officials of the Government; it being understood that in all such matters they act solely as agents and representatives of the Government.

107.20 Construction Safety Requirements. The manual entitled "Construction Safety Requirements," Federal Highway Projects, is a part of these specifications. The contractor shall also provide all safeguards, safety devices and protective equipment and take any other action on his own responsibility or as the contracting officer may determine reasonably necessary to protect the life and health of employees and of the public.

Should conflicts in the provisions of the Safety Manual and provisions of a rule or regulation of a State or local safety code occur, that provision which defines the higher safety standard shall govern.

107.21 Third Party Beneficiary Claims. It is specifically agreed between the parties executing this contract that it is not intended by any of the provisions of any part of the contract to create the public or any member thereof a third party beneficiary hereunder, or to authorize anyone not a party to this contract to maintain a suit for personal injuries or property damage pursuant to the terms or provisions of this contract.

Section 108.—PROSECUTION AND PROGRESS

108.01 Subcontracting. The Contractor shall not subcontract, sublet, sell, transfer, assign or otherwise dispose of

any portion of the contract work without written consent of the Engineer. Before consent is given to subcontract any work, the Contractor, if requested by the Engineer, shall present evidence that the proposed subcontractor is fully qualified to do the work. In case such consent is given, the Contractor will be permitted to subcontract a portion thereof, but shall perform with his own organization, work amounting to not less than 50 per cent of the original contract amount, except that any items designated in the contract as "speciality items" may be performed by subcontract and the cost of any such specialty items so performed by subcontract may be deducted from the original contract amount before computing the amount of work required to be performed by the Contractor with his own organization. No subcontracts shall in any case release the Contractor of his liability under the contract and bonds.

No subcontract, approval of a subcontract, or any other action shall create any contractural relation between subcontractors and the Government. The contractor shall be liable and responsible for any action or lack of action of a subcontractor. Contractors and subcontractors shall be charged with all direct, imputed or presumed knowledge the others might possess. As used throughout this contract a subcontractor shall mean a subcontractor in any tier.

108.02 Notice to Proceed. The "Notice to Proceed" will be issued by the Contracting Officer in accordance with the provisions stipulated in the Bid Form.

108.03 Prosecution and Progress. After the contract has been executed and before issuance of the notice to proceed with the work, the Engineer will designate a time and place for a preconstruction conference with the Contractor.

At the conference, the Contractor shall furnish the Engineer with a "Progress Schedule" for his approval. If required in the special provisions, the progress schedule shall be prepared on the basis of an accepted critical path method of scheduling. The progress schedule may be used as the basis for establishing major construction operations and as a check on the progress of the work. The Contractor shall provide sufficient materials, equipment, and labor to guarantee the completion of the project in accordance with the plans and specifications within the time set forth in the proposal.

If the contractor falls significantly behind the submitted schedule, the Contractor shall:

(a) Submit a revised schedule for completion of the work within the contract time.

(b) Modify his operation to provide such additional materials, equipment, and labor necessary to meet the revised time estimates.

Should the prosecution of the work for any reason be discontinued, the Contractor shall notify the Engineer at least 24 hours in advance of resuming operations.

108.04 Limitation of Operations. The Contractor shall conduct the work at all times in such a manner and in such sequence as will assure the least interference with traffic. He shall have the due regard to the location of detours and to the provisions for handling traffic. He shall not open up work to the prejudice or detriment of work already started. The Engineer may require the Contractor to finish a section on which work is in progress before work is started on any additional sections if the opening of such section is essential to public convenience.

108.05 Character of Workmen; Methods and Equipment. The Contractor shall at all times employ sufficient supervision, labor and equipment for prosecuting the several classes of work to full completion in the manner and time required by these specifications.

All workmen shall have sufficient skill and experience to perform properly the work assigned to them. Workmen engaged in special work or skilled work shall have sufficient experience in such work and in the operation of the equipment required to perform all work properly and satisfactorily.

Should the Contractor fail to remove such person or persons as required in subsection 102.14 or fail to furnish suitable and sufficient personnel and equipment for the proper prosecution of the work, the Engineer may suspend the work by written notice until such orders are complied with.

All equipment which is used on the work shall be of sufficient size and in such mechanical condition as to meet requirements of the work and to produce a satisfactory quality of work. Equipment used on any portion of the project shall be such that no injury to the roadway, adjacent property, or other highways will result from its use.

When the methods and equipment to be used by the Contractor in accomplishing the construction are not prescribed in the contract the Contractor is free to use any methods or equipment that he demonstrates to the satisfaction of the Engineer will accomplish the contract work in conformity with the requirements of the contract.

When the contract specifies that the construction be performed by the use of certain methods and equipment, such methods and equipment shall be used unless others are authorized by the Engineer. If the Contractor desires to use a method or type of equipment other than those specified in the contract, he may request authority from the Engineer to do so. The request shall be in writing and shall include a

full description of the methods and equipment proposed to be used and an explanation of the reasons for desiring to make the change. If approval is given, it will be on the condition that the Contractor will be fully responsible for producing construction work in conformity with contract requirements. If, after trial use of the substituted methods or equipment, the Engineer determines that the work produced does not meet contract requirements, the Contractor shall discontinue the use of the substitute method or equipment and shall complete the remaining construction with the specified methods and equipment. The Contractor shall remove the deficient work and replace it with work of specified quality, or take such other corrective action as the Engineer may direct. No change will be made in basis of payment for the construction items involved nor in contract time as a result of authorizing a change in methods or equipment under these provisions.

See also subsection 102.14.

108.06 Determination and Extension of Contract Time. The number of days allowed for the completion of the work included in the contract will be stated in the proposal and contract, and will be known as the "Contract Time."

When the contract time is on a working day basis, the Engineer will furnish the Contractor a weekly statement showing the number of days charged to the contract for the preceding week and the number of days specified for completion of the contract. The Contractor will be allowed one week in which to file a written protest setting forth in what respect said weekly statement is incorrect, otherwise the statement shall be deemed to have been accepted by the Contractor as correct.

When the contract time is on a calendar day basis it shall consist of the number of calendar days stated in the contract counting from the effective date of the Engineer's order to commence work, including all Sundays, holidays and non-work days. All calendar days elapsing between the effective dates of any orders of the Engineer to suspend work and to resume work for suspensions not the fault of the Contractor shall be excluded.

When the contract completion time is a fixed calendar date it shall be the date on which all work on the project shall be substantially completed.

The number of days for performance allowed in the contract as awarded is based on the original quantities as defined in subsection 102.04. If satisfactory fulfillment of the contract requires performance of work in greater quantities than those set forth in the proposal, the contract time allowed for

performance shall be increased on a basis commensurate with the amount and difficulty of the added work.

If the Contractor finds it impossible for reasons beyond his control to complete the work within the contract time as specified or as extended in accordance with the provisions of this subsection, he may, at any time prior to the expiration of the contract time as extended, make a written request to the Engineer for an extension of time setting forth therein the reasons which he believes will justify the granting of his request. The Contractor's plea that insufficient time was specified is not a valid reason for extension of time. If the Engineer finds that the work was delayed because of conditions beyond the control and without the fault of the Contractor, he may extend the time for completion in such amount as the conditions justify. The extended time for completion shall then be in full force and effect the same as though it were the original time for completion.

When the work is completed or accepted the daily time charge will cease.

108.07 Failure to Complete Work Within Contract Time. Pursuant to the general provisions of the contract, liquidated damages will be charged for each calendar day of delay until the work is completed. The total amount of such liquidated damages will be calculated from the daily charges given in the following table.

Daily charge for liquidated damages for each calendar day of delay

Original contract price		Daily charge
From more than	To and including	
0	25,000	$50
$25,000	50,000	100
50,000	100,000	150
100,000	500,000	250
500,000	1,000,000	350
1,000,000	2,000,000	400
2,000,000		500

108.08 Termination for Default—Damages For Delay—Time Extensions. The following clause of SF-23A applies and shall prevail in event of any conflict in contract provisions.

5. Termination for Default-Damages for Delay—Time Extensions:

(a) *If the Contractor refuses or fails to prosecute the work, or any separable part thereof, with such diligence as will insure its completion within the time specified in the contract, or any extension thereof, or fails to complete said work within such time, the Government may, be*

written notice to the Contractor, terminate his right to proceed with the work or such part of the work as to which there has been delay. In such event the Government may take over the work and prosecute the same to completion, by contract or otherwise, and may take possession of and utilize in completing the work such materials, appliances, and plant as may be on the site of the work and necessary therefor. Whether or not the Contractor's right to proceed with the work is terminated, he and his sureties shall be liable for any damage to the Government resulting from his refusal or failure to complete the work within the specified time.

(b) If fixed and agreed liquidated damages are provided in the contract and if the Government so terminates the Contractor's right to proceed, the resulting damage will consist of such liquidated damages until such reasonable time as may be required for final completion of the work together with any increased costs occasioned the Government in completing the work.

(c) If fixed and agreed liquidated damages are provided in the contract and if the Government does not so terminate the Contractor's right to proceed, the resulting damage will consist of such liquidated damages until the work is completed or accepted.

(d) The Contractor's right to proceed shall not be so terminated nor the Contractor charged with resulting damage if:

(1) The delay in the completion of the work arises from unforeseeable causes beyond the control and without the fault or negligence of the Contractor, including but not restricted to, acts of God, acts of the public enemy, acts of the Government in either its sovereign or contractual capacity, acts of another contractor in the performance of a contract with the Government, fires, floods, epidemics, quarantine restrictions, strikes, freight embargoes, unusually severe weather, or delays of subcontractors or suppliers arising from unforeseeable causes beyond the control and without the fault or negligence of both the Contractor and such subcontractor or suppliers; and

(2) The Contractor, within 10 days from the beginning of any such delay (unless the Contracting Officer grants a further period of time before the date of final payment under the contract), notifies the Contracting Officer in writing of the causes of delay.

The Contracting Officer shall ascertain the facts and the extent of the delay and extend the time for completing the work when, in his judgment, the findings of fact justify such an extension, and his findings of fact shall be final and conclusive on the parties, subject only to appeal as provided in these general provisions.

(e) If, after notice of termination of the Contractor's right to proceed under the provisions of this clause it is determined for any reason that the Contractor was not in default under the provisions of this clause or that the delay was excusable under the provisions of this clause the rights and obligations of the parties shall, if the contract contains a clause providing for termination for convenience of the Government, be the same as if the notice of termination had been issued pursuant to such clause. If, in the foregoing circumstances, the contract does not contain a clause providing for termination for convenience of the Government, the contract shall be equitably adjusted to compensate for such termination and the contract modified accordingly; failure to agree to any such adjustment shall be a dispute concerning a question of fact within the meaning of the clause of this contract entitled "Disputes".

(f) The rights and remedies of the Government provided in this clause are in addition to any other rights and remedies provided by law or under the contract.

108.09 Suspension of Work. The following clause of SF-23A applies and shall prevail in event of any conflict in contract provisions:

SUSPENSION OF WORK

(a) The Contracting Officer may order the Contractor in writing to suspend, delay, or interrupt all or any part of the work for such period of time as he may determine to be appropriate for the convenience of the Government.

(b) If the performance of all or any part of the work is, for an unreasonable period of time, suspended, delayed, or interrupted by an act of the Contracting Officer in the administration of this contract, or by his failure to act within the time specified in this contract (or if no time is specified, within a reasonable time), and adjustment shall be made for any increase in the cost of performance of this contract (excluding profit) necessarily caused by such unreasonable suspension, delay, or interruption and the contract modified in writing accordingly. However, no adjustment shall be made under this clause for any suspension, delay, or interruption to the extent (1) that performance would have been so suspended, delayed, or interrupted by any other cause, including the fault or negligence of the Contractor or (2) for which an equitable

adjustment is provided for or excluded under any other provision of the contract.

(c) No claim under this clause shall be allowed (1) for any costs incurred more than 20 days before the Contractor shall have notified the Contracting Officer in writing of the act or failure to act involved (but this requirement shall not apply as to a claim resulting from a suspension order), and (2) unless the claim, in an amount stated, is asserted in writing as soon as practicable after the termination of such suspension, delay, or interruption, but not later than the date of final payment under the contract.

See also subsection 105.01.

108.10 Final Settlement of Contract. The contract will be considered complete when all work has been completed and accepted in accordance with the provisions of subsection 105.16. The date of approval by the Government of the final voucher for payment will constitute the date of final settlement of the contract. This action will not preclude consideration of any claim which the Contractor, by appropriate statement on the final voucher, has reserved the right to submit in connection with the contract.

Section 109.—MEASUREMENT AND PAYMENT

109.01 Measurement of Quantities. All work completed under the contract will be measured by the Engineer according to the United States standard measure.

A station when used as a definition or term of measurement will be 100 linear feet.

The methods of measurement and computation to be used in the determination of quantities of materials furnished and work performed under the contract will be those generally recognized as conforming to good engineering practice chosen by the Engineer.

Plan Quantity

(a) When the contract specifies payment of an item or of a portion of an item on a plan quantity basis, the quantities for payment will be those shown on the plans with deductions from or additions to such quantities resulting from authorized deviations from the plans.

(b) If Contractor believes that a quantity which is specified for payment on a plan quantity basis is incorrect, he

may request the Government in writing to check the questionable quantity. The request shall be accompanied by calculations, drawings, or other evidence indicating why the plan quantity is believed to be in error. If the quantity is found to be in error, payment will be made in accordance with the corrected plan quantity.

Unless otherwise specified herein or on the plans for individual construction items longitudinal measurements for area computations will be made horizontally, and no deductions will be made for individual fixtures having an area of 9 square feet or less. Unless otherwise specified, transverse measurements for area computations will be the neat dimensions shown on the plans or ordered in writing by the Engineer.

Structures will be measured according to neat lines shown on the plans or as directed to fit field conditions.

All items which are measured by the linear foot, such as pipe culverts, guardrail, underdrains, etc., will be measured parallel to the base or foundation upon which such structures are placed, unless otherwise shown on the plans.

In computing volumes of excavation the average end area method or other acceptable methods designated in the special provisions will be used.

The term "gage" when used in connection with the measurement of plates, will mean the U.S. Standard Gage, except that when reference is made to the measurements of metal sheets used in the manufacture of corrugated metal pipe, metal plate culverts and arches, and metal cribbing, then the term "gage" or thickness will mean that specified in AASHO M36, M167, M196, M197 or M219, as applicable.

When the term "gage" refers to the measurement of wire, it will mean the wire gage specified in AASHO M32.

The term "ton" will mean the short ton consisting of 2,000 pounds avoirdupois. All materials which are measured or proportioned by weight shall be weighed on accurate approved scales or other weighing device by competent, qualified personnel at locations designated by the Engineer. If material is shipped by rail, the car weight may be accepted provided that only the actual weight of material be paid for. However, car weights will not be acceptable for material to be passed through mixing plants. Trucks used to haul material being paid for by weight shall be weighed empty at least once daily unless otherwise specified and at such times as the Engineer directs, and each truck shall bear a plainly legible identification mark.

Materials to be measured by volume in the hauling vehicle shall be hauled in approved vehicles and measured therein

at the point of delivery. Vehicles for this purpose may be of any size or type acceptable to the Engineer, provided that the body is of such shape that the actual contents may be readily and accurately determined. All vehicles shall be loaded to at least their water level capacity and any designated loads shall be leveled when the vehicles arrive at the point of delivery, if so directed by the inspector.

If mutually agreed by the Contractor and the Engineer in writing, material specified to be measured by the cubic yard may be weighed and such weights will be converted to cubic yards for payment purposes. Factors for conversion from weight measurement to volume measurement will be determined by the Engineer and shall be agreed to by the Contractor before such method of measurement of pay quantities is used.

When aggregates are weighed for payment determination, the moisture content will be paid for unless otherwise provided for in the special provisions. If moisture determination is required, the daily average moisture content will be determined by heat drying not less than three representative samples of aggregate taken at random intervals from each 8 hours production.

Bituminous materials will be measured by the gallon or ton as shown in the bid schedule.

Volumes will be measured at 60°F. or will be corrected to the volume at 60°F. using ASTM D 1250 for asphalts or ASTM D 633 for tars; except the quantity of emulsified asphalt will be determined by measuring the emulsified asphalt at a temperature of 60°F. or by converting the gallonage measured at another temperature to gallonage at 60°F., by means of the following formula:

$$\text{Gallons at } 60^\circ\text{F.} = \frac{\text{Gallons at } A^\circ\text{F.}}{1 + 0.00025\,(A^\circ\text{F.} - 60^\circ\text{F.})}$$

in which A°F. is the temperature of the material at the time the gallonage is measured.

Net certified scale weights or weights based on certified volumes in the case of rail shipments will be used as a basis of measurement, subject to correction when bituminous material has been lost from the car or the distributor, wasted, or otherwise not incorporated in the work.

When bituminous materials are shipped by truck or transport, net certified weights or volume subject to correction for loss or foaming may be used for computing quantities.

Cement will be measured by the barrel. The term "barrel" will mean 376 pounds of cement.

Timber will be measured by the thousand feet board

measure (M.F.B.M.) actually incorporated in the structure. Measurement will be based on nominal widths and thicknesses and the extreme usable length of each piece.

The term "lump sum" when used as an item of payment will mean complete payment for such work described in the contract.

When a complete structure or structural unit (in effect, "lump sum" work) is specified as the unit of measurement, the unit will be construed to include all necessary fittings and accessories.

When standard manufactured items are specified such as fence, wire, plates, rolled shapes, pipe conduits, etc., and these items are identified by gage, unit weight, section dimensions, etc., such identification will be considered to be nominal weights or dimensions. Unless more stringently controlled by tolerances in cited specifications, manufacturing tolerances established by the industries involved will be accepted.

109.02 Scope of Payment. Except as otherwise provided in the contract, the Contractor shall receive and accept compensation provided for pay items in the contract as full payment for furnishing all materials and for performing all work under the contract in a complete and acceptable manner and for all risk, loss, damage, or expense of whatever character arising out of the nature of the work or the prosecution thereof.

If the "Basis of Payment" clause in the specifications relating to any pay item in the contract requires that the contract unit price cover and be considered compensation for certain work or material essential to the item, this same work or material will not also be measured or paid for under any other pay item which may appear elsewhere in the specifications.

109.03 Compensation for Altered Quantities. When the accepted quantities of work vary from the quantities in the bid schedule, the Contractor shall accept as payment in full, so far as minor contract items are concerned, payment at the original contract unit prices for the accepted quantities of work done. No allowance except as provided in subsection 104.02 will be made for any increased expense, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the Contractor resulting either directly from such alterations or indirectly from unbalanced allocation among the contract items of overhead expense on the part of the bidder and subsequent loss of expected reimbursements therefor or from any other cause.

For variations in accepted quantities of major items, in accordance with subsection 104.02 the prices agreed upon and any agreed adjustment in contract time will be incorpor-

ated in the written order issued by the Engineer, which will be so written as to indicate acceptance on the part of the Contractor as evidenced by his signature. If prices cannot be agreed upon or agreement cannot be reached to perform work as provided in subsection 104.02, the Engineer may direct work to be performed in accordance with subsection 109.04.

109.04 Force Account Work. This work will be paid for at the unit prices or lump sum stipulated in the order authorizing the work, or the Government may require the Contractor to do such work on a force account basis to be compensated in the following manner:

(a) Labor.—For all labor and foremen employed on the specific operations, the Contractor will receive the rate of wage (or scale) agreed upon in writing before beginning work, for each and every hour that said labor and foremen are actually engaged in such work and paid therefor. Agreed wage rates will not be in excess of the rates paid for comparable work on the project.

The Contractor will receive compensation for his costs of payroll tax levies, insurance premiums, and employment benefits generally applicable to his employees, in proportion to the wages paid above. If a fixed percentage is stated in the special provisions the amount of such compensation will be the product of the fixed percentage and the actual cost of wages paid above. If no fixed percentage is stated in the special provisions, compensation will be the actual amount paid by the Contractor for these items. In addition he will receive an amount equal to 20 percent of the compensation as determined and paid for by one of the methods herein.

(b) Materials.—For materials accepted by the Engineer and used, the Contractor will receive the actual cost of such materials delivered on the work including transportation charges paid by him(exclusive of machinery rentals as hereinafter set forth), to which cost 15 percent will be added.

(c) Equipment.—For any machinery or special equipment (other than small tools), the use of which has been authorized by the Engineer, the contractor will be paid the rental rates agreed upon in writing before starting such work, except when the equipment rental rates to be paid are stated in the special provisions. Payment will be made for the actual number of hours that the equipment is in operation on the work and will include fuel and lubricants.

Transportation charges for each piece of equipment to and from the site of the work will be paid provided, (1) the equipment is obtained from the nearest approved source, (2) the return charges do not exceed the delivery charges,

(3) haul rates do not exceed the established rates of licensed haulers, and (4) such charges are restricted to those units of equipment not already available and on or near the project.

Whenever equipment has been ordered held on the job on a standby basis by the Engineer, half-time rates for the equipment will be paid for such standby time during normal working hours.

All equipment used will be presumed to be in good operating condition. No percentage shall be added to equipment rental rates, and no additional compensation will be made for repairs.

(d) *Miscellaneous.*—No additional allowance will be made for general superintendence, the use of small tools, or other costs for which no specific allowance is herein provided.

(e) *Records.*—The Contractor's representative and the Engineer shall compare records of the cost of work done each day as ordered on a force account basis. Copies of these records shall be made upon suitable forms provided by the Engineer for this purpose and signed by both the Engineer and the Contractor's representative, one copy being retained by each party.

(f) *Statements.*—No payment will be made for work performed on a force account basis until the signed records required in (e), detailed as follows have been prepared:

(1) Name, classification, date, daily hours, total hours, rate, and extension for each laborer and foreman.

(2) Designation, dates, daily hours, total hours, rental rate, and extension for each unit of machinery and equipment.

(3) Quantities of materials, prices, and extensions.

(4) Transportation of materials.

(5) Cost of payroll tax levies, insurance premiums, and employee benefits, if no fixed percentage appears in the special provisions.

Statements shall be accompanied and supported by receipted invoices for all materials used and transportation charges. However, if materials used on the force account work are not specifically purchased for such work but are taken from the contractor's stock, then in lieu of the invoices the Contractor shall furnish an affidavit certifying that such materials were taken from his stock, that the quantity claimed was actually used, and that the price and transportation claimed represent the actual cost to the Contractor.

(g) *Payment.*—Payment for authorized work done under this subsection will be made with the regular progress payments. The amounts to be paid will be based on the signed

daily records of work performed and the Contractor's statements of costs as required by (e) and (f) above.

109.05. Eliminated Items. Should any items contained in the contract be found unnecessary for the proper completion of the work, the Engineer may, upon written order to the Contractor, eliminate such items from the contract, and such action shall in no way invalidate the contract. When a Contractor is notified of the elimination of items he will be reimbursed by change order for actual work done, and all costs incurred, including mobilization of materials prior to said notification, but no allowance for profit or overhead expense will be made. No deduction from the contract time will be made for elimination of pay items.

109.06 Partial Payments. The following clause of SF-23A applies and shall prevail in event of any conflict in contract provisions:

7. Payments to Contractor

(a) *The Government will pay the contract price as hereinafter provided.*

(b) *The Government will make progress payments monthly as the work proceeds, or at more frequent intervals as determined by the Contracting Officer, on estimates approved by the Contracting Officer. If requested by the Contracting Officer, the Contractor shall furnish a breakdown of the total contract price showing the amount included therein for each principal category of the work, in such detail as requested, to provide a basis for determining progress payments. In the preparation of estimates the Contracting Officer, at his discretion, may authorize material delivered on the site and preparatory work done to be taken into consideration. Material delivered to the Contractor at locations other than the site may also be taken into consideration (1) if such consideration is specifically authorized by the contract and (2) if the Contractor furnishes satisfactory evidence that he has acquired title to such material and that it will be utilized on the work covered by this contract.*

(c) *In making such progress payments, there shall be retained 10 percent of the estimated amount until final completion and acceptance of the contract work. However, if the Contracting Officer, at any time after 50 percent of the work has been completed, finds that satisfactory progress is being made, he may authorize any of the remaining progress payments to be made in full. Also, whenever the work is substantially complete the Contracting Officer, if he considers the amount retained to be in excess of the amount adequate for the protection of the Government, at his discretion, may release to the Contractor all or a portion of such excess amount. Futhermore on completion and acceptance of each separate building, public work, or other division of the contract, on which the price is stated separately in the contract, payment may be made therefor without retention of a percentage.*

(d) *All material and work covered by progress payments made shall thereupon become the sole property of the Government, but this provision shall not be construed as relieving the Contractor from the sole responsibility for all material and work upon which payments have been made or the restoration of any damaged work, or as waiving the right of the Government to require the fulfillment of all of the terms of the contract.*

(e) *Upon completion and acceptance of all work, the amount due the Contractor under this contract shall be paid upon the presentation of a properly executed voucher and after the Contractor shall have furnished the Government with a release, if required, of all claims against the Government arising by virtue of this contract, other than claims in stated amounts as may be specifically excepted by the Contractor from the operation of the release. If the Contractor's claim to amounts payable under the contract has been assigned under the Assignment of Claims Act of 1940, as amended (31 U.S.C. 203, 41 U.S.C. 15), a release may also be required of the assignee.*

No partial payment will be made when the total value of the work done since the last estimate amounts to less than $1000.

Whenever the bid schedule contains a contingent sum pay item or items, the work covered thereby shall be performed only upon written order of the Engineer and payment will be made as provided in the order.

109.07 Payment for Material on Hand. Refer to subsection 109.06.

No partial payment will be made on living or perishable plant materials until planted.

109.08 Acceptance and Final Payment. Refer to subsection 109.06.

All prior partial estimates and payments will be subject to correction in any subsequent estimate, including the final estimate and payment.

109.09 Mobilization

(a) *Mobilization.*—This item shall consist of preparatory work and operations, including, but not limited to, those necessary for the movement of personnel, equipment, supplies and incidentals to the project site; for the establishment of

all offices, buildings and other facilities necessary for work on the project, and for all other work and operations which must be performed or costs incurred prior to beginning work on the various items on the project site.

When the Invitation for bids provides a fixed-amount set by the Contracting Officer or a bid item for Mobilization (Item 800), the following clauses shall apply:

(b) *Partial payments.* Partial payments may be made as follows:

(1) When 5% of the original contract amount is earned, 25% of the amount for mobilization, or 2½% of the original contract amount, whichever is lesser, may be paid.

(2) When 10% of the original contract amount is earned, 50% of the amount for mobilization or 5% of the original contract amount, whichever is lesser, may be paid.

(3) When 25% of the original contract amount is earned, 60% of the amount for mobilization, or 6% of the original contract amount, whichever is lesser, may be paid.

(4) When 65% of the original contract amount is earned, 90% of the amount for mobilization, or 9% of the original contract amount, whichever is lesser may be paid.

(5) When 80% of the original contract amount is earned, 100% of the amount for mobilization, or 10% of the original contract amount, whichever is lesser, may be paid.

(c) Upon completion of all work on the project, payment of any amount for mobilization in excess of 10% of the original contract amount will be paid.

Nothing herein shall be construed to limit or preclude partial payments otherwise provided for by the contract.

The following clauses of SF-22 and SF-23A and SF-19A in entirety have not previously been included, but are a part of the contract.

SF-22:

1. Explanations to Bidders.—*Any explanation desired by a bidder regarding the meaning or interpretation of the invitation for bids, drawings, specifications, etc., must be requested in writing and with sufficient time allowed for a reply to reach bidders before the submission of their bids. Any interpretation made will be in the form of an amendment of the invitation for bids, drawings, specifications, etc., and will be furnished to all prospective bidders. Its receipt by the bidder must be acknowledged in the space provided on the Bid Form (Standard Form 21) or by letter or telegram received before the time set for opening of bids. Oral explanations or instructions given before the award of the contract will not be binding.*

2. Conditions Affecting the Work.—*Bidders should visit the site and take such other steps as may be reasonably necessary to ascertain the nature and location of the work, and the general and local conditions which can affect the work or the cost thereof. Failure to do so will not relieve bidders from responsibility for estimating properly the difficulty or cost of successfully performing the work. The Government will assume no responsibility for any understanding or representations concerning conditions made by any of its officers or agents prior to the execution of the contract, unless included in the invitation for bids, the specifications, or related documents.*

SF-23A:

8. Assignment of Claims

(a) *Pursuant to the provisions of the Assignment of Claims Act of 1940, as amended (31 U.S.C. 203, 41 U.S.C. 15), if this contract provides for payments aggregating $1,000 or more, claims for moneys due or to become due the Contractor from the Government under this contract may be assigned to a bank, trust company, or other financing institution, including any Federal lending agency, and may thereafter be further assigned and reassigned to any such institution. Any such assignment or reassignment shall cover all amounts payable under this contract and not already paid, and shall not be made to more than one party, except that any such assignment or reassignment may be made to one party as agent or trustee for two or more parties participating in such financing. Unless otherwise provided in this contract, payments to an assignee of any moneys due or to become due under this contract shall not, to the extent provided in said Act, as amended, be subject to reduction or setoff. (The preceding sentence applies only if this contract is made in time of war or national emergency as defined in said Act; and is with the Department of Defense, the General Services Administration, the Atomic Energy Commission, the National Aeronautics and Space Administration, the Federal Aviation Agency, or any other department or agency of the United States designated by the President pursuant to Clause 4 of the proviso of section 1 of the Assignment of Claims Act of 1940, as amended by the Act of May 15, 1951 65 Stat. 41.)*

(b) *In no event shall copies of this contract or of any plans, specifications or other similar documents relating to work under this contract, if marked "Top Secret", "Secret", or "Confidential", be furnished to any assignee of any claim arising under this contract or to any other per-*

son not entitled to receive the same. However, a copy of any part or all of this contract so marked may be furnished or any information contained therein may be disclosed, to such assignee upon the prior written authorization of the Contracting Officer.

17. Covenant Against Contingent Fees

The Contractor warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the Contractor for the purpose of securing business. For breach or violation of this warranty the Government shall have the right to annul this contract without liability or in its discretion to deduct from the contract price or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

18. Officials Not To Benefit

No member of Congress or resident Commissioner shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

19. Buy American

(a) Agreement. *In accordance with the Buy American Act (41 U.S.C. 10a-10d) and Executive Order 10582, December 17, 1954 (3 CFR Supp.), the Contractor agrees that only domestic construction material will be used (by the Contractor, subcontractors, materialmen, and suppliers) in the performance of this contract, except for nondomestic material listed in the contract.*

(b) Domestic construction material. *"Construction material" means any article, material, or supply brought to the construction site for incorporation in the building or work. An unmanufactured construction material is a "domestic construction material" if it has been mined or produced in the United States. A manufactured construction material is a "domestic construction material" if it has been manufactured in the United States and if the cost of its components which have been mined, produced, or manufactured in the United States exceeds 50 percent of the cost of all its components. "Component" means any article, material, or supply directly incorporated in a construction material.*

(c) Domestic component. A component shall be considered to have been *"mined, produced, or manufactured in the United States" (regardless of its source in fact)*

if the article, material, or supply in which it is incorporated was manufactured in the United States and the component is of a class or kind determined by the Government to be not mined, produced, or manufactured in the United States in sufficient and reasonably available commercial quantities and of a satisfactory quality.

20. Convict Labor

In connection with the performance of work under this contract, the Contractor agrees not to employ any person undergoing sentence of imprisonment at hard labor.

21. Equal Opportunity Clause

(The following clause is applicable unless this contract is exempt under the rules and regulations, and relevant orders of the Secretary of Labor (41 CFR, CH. 60)..)

During the performance of this contract, the Contractor agrees as follows:

(a) The Contractor will not discriminate against any employee or applicant for employment because of race, creed, color, or national origin. The Contractor will take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, creed, color, or national origin. Such action shall include, but not be limited to, the following: employment, upgrading, demotion or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The Contractor agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the Contracting Officer setting forth the provisions of this Equal Opportunity clause.

(b) The Contractor will, in all solicitations or advertisements for employees placed by or on behalf of the Contractor, state that all qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

(c) The Contractor will send to each labor union or representative of workers with which he has a collective bargaining agreement or other contract or understanding, a notice, to be provided by the agency Contracting Officer, advising the said labor union or worker's representative of the Contractor's commitments under this Equal Opportunity clause, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

(d) The Contractor will comply with all provisions of Executive Order No. 11246 of September 24, 1965, and of

the rules, regulations, and relevant orders of the Secretary of Labor.

(e) The Contractor will furnish all information and reports required by Executive Order No. 11246 of September 24, 1965, and by the rules, regulations, and orders of the Secretary of Labor, or pursuant thereto, and will permit access to his books, records, and accounts by the contracting agency and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.

(f) In the event of the Contractor's noncompliance with the Equal Opportunity clause of this contract or with any of the said rules, regulations, or orders, this contract may be canceled, terminated, or suspended in whole or in part and the Contractor may be declared ineligible for further Government contracts in accordance with procedures authorized in Executive Order No. 11246 of September 24, 1965, and such other sanctions may be imposed and remedies invoked as provided in Executive Order 11246 of September 24, 1965, or by rule, regulation, or order of the Secretary of Labor, or as otherwise provided by law.

(g) The Contractor will include the provisions of paragraphs (1) through (7) in every subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to section 204 of Executive Order No. 11246 of September 24, 1965, so that such provisions will be binding upon each subcontractor or vendor. The Contractor will take such action with respect to any subcontract or purchase order as the contracting agency may direct as a means of enforcing such provisions, including sanctions for noncompliance: Provided, however, that in the event the Contractor becomes involved in, or is threatened with litigation with a subcontractor or vendor as a result of such direction by the contracting agency, the Contractor may request the United States to enter into such litigation to protect the interests of the United States.

22. Utilization of Small Business Concerns

(a) It is the policy of the Government as declared by the Congress that a fair proportion of the purchases and contracts for supplies and services for the Government be placed with small business concerns.

(b) The Contractor agrees to accomplish the maximum amount of subcontracting to small business concerns that the Contractor finds to be consistent with the efficient performance of this contract.

SF-19A:

1. DAVIS-BACON ACT (40 U.S.C. 276a-a(7))

(a) All mechanics and laborers employed or working directly upon the site of the work shall be paid unconditionally and not less often than once a week, and without subsequent deduction or rebate on any account (except such payroll deductions as are permitted by the Copeland Regulations (29 CFR, Part 3)), the full amounts due at time of payment computed at wage rates not less than the aggregate of the basic hourly rates and the rates of payments, contributions, or costs for any fringe benefits contained in the wage determination decision of the Secretary of Labor which is attached hereto and made a part hereof, regardless of any contractual relationship which may be alleged to exist between the Contractor or subcontractor and such laborers and mechanics. A copy of such wage determination decision shall be kept posted by the Contractor at the site of the work in a prominent place where it can be easily seen by the workers.

(b) The Contractor may discharge his obligation under this clause to workers in any classification for which the wage determination decision contains:

(1) Only a basic hourly rate of pay, by making payment at not less than such basic hourly rate, except as otherwise provided in the Copeland Regulations (29 CFR, Part 3); or

(2) Both a basic hourly rate of pay and fringe benefits payments, by making payment in cash, by irrevocably making contributions pursuant to a fund, plan, or program for, and/or by assuming an enforceable commitment to bear the cost of, bona fide fringe benefits contemplated by the Davis-Bacon Act, or by any combination thereof. Contributions made, or costs assumed, on other than a weekly basis shall be considered as having been constructively made or assumed during a weekly period to the extent that they apply to such period. Where a fringe benefit is expressed in a wage determination in any manner other than as an hourly rate and the Contractor pays a cash equivalent or provides an alternative fringe benefit, he shall furnish information with his payrolls showing how he determined that the cost incurred to make the cash payment or to provide the alternative fringe benefit is equal to the cost of the wage determination fringe benefit. In any case where the Contractor provides a fringe benefit different from any contained in the wage determination, he shall similarly show how he arrived at the hourly rate shown therefor. In the event of disagreement between or among the interested parties as to an equivalent of any fringe benefit, the Contracting Officer shall submit the

question, together with his recommendation, to the Secretary of Labor for final determination.

(c) The assumption of an enforceable commitment to bear the cost of fringe benefits, or the provision of any fringe benefits not expressly listed in section 1(b)(2) of the Davis-Bacon Act or in the wage determination decision forming a part of the contract, may be considered as payment of wages only with the approval of the Secretary of Labor pursuant to a written request by the Contractor. The Secretary of Labor may require the Contractor to set aside assets, in a separate account, to meet his obligations under any unfunded plan or program.

(d) The Contracting Officer shall require that any class of laborers or mechanics which is not listed in the wage determination decision and which is to be employed under the contract shall be classified or reclassified conformably to the wage determination decision, and shall report the action taken to the Secretary of Labor. If the interested parties cannot agree on the proper classification or reclassification of a particular class of laborers or mechanics to be used, the Contracting Officer shall submit the question, together with his recommendation, to the Secretary of Labor for final determination.

(e) In the event it is found by the Contracting Officer that any laborer or mechanic employed by the Contractor or any subcontractor directly on the site of the work covered by this contract has been or is being paid at a rate of wages less than the rate of wages required by paragraph (a) of this clause, the Contracting Officer may (1) by written notice to the Government Prime Contractor terminate his right to proceed with the work, or such part of the work as to which there has been a failure to pay said required wages, and (2) prosecute the work to completion by contract or otherwise, whereupon such Contractor and his sureties shall be liable to the Government for any excess costs occasioned the Government thereby.

(f) Paragraphs (a) through (e) of the clause shall apply to this contract to the extent that it is (1) a prime contract with the Government subject to the Davis-Bacon Act or (2) a subcontract also subject to the Davis-Bacon Act under such prime contract.

2. CONTRACT WORK HOURS STANDARDS ACT—OVERTIME COMPENSATION (40 U.S.C. 327-330)

(a) The Contractor shall not require or permit any laborer or mechanic in any workweek in which he is employed on any work under this contract to work in excess of 8 hours in any calendar day or in excess of 40 hours in such workweek on work subject to the provisions of the Contract Work Hours Standards Act unless such laborer or mechanic receives compensation at a rate not less than one and onehalf times his basic rate of pay for all such hours worked in excess of 8 hours in any calendar day or in excess of 40 hours in such workweek, whichever is the greater number of overtime hours. The "basic rate of pay," as used in this clause, shall be the amount paid per hour, exclusive of the Contractor's contribution or cost for fringe benefits and any cash payment made in lieu of providing fringe benefits or the basic hourly rate contained in the wage determination, whichever is greater.

(b) In the event of any violation of the provisions of paragraph (a), the Contractor shall be liable to any affected employee for any amounts due, and to the United States for liquidated damages. Such liquidated damages shall be computed with respect to each individual laborer or mechanic employed in violation of the provisions of paragraph (a) in the sum of $10 for each calendar day on which such employee was required or permitted to be employed on such work in excess of 8 hours or in excess of the standard workweek of 40 hours without payment of the overtime wages required by paragraph (a).

3. APPRENTICES

(a) Apprentices shall be permitted to work as such only when they are registered, individually, under a bona fide apprenticeship program registered with a State apprenticeship agency which is recognized by the Bureau of Apprenticeship and Training, U.S. Department of Labor; or, if no such recognized agency exists in a State, under a program registered with the aforesaid Bureau of Apprenticeship and Training. The allowable ratio of apprentices to journeymen in any craft classification shall be not greater than the ratio permitted to the Contractor as to his entire work force under the registered program. Any employee listed on a payroll at an apprentice wage rate, who is not registered as above, shall be paid the wage rate determined by the Secretary of Labor for the classification of work he actually performed.

(b) The Contractor shall furnish written evidence of the registration of his program and apprentices as well as of the ratios allowed and the wage rates required to be paid thereunder for the area of construction, prior to using any apprentices in the contract work.

4. PAYROLLS AND BASIC RECORDS

(a) *The Contractor shall maintain payrolls and basic records relating thereto during the course of the work and shall preserve them for a period of 3 years thereafter for all laborers and mechanics working at the site of the work. Such records shall contain the name and address of each such employee, his correct classification, rate of pay (including rates of contributions for, or costs assumed to provide, fringe benefits), daily and weekly number of hours worked, deductions made and actual wages paid. Whenever the Contractor has obtained approval from the Secretary of Labor as provided in paragraph (c) of the clause entitled "Davis-Bacon Act," he shall maintain records which show the commitment, its approval, written communication of the plan or program to the laborers or mechanics affected, and the costs anticipated or incurred under the plan or program.*

(b) *The Contractor shall submit weekly a copy of all payrolls to the Contracting Officer. The Government Prime Contractor shall be responsible for the submission of copies of payrolls of all subcontractors. The copy shall be accompanied by a statement signed by the Contractor indicating that the payrolls are correct and complete, that the wage rates contained therein are not less than those determined by the Secretary of Labor, and that the classifications set forth for each laborer or mechanic conform with the work he performed. Submission of the "Weekly Statement of Compliance" required under this contract and the Copeland Regulations of the Secretary of Labor (29 CFR, Part 3) shall satisfy the requirement for submission of the above statement. The Contractor shall submit also a copy of any approval by the Secretary of Labor with respect to fringe benefits which is required by paragraph (c) of the clause entitled "Davis-Bacon Act."*

(c) *The Contractor shall make the records required under this clause available for inspection by authorized representatives of the Contracting Officer and the Department of Labor, and shall permit such representatives to interview employees during working hours on the job.*

5. COMPLIANCE WITH COPELAND REGULATIONS

The Contractor shall comply with the Copeland Regulations of the Secretary of Labor (29 CFR, Part 3) which are incorporated herein by reference.

6. WITHHOLDING OF FUNDS

(a) *The Contracting Officer may withhold or cause to be withheld from the Government Prime Contractor so*

much of the accrued payments or advances as may be considered necessary (1) to pay laborers and mechanics employed by the Contractor or any subcontractor on the work the full amount of wages required by the contract, and (2) to satisfy any liability of any Contractor for liquidated damages under the clause hereof entitled "Contract Work Hours Standards Act—Overtime Compensation."

(b) *If any Contractor fails to pay any laborer or mechanic employed or working on the site of the work, all or part of the wages required by the contract, the Contracting Officer may, after written notice to the Government Prime Contractor, take such action as may be necessary to cause suspension of any further payments or advances until such violations have ceased.*

7. SUBCONTRACTS

The Contractor agrees to insert the clauses hereof entitled "Davis-Bacon Act," "Contract Work Hours Standards Act—Overtime Compensation," "Apprentices," "Payrolls and Basic Records," "Compliance With Copeland Regulations," "Withholding of Funds," "Subcontracts," and "Contract Termination—Debarment" in all subcontracts. The term "Contractor" as used in such clauses in any subcontract shall be deemed to refer to the subcontractor except in the phrase "Government Prime Contractor."

8. CONTRACT TERMINATION—DEBARMENT

A breach of the clauses hereof entitled "Davis-Bacon Act," "Contract Work Hours Standards Act—Overtime Compensation," "Apprentices," "Payrolls and Basic Records," "Compliance With Copeland Regulations," "Withholding of Funds," and "Subcontracts" may be grounds for termination of the contract, and for debarment as provided in 29 CFR 5.6.

Compendium 16

Text 5

SELECTED STUDIES

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JOHN C. VANCE

Counsel for Legal Research
Transportation Research Board

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Chapter VI. Highway Contract Law

Licensing and Qualification of Bidders 1043
By Dr. Ross D. Netherton

Public Policy Concerning Qualification of Bidders on Public Highway Construction Contracts 1043
State Laws and Regulations Relating to Licensing of Public Works Contractors 1056
State Practice Regarding Prequalification of Bidders on Highway Construction Contracts 1072
State Practice Regarding Postqualification of Bidders on Highway Construction Contracts 1121
Conclusion 1122

* Competitive Bidding and Award of Highway Construction Contracts ... 1125
By Dr. Ross D. Netherton

** The Basis and Purpose of Competitive Bidding 1125
** Competitive Bidding Requirements for Federal and Federally Aided Highway Construction Contracts 1131
* Scope of State Competitive Bidding Laws 1134
* Advertisement for Bids 1152
** Preparation of Bids 1175
* Submission of Bids and Award of Contract 1190
** The Effect of Bid Mistakes in Contract Awards 1205
** Conclusion 1213

Bid Mistakes: A Practical Approach to the Problem 1215
By Richard W. Phillips

The Practical Problem 1215
The Strict Approach 1216
The Equitable Approach 1219
The Practical Approach 1224
Significant Annotations 1228

Indemnification and Suretyship in Highway Construction Contracts 1231
By Dr. Ross D. Netherton

Introduction 1231
Suretyship and Indemnification: Basic Concepts and Distinctions .. 1232
Public Policy Regarding Contractors' Bonds 1234
Contractor Bonding in Federal Construction Contracts 1242
State Laws and Regulations Relating to Contractor Bonds 1256
Conclusion 1292

Labor Standards in Federal-Aid Highway Construction Contracts 1295
By Dr. Ross D. Netherton

Introduction 1295
Convict Labor 1296
"Anti-Kickback" Legislation 1298
Minimum Wage Standards 1301
Hours and Conditions of Work 1316
Equal Employment Opportunity 1321
Conclusion 1329

Control of Conflicts of Interest in Highway Construction Contract Administration 1331
By Dr. Ross D. Netherton

The Morality Issue in Government 1331
The Evolving Definition of "Conflict of Interest" 1346
Bribery and Related Crimes 1351
Conflict of Interest in Public Contracts 1356
Conflict of Interest: Prohibited Practices 1368
Disclosure of Financial Interests 1382
Official Misconduct 1388
Conclusion 1399
Appendix — Summary of State Laws Relating to Control of Conflict of Interest in Highway Contract Administration 1401

Legal Problems Arising from Changes, Changed Conditions, and Disputes Clauses in Highway Construction Contracts 1441
By Ben H. Walley and John C. Vance

Introduction 1441
Changes Article 1442
Changed Conditions Article 1450
Disputes Article 1458
Conclusion 1467
Appendix 1468

Legal Effect of Representations as to Subsurface Conditions 1471
By John C. Vance and A. Alling Jones

Introduction 1471
The Development of Governmental Liability for Representations in Construction Contracts 1473
The Modern View: *Wunderlich* and Beyond 1478
Conclusion 1492
Appendix—Bibliography 1494

Liability for Delay in Completion of Highway Construction Contract 1495
By Darrell W. Harp

Introduction 1495
Delay Caused By Contractee 1495
Delay Caused By Contractor 1507
Work Stoppage Under Court Order 1520

Trial Strategy and Techniques in Highway Contract Litigation 1525
By Kingsley T. Hoegstedt and Orrin F. Finch

Introduction 1525
Preparation of the Case 1527
Pleadings and Motions Before Trial 1565
Presentation of the Case 1571
Appendix — List of Affirmative Defenses 1581

Chapter VII. Environmental Law

Environmental Litigation: Rights and Remedies 1583
By Hugh J. Yarrington

Introduction 1583
Standing to Sue 1598
Applicability of Procedural Requirements of Federal Environmental Statutes to Specific Highway Projects 1627
Failure to Comply With Procedural Requirements of Federal Environmental Statutes 1650
Failure to Comply with the Substantive Requirements of Federal Environmental Statutes 1683
Judicial Review 1692
Remedies 1699
Appendix — The National Environmental Policy Act 1708

Trial Strategy and Techniques in Environmental Litigation 1713
By Norval C. Fairman and Elias D. Bardis

Introduction 1713
Preliminary Observations 1714
Issues Often Joined With and Related to Environmental Litigation .. 1718
Discovery 1736
Complaint 1745
Defensive Strategy 1749
Preliminary Injunction 1759
Trial 1762
Summary 1769

Chapter VIII. Tort Liability

Liability of State Highway Departments for Design, Construction, and Maintenance Defects 1771
By Larry W. Thomas

Introduction 1771
The Defense of Sovereign Immunity to Tort Suits 1776
Statutes Waiving Tort Immunity of the State Highway Department.. 1784
State's Duty to Traveling Public Generally 1786
Highway Defect Statutes—Breach of Statutory Duty 1793
The Governmental-Proprietary Test of Immunity 1796

Immunity from Liability Based on Discretionary Function or Activity 1800
Conclusion 1820
Appendix A—State Tort Liability According to Constitutional or Statutory Provisions or Judicial Decisions 1822
Appendix B—Bibliography 1833

Personal Liability of State Highway Department Officers and Employees.. 1835
By John C. Vance

Introduction 1835
Absolute Immunity 1837
Liability on Ordinary Negligence Grounds 1839
Discretionary-Ministerial Distinction 1840
Design Activities 1843
Maintenance Activities 1846
Operation of Vehicles 1853
Excess of Jurisdiction 1854
Public Duty-Private Duty Distinction 1855
Misfeasance-Nonfeasance Distinction 1859
Defense of Acting Under Orders 1863
Doctrine of Respondeat Superior 1864
Recovery by State Against Negligent Employee 1865
Conclusion 1866
Appendix—Bibliography 1868

Liability of State and Local Governments for Snow and Ice Control 1869
By Larry W. Thomas

Introduction 1869
Duty of Public Agencies to Remove Snow and Ice from Highways ... 1870
Liability in Eminent Domain, Trespass, and Nuisance for Snow Removal and Salting Operations 1879
Liability of Public Works Agencies Under "Highway Defect" Statute 1880
Special Defenses of Public Agencies to Negligence Actions 1882
Liability of Public Agencies Under Tort Claims Acts 1885
Conclusion 1887

Liability for Wet-Weather Skidding Accidents and Legal Implications of Regulations Directed to Reducing Such Accidents on Highways 1889
By Larry W. Thomas

Introduction 1889
State's Duty to Guard Against Slippery Road Conditions 1895
Provisions of Wet-Weather Skid-Reduction Program Discretionary in Nature 1899
Initiation of the Wet-Weather Skid-Reduction Program 1906
Discretion Exercised in the Design and Selection of Pavement Surfaces 1912
Exceptions to Immunity for Pavement Design 1915
Liability for Negligence in the Construction or Execution Phase of Wet-Weather Skid Reduction 1923
Liability for Failure to Correct Hazardous Wet-Weather Skidding Locations 1929

Use of Wet-Weather Skid-Reduction Regulations at Trial 1933
Conclusion 1941

Liability of State and Local Governments for Negligence Arising Out of the Installation and Maintenance of Warning Signs, Traffic Lights, and Pavement Markings 1943
By Larry W. Thomas

Introduction 1943
Duty of State or Governmental Agency to Install and Maintain Highway Warnings, Traffic Lights, or Pavement Markings 1944
State or Local Government Defenses Against Negligence Actions Arising Out of Highway Signs, Traffic Lights, or Pavement Markings.. 1952
Uniform Laws, Regulations, or Standards As Affecting Liability 1960
Conclusion 1964

Chapter IX. Intergovernmental Relations

The Federal-State Relationship in the Federal-Aid Highway Program .. 1967
By David E. Wells, Nolan H. Rogers, and David C. Oliver

Introduction 1967
Judicial Interpretation of the Federal-State Relationship 1968
Federal Legislation As Affecting the Federal-State Relationship .. 1980
Summary 1996
State Legislation and Constitutional Provisions As Affecting the Federal-State Relationship 1997

Index 2019

Competitive Bidding and Award of Highway Construction Contracts

By Dr. Ross D. Netherton

Office of Research
Federal Highway Administration
Washington, D.C.

THE BASIS AND PURPOSE OF COMPETITIVE BIDDING

The Purpose of Competitive Bidding on Public Contracts

Procedures for selection of contractors to construct, maintain, improve, and repair public highways are based on a well-defined body of legislative and administrative rules. These rules have no common law antecedents, and thus they constitute a set of positive policies and requirements which distinguish the conduct of public officials from the practices of executives in private business. Whereas in private transactions the propriety of a decision regarding the award of a contract generally is judged by the balance sheet results of the transaction, public contracting officers must adhere to rules designed not only to assure administrative efficiency, but also to protect certain moral values and promote certain socio-economic goals. It is to facilitate the accounting for these two types of consequences—the prevention of favoritism in spending public funds, and the stimulation of competition in the construction industry—that most modern laws and regulations requiring competitive bidding have been developed. 83

Important as these aspects may be, however, they are not the basic purpose of the rules for awarding contracts. The central object of this process always has been and must be to obtain the full and fair return for an expenditure of public funds. The interest of the public in this respect generally is best served by extending invitations for public contract work on an open and equal basis to all persons who are able and willing to perform such work. Through effectively supervised competition among the parties, it is felt that the public has its best assurance that there will emerge a real and honest cost basis for the work desired.[1]

Competitive bidding requirements therefore serve multiple purposes, and statements of such purposes by the courts have varied in emphasis. An illustrative list of the major objectives of competitive bidding is found in *Wester v. Belote*, as follows:

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[1] H. COHEN, PUBLIC CONSTRUCTION CONTRACTS AND THE LAW at 2 (New York, F. W. Dodge Corp., 1961) [hereinafter cited as COHEN].

> [T]o protect the public against collusive contracts; to secure fair competition upon equal terms to all bidders; to remove not only collusion but temptation for collusion and opportunity for gain at public expense; to close all avenues to favoritism and fraud in its various forms; to secure the best values for the [public] at the lowest possible expense; and to afford an equal advantage to all desiring to do business with the [public], by affording an opportunity for an exact comparison of bids.[2]

The Essential Principles of Competitive Bidding

The Form of Competitive Bidding Rules

Legislators appear to have regarded the objectives of competitive bidding as satisfied where there is general adherence to uniform procedures relating to the following actions: (1) public advertisement to bidders inviting the submission of proposals; (2) preparation of plans, specifications, and related information about the work and the location where such materials can be obtained by prospective bidders; (3) formal submission of proposals to the contracting agency, together with the deposit of financial security guaranteeing that the bidder will accept the award of a contract if he is the lowest responsible bidder; and (4) consideration of proposals under uniform criteria, and award of contracts to successful bidders.

84

Constitutional requirements for unambiguous directives and limitations on delegation of power combine to force legislatures to be explicit about these matters. But the nature of the subject matter makes it necessary that many details of bidding procedure be set forth in the form of rules promulgated by policy-making bodies or chief administrative officers of the contracting agencies. Any effort to fully describe the law relating to competitive bidding and award of contracts must, therefore, take into account not only the statutes, but also the formally promulgated administrative regulations and the informally followed customs and practices of the contracting agency.

Patterns regarding the mix of statutory and administrative elements in the law vary from State to State. Connecticut's statute illustrates an unusually broad delegation of procedural rulemaking authority to administrative officials, as follows:

> The Commissioner may, at any time, call for bids to construct, alter, reconstruct, improve, relocate, widen or change the grade of sections of state highways or bridges. All bids shall be submitted on forms provided by the commissioner and shall comply with the rules and regulations provided in the specifications.[3]

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[2] 103 Fla. 976, 138 So. 721 (1931). *See also*, Colorado Paving Co. v. Murphy, 78 F.28 (8th Cir. 1897); Fonder v. City of South Sioux Falls, 76 S.D. 31, 71 N.W.2d 618, 53 A.L.R.2d 493 (1955).

[3] CONN. GEN. STAT. ANN. § 13a-95 (1964).

In contrast, other States consign certain aspects of bidding to administrative judgment, and specify other aspects in statutes.[4] Such variations in the form of competitive bidding laws appear to be responsive to particular local conditions or previous experience, for they seldom indicate any common source of language or policy. To date the most effective influence for uniformity in State bidding procedures appears to be the standard specifications for construction of federal-aid highway projects.[5] On the other hand, a continuing need to accommodate the particular circumstances of municipal and county governments and special-purpose agencies has led legislatures to provide separate rules for contract awards at these levels.

Effect of Failure to Follow Required Procedures

Bidding procedures set forth in statutes and administrative rules are regarded as jurisdictional prerequisites for valid exercise of a contracting agency's authority. Courts have made it plain they seek constructions of these rules that will fully and reasonably realize the intent of the law in varying situations, but will not weaken the effectiveness of the law through exceptions.[6] Thus, failure to comply with all the specified steps before an award almost invariably results in failure to create any enforceable obligation or liability on the part of the public agency. Where an agency does not follow exactly its specified procedures, a transaction purporting to be a contract award is a nullity. 85

Contractors who perform construction work, or supply materials under an innocent impression that their contract was awarded through correct procedures understandably complain of the hardship resulting from application of this rule. But, even where the public agency accepts and uses the results of a contractor's work, he may not recover *quantum meruit;* and, generally, he is liable to repay to the agency any funds he received under the arrangement.[7]

Apparent exceptions to this rule have been noted, chiefly where courts have been able to find factual bases for enforcing an implied contract,[8] or have found that in addition to noncompliance with bidding statutes

[4] GA. CODE § 95A-806, "in such newspapers or other publications, or both as will insure adequate publicity"; OHIO REV. CODE, § 5525.01 (Supp. 1974), two newspapers of opposite political parties, if there are such, in the counties where the work is to be done; N.J. STAT. ANN. § 27:7-29 (1966); D.C. CODE § 7-601 (1973); W.VA. CODE § 17-4-19 (1974), designated urban centers and trade journals as well as county where project located.

[5] Federal Highway Administration, *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects*, FP-74, (Washington: GPO, 1974).

[6] Fonder v. City of South Sioux Falls, 76 S.D. 31, 71 N.W.2d 618 (1955).

[7] Miller v. McKinnon, 20 Cal. 2d 83, 124 P.2d 34 (1942).

[8] Johnson County Savings Bank v. City of Creston, 212 Ia. 929, 231 N.W. 705 (1930).

there was proof of fraud in the award.[9] In the absence of such findings, however, contractors have little prospect of recovering for work performed because theories of a quasi-contract will not be applied to promises that are beyond the authority of a public agency to make.[10]

Genuine exceptions to the mandatory competitive bidding rules are authorized, however, for certain situations in which legislative common sense recognizes that the public interest is best served by that result. Accordingly, competitive bidding laws frequently exclude contracts involving less than a specified minimum amount, contracts calling for highly specialized goods or professional services not generally available in the market, and contracts made to deal with emergency conditions requiring speedy action. A more detailed discussion of these exceptions appears later herein; it suffices here to note that unless a public contract comes within an authorized exception its award must comply with applicable mandatory competitive bidding rules.

Effect of Collusion in Bidding

Public policy favoring award of public contracts through competitive bidding serves the interest of the contracting agency by assuring that it obtains needed goods and services at fair prices, and serves the interest of contractors by assuring that all bidders will have equal opportunity to bid and receive equal treatment in consideration of their proposals. This policy is implicit in statutes and regulations directing that competitive bidding be used, and is explicitly implemented in legislation prohibiting fraud and combinations in restraint of trade and competition. All these interests are endangered when there is collusion among bidders to submit noncompetitive or rigged proposals, or otherwise restrict competition and thereafter conceal the fact that such unfair advantage exists.

86

Collusion of this sort may take the form of agreements among bidders to submit proposals that are artificially high, or to submit identical bids, or for some bidders to withhold or withdraw their bids in favor of others.[11] The damaging effects of contractor combinations may sometimes be less direct and obvious. For example, *Kentucky Ass'n of Highway Contractors v. Williams*[12] involved an association created for many purposes, most of which were both lawful and usual, namely:

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[9] Griswold v. Ramsey County, 242 Minn. 529, 65 N.W.2d 647 (1954); Gerzof v. Sweeney, 16 N.Y.2d 206, 211 N.E.2d 826 264 N.Y.S.2d 376 (1965).

[10] E. McQUILLIN, MUNICIPAL CORPORATIONS § 29.112 (3d ed. F. Ellard 1966).

[11] Morgan v. Gove, 206 Cal. 627, 275 P. 415 (1929); State *ex rel.* Washington Paving Co. v. Clausen, 90 Wash. 450, 156 P. 554 (1916); State v. La Fera, 35 N.J. 75, 171 A.2d 311 (1961). Annot., 62 A.L.R. 224 (1929).

[12] 213 Ky. 167, 280 S.W. 937, 45 A.L.R. 544 (1926).

> [Promote] better relations between the state highway commission, its engineers and inspectors, and fiscal courts on the one hand, and contractors on the other hand; to maintain a high standard of contracting work; to combat unfair practices; to encourage efficiency among contractors; to support contractors in efforts to rectify conditions of an unsatisfactory character; to encourage those methods of contracting work which relieve the contractor of improper risks; to encourage sound business methods tending to raise the standing of contractors in the business world; and to assist the state of Kentucky in building a comprehensive system of roads throughout the state.[13]

Members of the association were required to pay annual dues of $50, plus 0.025 percent of Federal, State, and county highway work performed. The legality of this arrangement was tested in a suit by the association against a member who refused to pay the latter fee. The Court affirmed dismissal of the suit. Although conceding that it was difficult to define precisely the public policy regarding such associations, the Court felt such policy must oppose any combination having a predictable tendency to injure the public interest.[14] In the Court's view, the association's practice caused contractors to increase the amount of their bids so as to cover the "dues" or fees levied by the association.

In addition to providing grounds for voiding any contract awarded as a result of rigged or noncompetitive bids, collusion to restrain competition may expose the guilty parties to criminal penalties and disqualification from bidding on future contracts of the governmental agency involved. However, selection of penalties for guilty contractors may be unusually difficult, as illustrated by a proceeding in Wisconsin where 12 corporate contractors were prosecuted for conspiring to submit noncompetitive bids for bituminous highway paving contracts.[15] Under Wisconsin statutes each of the defendants was fined $5,000, the maximum amount authorized by the law, and was enjoined from engaging in any collusive action in the future.[16] The State's highway statute also

87

[13] *Id.* at 168, 280 S.W. at 938.

[14] Certain associations acting under Codes of Fair Competition adopted in conjunction with the National Industrial Recovery Act (NIRA) in the 1930's became guilty of unfair restraint of trade by advising members to bid only when other members of the association also were bidding. Jackson v. Sullivan, 276 Ky. 666, 124 S.W.2d 1019 (1939). On appeal, the Court felt the association was guilty of restraint of trade. *See also*, annotations in 121 A.L.R. 345 (1939) and 45 A.L.R. 549 (1926).

[15] On September 13, 1974, defendants were convicted after entering pleas of nolo contendere to felony charges of conspiring to restrain trade in construction projects for the State Highway Commission over a period of six years. Pending civil and criminal anti-trust claims were settled by payment of damages and penalties amounting to $660,000, agreed to in a consent decree which also enjoined future illegal conduct. Letter from Robert N. Warren, Attorney General of Wisconsin to Robert T. Huber, Chairman, State Highway Commission, September 13, 1974.

[16] WIS. STAT. ANN. § 133.01 (1974, as amended Supp. 1976).

authorizes the highway commission to disqualify the convicted contractors from bidding on any of the commission's contracts for a specified period in the future.[17] Normally such a suspension of eligibility would have been a routine action. Here, however, it was noted that the 12 defendants altogether had been responsible for 85 percent of the bituminous concrete paving in Wisconsin during the previous 6 years. Their suspension would leave very few contractors in the State with the necessary qualifications to bid on bituminous road paving projects. The Attorney General described the State's dilemma precisely when he declared: "In short, a suspension . . . could have an anti-competitive result rather than a procompetitive result as demanded by sound antitrust policy." [18]

Admittedly, Wisconsin's circumstances here may have been unusual. However, as industry-wide organization and collaboration increases in response to needs for trade information, so, also, does the need for safeguards that such information will not be used to facilitate unlawful combinations in the marketplace. The interpretation of statutes and rules regarding competitive bidding must be careful to provide clear and realistic distinctions between helpful and harmful combinations of bidders.

88 *Permissible Types of Combined Bidding by Contractors*

In contrast to combinations which arise from collusion, certain other types of combinations for purposes of bidding are permitted. Indeed, where contracting agencies desire to carry out projects that are unusually large, or that have an unusually wide range of specialty requirements, it often will be impossible for one contractor to undertake the work desired in a single contract. Under these circumstances joint bids by contractors who combine their resources to organize and perform this work provide a sensible solution to a recurring problem.

Courts' acceptance of the practice of joint bidding by contractors has emphasized the distinction between these open agreements and the secrecy typically associated with collusive combinations. An early decision of a New York court illustrates this view, as follows:

> [A] joint proposal, the result of honest cooperation though it might prevent the rivalry of the parties, and thus lessen competition, is not an act forbidden by public policy. Joint adventures are allowed. They are public and avowed and are not secret. The risk as well as the profit, is joint and openly assumed. The public may obtain at least the benefit of the joint responsibility, and of the joint ability to do the service.

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[17] WIS. STAT. ANN. § 84.06 (Supp. 1976); Wis. Div. of Highways, *Standard Specifications for Road and Bridge Construction*, § 102.12 (1969 ed.).

[18] Letter from Robert Warren to Robert Huber, *supra* n. 15.

> The public agents know, then, all that there is in the transaction, and can more justly estimate the motives of the bidders and weigh the merits of the bid.[19]

Joint ventures resemble partnerships by providing for the combination of the participants' resources, labor, and equipment; and such ventures establish a joint responsibility for the results. The chief distinction between joint ventures and partnerships, therefore, is that the joint venture is created only for a single transaction. Joint ventures may include more than two parties, and in some instances the existence of a joint venture has been recognized from the conduct of the parties even though the arrangement was not formalized in writing.[20]

COMPETITIVE BIDDING REQUIREMENTS FOR FEDERAL AND FEDERALLY AIDED HIGHWAY CONSTRUCTION CONTRACTS

Selection of contractors for construction projects in which an agency of the United States Government is the contracting party is governed by the requirements of 41 U.S.C. § 5 (Supp. V 1975), which provides that, unless otherwise specified in appropriation legislation or unless they come within an authorized exception, contracts for materials, supplies, or services for the government must be awarded through public advertisement and competitive bidding. The authorized exceptions to this rule include contracts in which (1) the amount involved does not exceed $10,000, (2) immediate delivery of materials or performance of services is required because of "public exigencies," (3) only one source of supply is available, or (4) the services required must be performed by the contractor in person and are of a technical or professional nature, or are under government supervision and paid for on a time basis. 89

A similar policy is applied to federal-aid highway projects where construction is performed under contracts awarded by a State highway agency or a local government using federal funds for all or part of the cost.[21] Exceptions to this requirement are not specified, as in the case of direct federal construction, and the need to provide flexibility is accommodated by authorizing the Secretary of Transportation to approve modifications of the usual methods of advertisement for proposals, provided that any such methods "shall be effective in securing competition."[22] The policy favoring competition is further safeguarded by the following requirements:

> (b) Construction of each project, subject to the provisions of subsection (a) . . . shall be performed by contract awarded by competitive bid-

[19] Atcheson v. Mallon, 43 N.Y. 147, 151 (1870). *See also*, McMullen v. Hoffman, 174 U.S. 639, 43 L.Ed. 1117, 195 S.Ct. 839 (1899).

[20] Libby v. L. J. Corp., 247 F.2d 78 (D.C. Cir. 1957).

[21] 23 U.S.C. § 112 (1970).

[22] 23 U.S.C. § 112(a) (1970).

> ding, unless the Secretary shall affirmatively find that, under the circumstances relating to such projects, some other method is in the public interest. . . . Contracts for the construction of each project shall be awarded only on the basis of the lowest responsive bid submitted by a bidder meeting established criteria of responsibility. No requirement or obligation shall be imposed as a condition precedent to the award of a contract to such bidder, . . . unless [it] is otherwise lawful and is specifically set forth in the advertised specifications.
>
> (e) The Secretary shall require as a condition precedent to his approval of each contract . . . a sworn statement, executed by, or on behalf of, the person, firm, association, or corporation to whom such contract is to be awarded, certifying that such person . . . has not, either directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken any action in restraint of free competitive bidding in connection with such contract.[23]

This policy is reflected in the Federal Highway Administration's (FHWA) regulations applying to projects which in any part are paid for with federal funds.[24] Addressed to the State highway and transportation departments, the regulations require that federal-aid highway construction work must be performed by contract awarded to the lowest responsible bidder, unless it is undertaken by the State as a force account activity, or unless the Federal Highway Administrator finds that "unusual circumstances" make it necessary to undertake some other method. For work performed by contract, the State highway agency must assure opportunity for free, open, and competitive bidding, including adequate publicity of the advertisement or call for bids, and must comply with the procedures prescribed by the Administrator.[25]

90

Arrangements for performance of work as force account projects requires that the Administrator find that such arrangements are necessary, and that the State determine that the project can be staffed and equipped satisfactorily and economically.[26]

Although these requirements for competitive bidding in the award of construction contracts have been part of the federal-aid highway law since 1938,[27] the present procedural requirements for contract award are also influenced by congressional legislation and presidential directives having general applicability to federal grant-in-aid funds. When Congress, in 1968, enacted the present competitive bidding policy for federal-aid highway construction contracts, it also enacted the Inter-

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[23] 23 U.S.C. § 112 (1970).

[24] A statutory exception is provided in 23 U.S.C. § 112(e) (1970), and permits the Secretary to satisfy his responsibility for encouraging competitive bidding and award of contracts for work on the Federal-Aid Secondary System by acceptance of the State's certification as to compliance. *See also*, 23 U.S.C. § 117 (Supp. V 1975).

[25] 23 C.F.R. § 635.107 (1976).

[26] 23 C.F.R. § 635.105 (1976).

[27] Act of June 8, 1938, ch. 328, § 12, 52 Stat. 636. *See also*: Act of May 6, 1954, ch. 181, § 17, 68 Stat. 75; Federal-Aid Highway Act of 1968, Pub. L. No. 90-495, 82 Stat. 815.

governmental Cooperation Act of 1968,[28] designed, among other things, to "improve the administration of grants-in-aid to the States," and "provide for periodic congressional review of federal grants-in-aid." The Bureau of the Budget was authorized to prescribe implementing regulations which would promote uniformity of procedures. A year later, the Bureau—now the Office of Management and Budget—issued the first of a series of circulars which are the present uniform administrative requirements for grants-in-aid to State and local governments.[29] These regulations provide standards for State and local procedures for procurement of supplies, equipment, construction, and other services with federal grant funds.[30]

Although these regulations contemplate that State and local agencies, as grantees of federal funds, may use contracting procedures that reflect their own laws and administrative practices, such procedures will be held to compliance with the "fundamental federal norm." This latter standard is discussed by the Comptroller General in a 1974 opinion issued after reviewing the sufficiency of a State contract procedure.

> [A] grantee receiving Federal funds takes such funds subject to any statutory or regulatory restrictions which may be imposed by the Federal government. . . . [A] grantee must comply with the conditions attached to the grant in awarding federally assisted contracts.
>
> We believe that, where open and competitive bidding or some similar requirement is required as a condition to receipt of a Federal grant, certain basic principles of Federal procurement law must be followed by the grantee in solicitations which it issues pursuant to the grant. . . . In this regard, it is to be noted that the rules and regulations of the vast majority of Federal departments and agencies specify generally that grantees shall award contracts using grant funds on the basis of open and competitive bidding. This is not to say that all of the intricacies and conditions of Federal procurement law are incorporated into a grant by virtue of this condition of open and competitive bidding. . . . However, we do believe that the grantee must comply with those principles of procurement law which go to the essence of the competitive bidding system. . . . One of these basic principles is that all bidders must be advised in advance as to the basis upon which their bids will be evaluated, so that they may compete for award on an equal basis.[31]

91

In a subsequent decision, the Comptroller General quoted the foregoing passage and went on to say:

> Obviously, it is difficult to detail all that is "fundamental" to the Federal system of competitive bidding. However, basic Federal principles

[28] Act of Oct. 16, 1968, Pub. L. No. 90-577, 82 Stat. 1098.

[29] 34 C.F.R., part 256 (1975).

[30] 34 C.F.R., part 256, App. O (1974).

[31] Illinois Equal Employment Opportunity Regulations for Public Contracts, 54 COMP. GEN. 6, 9 (1974).

of competitive bidding are intended to produce rational decisions and fair treatment. To the extent, therefore, that a grantee's procurement decision (and the concurrence in that decision by the grantor agency) is not rationally founded, it may be considered as conflicting with a fundamental Federal norm. The decision will, in all likelihood, also be considered inconsistent with fundamental concepts inherent in any system of competitive bidding.[32]

Review of State and local highway construction contract awards by the grantor agency (Federal Highway Administration) is the chief means of supervising the grantee agencies' contracting practices. Striking growth of the number and scope of federal grant-in-aid programs in the period 1966 to 1976, with a correspondingly striking rise in the amount of federal funds, however, has prompted the General Accounting Office (GAO) to widen the scope of its review activities. A policy of granting reviews of complaints filed by contractor-bidders prior to contract award replaced the traditional curative procedure of the office; and in his first opinion under the new procedure, the Comptroller General broke further with tradition by accepting jurisdiction of a protest by a prospective subcontractor who complained against the award of a subcontract at the direction of the grantee agency.[33]

92 Federal requirements regarding competitive bidding in the award of federal and federally aided construction contracts thus reach through the grantor agencies of the Federal Government to grantee agencies of all types, with procedures for the enforcement of these standards. Formal protest procedures available to contractors and subcontractors provide opportunities for enforcement of bidding standards on the initiative of contractor-bidders as well as through the regular monitoring of the grantor agency. It appears to be the intent of the Comptroller General to see that throughout the entire structure of federally funded construction contracts the controlling standards will meet or exceed the "fundamental federal norm." Always elusive to define in the law, this norm appears to call for open competitive bidding, with bidders knowing in advance the bases for evaluation and selection of the lowest responsible bidder.

SCOPE OF STATE COMPETITIVE BIDDING LAWS

Types of Contracts Subject to Competitive Bidding Requirements

The policy favoring competitive bidding in the award of public contracts is comprehensive in scope; and, although limited exceptions are recognized, interpretation of State laws governing the award of public works construction contracts generally has reflected this scope. Legislative language describing these requirements varies substantially,

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[32] Copeland Systems, Inc., 55 COMP. GEN. 390, 393 (1975).

[33] *Id.*

however, and ranges from very broad and inclusive phrases—"any contract for public improvement"[34]—to highly specific descriptions containing references to particulars of the public works program, funding, or administrative responsibility involved.[35] Requirements for competitive bidding and the criteria for award of construction contracts are given in Table 1, p. 1138, *infra*.

Where the latter types of specifications are used, with the effect of limiting the scope of the requirements to which they apply, State legislatures often have adopted the practice of prescribing the rules for contract awards in separate statutes for each State agency and each type of local government concerned. Thus, with regard to highway construction contracts, it is common to see separate laws and differing bidding procedures for State highway commissions, county road officials, municipalities of various classes, and, occasionally, special-purpose commissions responsible for turnpikes, bridges, tunnels, ferries, local roads, and the like.[36] Although these rules vary in such details as the manner of public advertisement, the handling of plans and specifications, and the requirements for bid security, they generally show similar treatment of certain other questions.

One such group of questions is concerned with activities associated with construction of public works, but not themselves a form of "construction." Rental of road construction equipment illustrates this type of borderline contract; and, in Kentucky, it has been held that the State highway department was not required to use competitive bidding for such contracts.[37] Similarly, installation of street and parking lot lighting fixtures was held to be outside the scope of Arkansas' law requiring competitive bidding on highway "construction," the Court observing that the meaning of this term in the statute was limited to major repairs or alterations, erection of structures, and other improvments of a permanent character.[38]

When statutes are enacted to apply generally to all public agencies, or to a particular class of governmental agencies, the applicability of

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[34] ALA. CODE, tit. 50, § 15(1) (Supp. 1973).

[35] FLA. STAT. ANN. § 337.11 (Supp. 1976) (State highway system, State park road system, State assistance to counties for construction and maintenance); S.D. COMP. LAWS § 31 5 10 (1976) (contracts of State Highway Commission for improvements on State trunk highway system); WYO. STAT. § 24 36 (Supp. 1975) (construction work paid for from State Highway Fund).

[36] Detailed comparative descriptions of these State statutes and the key features of their bidding procedures are compiled in *Highway Contracts: A Legal Analysis*, HWY. RES. BD. SPEC. REPT. at 31-69, (Washington: Hwy. Res. Bd., 1960).

[37] Hall v. Commonwealth *ex rel.* Ferguson, 331 S.W.2d 272 (Ky. 1959). Purchase of equipment does not admit of competition where no one can undersell sole sales agent except at a loss. HAWAII OP. ATT'Y GEN. 70-24.

[38] Moore v. East, 250 Ark. 43, 464 S.W.2d 52 (1971).

the law may depend on the status of the contracting agency. Special purpose agencies, particularly at local levels, have presented this problem, and the courts have held that these bodies are not subject to general competitive bidding rules.[39]

A second group of questions calls for considering the effects of change orders and other actions that occur after a contract has been awarded. The extent to which such changes may be negotiated without resort to competitive bids is determined by the generally accepted rule that where a subsequent change is so great as to result in a new contract, the resulting new contract must be awarded through competitive bidding. Each case must be scrutinized on its own facts to determine the nature and extent of the modification being made.[40] Renegotiation and changes of orders always may be used to make substantive changes within reasonable limits; but they cannot be permitted to provide excuses for circumvention of mandatory competitive bidding procedures.[41]

Exceptions to the Competitive Bidding Rule

In order to prevent the interpretation of competitive bidding requirements in ways that actually impede the orderly and timely transaction of public business, it is customary for statutes, municipal charters, and
94 administrative regulations to specify certain circumstances in which competitive bidding procedures shall not apply. The most common classes of exceptions are concerned with the amounts of money involved in a contract, the need for responding to emergency situations, and the impracticality of procuring certain forms of services through price competition.

Statutory Minimum Amounts

Most State statutes and local ordinances that impose competitive bidding requirements apply only to contracts that involve more than specified minimum amounts of money. The rationale of this exception appears to be the practical consideration that when less than this minimum amount is involved, the cost of administering competitive bidding procedures is more expensive than the risk of loss to the public justifies. Minimum levels set by statute typically are low, so that only the most minor projects are within the scope of the exception.

Questionable contracting practices and uncertainties introduced by contract language are responsible for a large share of the cases in which the application of this exception is challenged. Even with a clear statutory designation of the minimum amount required for competitive bidding, it is still possible for a contracting officer to be indefinite about

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[39] Fagan Elec. Co. v. Housing Auth., 216 Ark. 932, 228 S.W.2d 39 (1950); KY. OP. ATT'Y GEN. 60-486.

[40] KY. OP. ATT'Y GEN. 62-845.

[41] MASS. OP. ATT'Y GEN. 126 (Sept. 25, 1963).

the contract's total amount because unit prices rather than job prices are quoted.

In such cases, evidence suggesting advance knowledge of the ultimate magnitude of the contract's cost, implying intent to circumvent the competitive bidding law, is important. Thus, where a contract was negotiated to purchase gravel at a fixed price per yard for use in road and street repair, and thereafter 74 separate purchases (each costing less than $500) were made on identical terms over a period of 8 months, the Court concluded that the arrangement violated the State's law requiring competitive bidding for all public contracts in excess of $500.[42] Arguing that the legislature could not have intended to allow its main objective to be "circumvented by multiple small market purchases," the Court emphasized that nothing in the record indicated that the contracting agency could not and did not realize the full extent of its need for road repair material. Accordingly,

> . . . given a recognized current need for such a supply of gravel for application over a period of weeks or months, a city would violate this statute if, without competitive bidding, it attempted to meet that apparent need through multiple noncontemporaneous contracts. To arrive at a different conclusion, we would be compelled to ignore the object and spirit of this legislation.[43]

A brief dissent to this opinion observed that a strict, literal reading of the record showed that the contracting officer did in fact comply with the law, and asserted that the majority of the court appeared to condemn him for failing to correctly anticipate his seasonal need for gravel.

Similar problems may be present where contracts are made on the basis of unit price bids, and the total number of units is not predetermined. Appreciation of the difficulty sometimes involved in predetermination of total work material appears to have made other courts more sympathetic to such contracts. For example, despite a statutory minimum of $200, an Illinois court approved payment of a contractor's $1,200 claim, based on purchases of 131 items used in road repairs over a 3-year period.[44] In the Court's view, the purchases were authorized, and the claims were separately enforcible despite failure to comply with competitive bidding procedures in awarding the contract.

Various other considerations have been used to sustain the validity of contracts negotiated without competitive bids, but the decisions clearly split on the policy that should prevail in interpreting the scope of this exception.[45]

Closely related to the situations in which contracts are made in good faith but left with indefinite costs is a second group of situations in

[42] Fonder v. City of South Sioux Falls, 76 S.D. 31, 71 N.W.2d 618 (1955).

[43] *Id.* at 35, 71 N.W.2d at 621.

[44] Euziere v. Highway Comm'r, 346 Ill. 131, 178 N.E. 397 (1931).

[45] Annot., 53 A.L.R.2d 498 (1957).

TABLE 1

REQUIREMENTS FOR COMPETITIVE BIDDING AND CRITERIA FOR AWARD OF HIGHWAY CONSTRUCTION CONTRACTS

STATE & CITATION	CLASSES OF CONTRACTS	CRITERIA FOR AWARD	AUTHORITY TO REJECT BID
ALA. CODE, tit. 50 §§ 15(1), 15(5) (1958, as amended, Supp. 1973)	"Any public works contract involving an amount in excess of $500.00"	Lowest responsible bidder complying with conditions of bid invitation, unless awarding authority finds bid unreasonable or it is not in awarding authority's interest to accept it.	If bids are unreasonable and it is not in awarding authority's interest to accept any, bids may be rejected and work done by force account by awarding authority.
tit. 23, § 54 (1958)	County road work: Contracts for road work exceeding $250 must be advertised, except in event of destruction of bridge rendering it impassable or other emergency.	Lowest reasonable and responsible bidder.	Right reserved to reject all bids.
ALASKA STAT. §§ 19.10.170, 19.10.190, 19.10.210 (1972)	All highway construction with estimated cost exceeding $20,000. For construction costing less than $20,000 or where it appears to be in best interest of State, department may perform work directly.	Lowest responsible bidder.	If no satisfactory bids are received, department may reject all bids and readvertise, or perform the work directly.
ARIZ. REV. STAT. § 28-1804 (Supp. 1975)	All items of construction or reconstruction involving more than $50,000 in cost.	Lowest responsible bidder.	If no satisfactory bids, department shall readvertise. If second call fails to obtain satisfactory bid, director may construct project "as he deems most advantageous."

NOTE: Table deleted except for representative sample.

TABLE 1—Continued

STATE & CITATION	CLASSES OF CONTRACTS	CRITERIA FOR AWARD	AUTHORITY TO REJECT BID
WIS. STAT. ANN. § 66.29 (1965 as amended, Supp. 1976) § 84.06 (Supp. 1976) Std. Specs. 103.1, 10.32	Contracts for construction, repair, remodeling, or improvement of public works, or furnishing of supplies and materials therefor.	Lowest responsible bidder.	Right is reserved to reject any and all bids if, in Highway Commission's judgment, State's best interest is served thereby.
WYO. STAT. § 24-36 (Supp. 1975)	Contracts for highway improvements exceeding $20,000, or for services exceeding $1,500.	Lowest responsible bidder.	State Highway Commission may reject any or all bids, and readvertise project.
D.C. CODE § 7-601 (Supp. II, 1975)	Contracts for repair of streets and avenues, new pavements, or any other works exceeding $1,000.	Lowest responsible bidder.	In discretion of the Commissioner may reject all bids.
P.R. LAWS tit. 22, § 46 (1964)	Contracts for public works and services exceeding $10,000.	Lowest responsible bidder.	Right reserved to reject all bids.

[1] Under OHIO REV. CODE § 5525.15, estimates may be kept confidential, and contract may be awarded to a bidder even though his bid exceeds the requirements of § 5525.10, provided the bid is deemed "fair and reasonable" and does not exceed federal standards.

97

which there has been deliberate splitting of a public construction project so that it can be performed under several contracts, some or all of which may fall below the statutory minimum amount for competitive bidding. Sound engineering and financial and administrative reasons may combine to support the decision to split a single project into segments for contracting; yet where it appears that this has been done for the purpose of evading a mandatory competitive bidding statute, courts generally have held the negotiated contracts invalid.[46]

As in the case of indefiniteness about the total cost, instances of intentionally splitting large contracts tend to be judged by the facts that disclose the parties' intent and the consequences of their actions. An illustration of the courts' approach to these situations is provided by *Tobin v. Town Council*,[47] in which a municipality contracted to have gravel placed on its streets over a period of several months. Although none of the individual jobs cost more than $200, which was the maximum

[46] Miller v. McKinnon, 20 Cal. 2d 83, 124 P.2d 34 (1942); Horrabin Paving Co. City of Creston, 221 Ia. 1237, 262 N.W. 480 (1935); Brownell Improvement Co. v. Highway Comm'r, 280 Ill. App. 43, (1935); State v. Kollarik, 22 N.J. 558, 126 A.2d 875 (1956).

[47] 45 Wyo. 219, 17 P.2d 666 (1933).

amount permitted by statute without competitive bidding, the total cost was over $5,000. When the transaction was challenged for failure to comply with the competitive bid procedure, it was argued that the contract had been changed by the parties after the work had commenced, and so became a hiring from day to day. The Court disagreed with this reasoning, and held that all the changes in work instructions from job to job were within the understanding of the initial contract. The parties must be considered as having known that a substantial number of separate locations would require similar treatment, and contemplating that this treatment would be given by the contractor.

A similar ruling was given in an analogous situation in *Kelly v. Cochran County*,[28] where county commissioners entered into a series of 20 separate contracts with plaintiff for road construction. Each contract covered construction of one segment of one continuous road, and all were identical except for the location of the work. The Court viewed this series as constituting one contract for purposes of compliance with the statutory competitive bidding requirement.

Instances of the deliberate splitting of large projects into smaller segments that do not require competitive bidding are relatively few and generally involve some unusual circumstance. Thus, in *Sittig v. Raney*,[29] a county purchased 2,500 cubic yards of crushed stone from a contractor in a series of 12 separate orders, each in a varying amount for use on a different road, and each involving less than the statutory minimum amount. In this case the county initially advertised for bids, but found none acceptable. The county thereafter negotiated directly with plaintiff alone, and, in the Court's view, the resulting series of orders were separate transactions, none of which exceeded the statutory maximum for such procedure.[30]

98

Specialized Personal and Professional Services

Contracts for personal or professional services form another generally recognized exception to mandatory competitive bidding procedures. A leading case on this matter has explained the exception as follows:

> The theory upon which the doctrine rests is that the competitive bidding statutes cannot be rationally or practically applied to contracts for the employment of architects or other persons whose services are required because of the special training, skill, and scientific or technical knowledge necessary to the object to be accomplished. . . . The value of such services is not to be measured by a mere matching of dollars, so to speak; it is not to be determined upon the irrational assumption that all men in the particular class are equally endowed with technical or professional

[28] 125 Tex. 424, 82 S.W.2d 641 (1935).

[29] 53 Cal. App. 709, 200 P. 824 (1921).

[30] *See also*, Fonder v. City of South Sioux Falls, 76 S.D. 31, 71 N.W.2d 618, 53 A.L.R.2d 493 (1955).

> skill, knowledge, training, and efficiency, nor are such services rendered more desirable because afforded more cheaply in a competitive bidding contest. The selection of a person to perform services requiring those attributes calls for the exercise of a wise and unhampered discretion in one seeking such services, for it involves not only those attributes, but the qualities of reputation and personal and professional trustworthiness and responsibility as well. The services of the person selected cannot be squared to, nor his accomplishment circumscribed by, nor forced and expanded to fill, specific measurements, as in cases of contracts for construction, where the service is to be performed, and may be required to be done by accurately ascertainable and designated standards, with specific materials, and in accordance with prescribed plans and minutely detailed specifications; the nature and mode of performance of the services to be done in the employment under the excepted contract are such as to be determinable largely by the professional or scientific person so employed.[51]

These remarks concerned a contract for landscaping, to be carried out in accordance with a general plan, leaving the contractor to select, obtain, and place the plants and other materials on the designated site.[52] Essentially similar views have been expressed about the services of artists;[53] attorneys retained to draft contracts, ordinances, or administrative regulations,[54] or represent the contracting agency in litigation;[55] auditors and accountants;[56] traffic engineers;[57] and real estate appraisers.[58]

Less assurance of coming within the exception exists for an individual hired to supervise actual construction operations. Where services under the contract involve over-all management responsibilities, they generally are held to be within the exception. Again, as in the case of scientific and technical expertise, the courts explain their view in terms of special competence required for the job. For example, in *Gulf Bitulithic Co. v. Nueces County*,[59] the local government employed a contractor to act as its representative to supervise and manage an extensive road construction program. Holding that the contracting agency was not

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[51] State v. McIlhenny, 201 La. 78, 9 So. 2d 467 (1942).

[52] McNichols v. City and County of Denver, 130 Colo. 202, 274 P.2d 317 (1954); State v. Brown, 159 Tenn. 591, 21 S.W.2d 721 (1929); Cress v. State *ex rel.* Flynn, 198 Ind. 323, 152 N.E. 822 (1926); Stephens County v. J. N. McCammon, Inc., 122 Tex. 148, 52 S.W.2d 53 (1932).

[53] Adams v. Ziegler, 22 Cal. App. 2d 135, 70 P.2d 537 (1937).

[54] Jeffersontown v. Cassin, 267 Ky. 568, 102 S.W.2d 1001 (1937).

[55] Neal v. Board of Education, 40 N.M. 13, 52 P.2d 614 (1935).

[56] Cochran County v. West Audit Co., 10 S.W.2d 229 (Tex. Civ. App. 1928).

[57] City and County of San Francisco v. Boyd, 17 Cal. 2d. 606, 110 P.2d 1036 (1941); Flottum v. City of Cumberland, 234 Wis. 654, 291 N.W. 777 (1940).

[58] Parker v. Panama City, 151 So. 2d 469, (Fla. Dist. Ct. App. 1963).

[59] 11 S.W.2d 305 (Tex. Comm'n. App. 1928).

required to award this contract through competitive bids, the Court said:

> If [the statute] be so construed as to bring . . . this case within its provisions, the very object of the statute would be defeated, for the obvious reason that, when a county does a given piece of construction work, paying for the materials and labor, the ultimate cost thereof is necessarily largely dependent upon the skill, experience, and business judgment exercised in the management and supervision of such work.
>
> It would be ludicrous indeed if a county should publish to the world that it desired to let to the lowest bidder a contract to supervise the building of an elaborate road system . . . Under such an advertisement, it might be compelled to place the supervision of this immense construction program and disbursement of this vast sum of money under one of its local road overseers.[60]

Other forms of service connected with construction must be considered on its own merits in relation to this rationale. Where the amount of managerial discretion and responsibility is considered sufficient, the contract will be considered one of a technical or professional nature; where this character cannot be established, the parties must expect to comply with competitive bidding statutes applicable to the contracting agency.[61]

100

Response to Emergencies

Legislation defining competitive bidding requirements may provide for exceptions to accommodate emergency situations in which the temporary necessity for speedy action to protect public safety and welfare overrides the interest in promoting healthy competition in public contracting. Where an exception of this type is formally established, the legislative language controls the scope of the exception and the criteria for applying it. Generally, such statutory definitions have stressed "imminent danger to life or destruction of property," or have contained some similar expression of unforeseen, unusual, and unacceptable hardships or costs.[62]

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[60] 11 S.W.2d at 309-10. *See also*, Krohnberg v. Pass, 187 Minn. 73, 244 N.W. 329 (1932).

[61] Annot., 44 A.L.R. 1150 (1926); Annot., 142 A.L.R. 542 (1943).

[62] ILL. ANN. STAT. ch. 127, § 132.6(a)(3) (Supp. 1976), is somewhat more specific, as follows: "In emergencies involving public health, public safety, or where immediate expenditure is necessary for repairs to State property in order to protect against further loss or damage. . . , to prevent or minimize serious disruption in State services or to insure the integrity of State records."

Federal procurement of supplies and services is also subject to exceptions created by "public exigencies" due to wartime needs for immediate delivery and special performance requirements. United States v. Speed, 75 U.S. (8 Wall.) 77, 19 L.Ed. 449 (1869); American Smelting & Refining Co. v. United States, 259 U.S. 75, 66 L.Ed. 833, 42 S.Ct. 420 (1922).

Judicial interpretation of this language has insisted on the element of surprise, or a showing that preventive measures could not have avoided or lessened the risk. Accordingly, resort to emergency procedures has been approved where evidence showed that immediate action was needed to restore interrupted supply of water, heat, and electricity,[63] or to stop pollution of public water supply.[64] On the other hand, courts have refused to approve exceptions to competitive bidding rules where the purpose was to expedite construction of an addition to a courthouse to accommodate a new judge,[65] or repair roads in spring following a normal winter,[66] or construct a bridge where there was no threat of interruption of transport services.[67]

This aspect of the exception was discussed in some detail in *Safford v. City of Lowell*, as follows:[68]

> [The exception] does not apply to a condition which may clearly be foreseen in abundant time to take remedial action before serious damage to the health or to the safety of person or property is likely to occur. Without doubt, lack of foresight and failure to take proper precaution to meet contingencies which any prudent person would anticipate might occasion a condition which would jeopardize public health and safety, and to which the words of the statute would be applicable. It would be remarkable, however, if the legislators used them to describe such a situation. It is not to be supposed that they intended to make it possible for municipal officers to avoid advertising for bids for public work by merely delaying to take action to meet conditions which they can foresee until danger to public health and safety has become so great that the slight further delay caused by advertising will entail public calamity.[69]

101

In the absence of formal provisions for emergency contracting procedures through legislation, the exception may be implied from the nature of the contract and other provisions of the public contracting law.[70] In such cases, the special circumstances of the case also are influential. Unexpected necessity requiring prompt action must be shown.[71] Economic advantage and convenience for the public agency are not enough, even though the contracting officer believes in good faith that these benefits can be more readily obtained for the public through

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[63] Merchants Nat'l. Bank & Trust Co. v. City of Grand Forks, 130 N.W.2d 212 (N.D. 1964).

[64] Northern Improvement Co. v. State, 213 N.W.2d 885 (N.D. 1973); Los Angeles Dredging Co. v. City of Long Beach, 210 Cal. 348, 291 P. 839 (1930).

[65] Reynolds Constr. Co. v. County of Twin Falls, 92 Ida. 61, 437 P.2d 14 (1968).

[66] Bak v. Jones County, 87 S.D. 468, 210 N.W.2d 65 (1973); Tobin v. Town Council, 45 Wyo. 219, 17 P.2d 666 (1933); Johnson County Savings Bank v. City of Creston, 212 Ia. 929, 231 N.W. 705 (1930).

[67] Green v. Okanogan County, 60 Wash. 309, 111 P. 226 (1910).

[68] 255 Mass. 220, 151 N.E. 111 (1926).

[69] *Id.* at 225, 151 N.E. at 113.

[70] Los Angeles Dredging Co. v. City of Long Beach, 210 Cal. 348, 291 P. 839, 71 A.L.R. 161 (1930).

[71] Annot., 71 A.L.R. 173 (1931).

direct negotiation than through advertisement for competitive bidding.[72]

Where emergency circumstances meet the criteria for an exception to the statutory competitive bidding rules, the extent of the exception and the alternative procedure for use in lieu of normal advertisement and competitive bidding generally are specified in the statute. To the extent the statute sets forth alternative procedures, such procedures must be complied with fully in order to produce valid contracts.

Alternative emergency procedures vary substantially in detail; however, because the need for speedy action is critical in an emergency, a common feature of all such procedures is the temporary suspension of the mandatory requirement for advertisement over a specified period. When freed of this requirement, some highway agencies have found it most advantageous to procure supplies, services, and construction through direct negotiation with contractors whose capabilities are known from past performance. The resulting contracts have the legal status of day-to-day hirings. In some instances, statutory provision for emergencies specify this course.[73] In others, the requirement of competitive bidding is retained in the emergency situation, but the contracting agency is authorized to compress the process into a shorter time period, or negotiate at the discretion of the agency's officials subject to the approval of the contract by the Governor and his Council.[74]

102

In a few cases, special reporting and accounting requirements are established for expenditures of public funds in emergency situations where regular competitive bidding procedure was not followed. An illustration of such procedure is offered by the Illinois Purchasing Act,[75] which applies in emergencies involving public health, public safety, immediate repairs needed to avoid further loss or damage of State property, disruption of State services or the integrity of State records. Under this law, funds spent in emergencies must be reported to the State's Auditor General within 10 days after execution of the contract for those funds, with full details of the circumstances. Quarterly reports by the Auditor General to the Governor and Legislative Audit Commission permit both offices to thoroughly review these transactions and evaluate any apparent abuse of the emergency procedures.

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[72] Reynolds Constr. Co. v. County of Twin Falls, 92 Ida. 61, 437 P.2d 14 (1968); Grimm v. City of Troy, 60 Misc. 2d 579, 303 N.Y.S.2d 170 (Sup. Ct. 1969); Board of Education v. Hoek, 38 N.J. 213, 183 A.2d 633 (1962).

In *Grimm*, a resolution of the contracting agency reciting certain facts and declaring that they constitute an emergency is not conclusive, but is sufficient prima facie evidence of an emergency to shift the burden of proof to the party attacking the validity of the award. Los Angeles Dredging Co. v. City of Long Beach, 210 Cal. 348, 291 P. 839 (1930).

[73] NEV. REV. STAT. § 408.860 (1975).

[74] TENN. CODE § 54-514 (Supp. 1975); ME. REV. STAT. ANN. § 23-753 (Supp. 1976).

[75] ILL. ANN. STAT. ch. 127, § 132.6 (Supp. 1976).

Contracts of Special Nature

Most States recognize contracts for public utility services and contracts for land acquisition as being among the situations in which it is impractical to insist on strict compliance with competitive bidding procedures. Exemption of contracts for supply of electricity, heat, water, and other public utilities from competitive bidding rules generally is explained in terms of the monopolistic nature of the utility and the public regulation of its prices.[76] The anomaly of requiring the parties to these contracts to comply with rules designed to promote open and equal competition among all bidders is readily apparent. Thus, although a few States still do not recognize an exception for utility contracts as a class,[77] some of the factual situations involving public utilities sometimes are brought within the purview of other authorized exceptions.

Another situation in which practical considerations have justified an exception to mandatory competitive bidding involves the purchase of real property for public use. Because the specific site and condition of land are among the chief factors that make it desirable or necessary for public use, the purpose of encouraging competition among suppliers is not served by the kind of bidding provided for in the statutes. Reference to the "uniqueness of land" generally suffices to justify an exception for purchases, rentals, and other acquisitions of land or rights in land.[78] 103

ADVERTISEMENT FOR BIDS

General Requirements for Advertisement

For effective competition to be fostered in bidding on public contracts, two conditions must be created, namely: (1) everyone qualified and desiring to bid on the project under consideration must be adequately informed of it, and (2) all bidders must be given equal opportunity to bid and have their bids considered on the same terms. Statutory and administrative directives relating to public advertisement of projects and invitation to bid must be implemented not only through a formal call for proposals, together with the essential information about how they should be submitted, but also by informing bidders of all the essential features of the work called for.

Like the basic requirement for competitive contracting, the requirement for public advertisement, and the terms on which it must be pro-

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[76] Note, *The Necessity of Competitive Bidding in Municipal Contracts*, 27 U. PITT. L. REV. 117, 121 (1965).

[77] Annot., 128 A.L.R. 168 (1940); Annot., 92 A.L.R. 835 (1934).

[78] Massey v. City of Franklin, 384 S.W.2d 505 (Ky. 1964); Hickey v. Burke, 78 Ohio App. 351, 69 N.E.2d 33, *appeal dismissed*, 79 Ohio St. 217, 70 N.E.2d 274 (1946); Cleary v. Dade County, 160 Fla. 892, 37 So. 2d 248 (1948); Ambrozich v. City of Eveleth, 200 Minn. 473, 274 N.W. 635 (1937).

vided, may be traced to statute law. In the absence of legislation, public advertisement for bids would be entirely discretionary with the contracting agency,[79] and, when utilized would follow procedures designated in the contracting agency's resolution authorizing the contract. Failure to comply with the requirements of such a resolution can defeat the validity of a contract just as surely as failure to comply with procedures specified by statutes or regulations.

Typically, requirements relating to advertisement of public works projects set forth the times, places, and forms of publication of the advertisement. Comparative data on State laws relating to advertisement of invitations to bid on highway construction contracts are given in Table 2. Newspapers of general circulation in the county where the work is to be done are favored as the principal means of advertisement. In several States, however, highway construction and maintenance projects at the county level must be posted at the courthouse or other public place in addition to newspaper advertisement, or in lieu thereof if no newspapers are published in the county where the project is located.[80] Recognizing that contractors may be concentrated in certain urban centers, some States require that projects be advertised in these areas as well as the counties where the work will be done.[81] In addition, it is recognized that contractors often carry on their business in multi-State regions, and may be contacted much more easily through the trade journals of their industry than through local papers where a project is located. Therefore, in about one-third of the States, contracting officers are either directed or authorized to publish notices of their projects and invitations to bid in other newspapers, journals or periodicals capable of giving this information the desired publicity.[82] Other devices for accomplishing this same purpose include publication in an "official newspaper" of the State,[83] and listing in a departmental bulletin published by the State highway agency.[84] A few States specifically authorize

104

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[79] Reiter v. Chapman, 177 Wash. 392, 31 P.2d 1005, 92 A.L.R. 828 (1934).

[80] COLO. REV. STAT. § 43-2-209 (1973); GA. CODE ANN. § 23-1703 (1971); KY. REV. STAT. §§ 178.050, 178.260, 184.110 (1971); MASS. GEN. LAWS ANN. ch. 29, § 8A (Supp. 1976); MICH. STAT. ANN. §§ 16.07, 161.32; MISS. CODE § 65-1-85 (Supp. 1976); OHIO REV. CODE § 5525.01 (Supp. 1974); S.C. CODE § 33-995 (1962); TENN. CODE ANN. § 54-514 (Supp. 1975); TEX. CIV. STAT. art. 2368a § 2 (Supp. 1976); UTAH CODE ANN. § 27-12-108.1 (1976).

[81] CAL. GOV'T CODE § 14290 (West Supp. 1976); IND. STAT. ANN. § 8-13-5-3 (1973); MD. ANN. CODE, art. 89B, § 24 (Supp. 1976); N.J. STAT. ANN. § 27:7-29 (1966).

[82] *E.g.*, ARK. STAT. § 14-611 (1968); GA. CODE § 95A-806; MISS. CODE § 65-1-85 (Supp. 1976); NEB. REV. STAT. § 39-1348 (1974); N.J. STAT. ANN. § 27:7-29 (1966); PA STAT. ANN. tit. 36, § 670-405 (1961); WASH. REV. CODE ANN. § 47.28.-050 (Supp. 1975).

[83] KAN. STAT. ANN. § 68-408 (Supp. 1975); LA. REV. STAT. §§ 48:205, 252 (1965); N.D. CENT. CODE § 24-02-19 (1970).

[84] Ill. Dep't of Transp. *Rules & Regulations*, §§ 1.4-1.6; KY. REV. STAT. §§ 176.050, 176.080; LA. REV. STAT. §§ 48:205, 252 (1965).

notification of contractors directly by mail when projects are opened for bidding. In Montana and Texas, such notification is in addition to newspaper advertisement, and is a service or convenience provided for contractors who request it.[85] However, in Connecticut, this supplementary mailing of construction project announcements is directed to the State's prequalified bidder list.[86]

Current State legislation outlining competitive bidding procedures thus provides a variety of ways of reaching members of the industries, businesses, and professional groups capable of undertaking highway construction projects. Parallel to these activities, which are initiated in accordance with statutory provisions, other practices have developed as unofficial or informal actions in the nature of informational activities of State highway agencies. Commercial publishers also periodically list project announcements and awards of highway construction contracts.

The time for publication of bid announcements must be as scrupulously respected as the place of publication. Generally the times for publication are set forth in statutory language. Where exact dates are not given, the rules must be construed so that the legislative purpose of adequate and reasonable notice is accomplished. In this regard confusion occasionally has arisen over the method of correctly calculating the period over which notices must appear. One typical style of drafting this provision states that the highway agency shall advertise "for two consecutive weeks" in designated newspapers. Assuming proper publication on the 5th and 12th day of a month, the prevailing interpretation of this phrase would call for setting the date for bid opening no earlier than the 20th day of the month. An Ohio court has explained the reason as follows: 105

> In our opinion, the word "for" [means that] such advertisement is required "during the continuance of" or "throughout" the period of two weeks. . . . [I]t follows that two full calendar weeks must elapse subsequent to the date of the first publication before the date fixed for receiving the bids.[87]

Provisions as to time, place, and form of publication of bid announcements are contained in the statutes of all States except Michigan, and the Attorney General of Michigan has given his opinion that when State funds only are involved in a highway project, and there is no special contrary requirement from the State Administrative Board, the State highway commission may or may not advertise, as it sees fit.[88] The opinion states, however, that for work done under the Federal-Aid

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[85] MONT. REV. CODE § 82-1917 (Supp. 1975); TEX. CIV. STAT., art. 6674h (1969).

[86] CONN. GEN. STAT. § 13a-95.

[87] State *ex rel.* Dacek v. Cleveland Trinidad Paving Co., 35 Ohio App. 118, 171 N.E. 837, 840-41 (1929).

[88] MICH. OP. ATT'Y GEN. 2952 at 238 (May 8, 1957).

TABLE 2

PUBLICATION OF INVITATIONS TO BID ON HIGHWAY CONSTRUCTION CONTRACTS

STATE & CITATION	NEWSPAPER NOTICE	PUBLIC POSTING	OTHER REQUIREMENTS
ALA. CODE tit. 50 § 15(1) (Supp. 1973)	Publication once each week for 3 consecutive weeks in newspaper of general circulation in counties where project will be located; also in other publications as deemed desirable.		
tit. 23 § 54 (1958)	County projects: Publication for 30 days in "some newspaper published in the county." If project costs more than $2,500, notice must also be published once a week for 30 days in a daily paper of at least 5,000 circulation published in State.		
ALASKA Dep't Regs.	Publication for 3 consecutive days in daily newspaper of general circulation in Alaska, and in trade journals in Seattle, Wash. and Portland, Ore. Also, publication for 3 consecutive weeks in weekly publications of general circulation in Alaska.		
ARIZ. REV. STAT. 28-1804 (Supp. 1975)	Announcement in a newspaper of general circulation, with two consecutive insertions if paper is a weekly; two insertions not less than 6 nor more than 10 days apart if paper is a daily.		
ARK. STAT. § 14-611 (1968)	Once a week for not less than 2 consecutive weeks in newspaper of general circulation in county where proposed project is located. If no newspaper regularly published in county, then notice in any newspaper having general circulation in that county.		Announcement in trade journal reaching the construction industry.

106

NOTE: Table deleted except for representative sample.

STATE & CITATION	NEWSPAPER NOTICE	PUBLIC POSTING	OTHER REQUIREMENTS
			ments advertisement at least 3 weeks before bid opening, unless shorter period is specially approved.
D.C. Code § 7-601 Material Management Manual § 26-42	Publication of notice in newspaper in Washington, D.C., for all projects in excess of $2,000.	See "Other Requirements" column.	Mailed announcement to current bidders list; published announcement in specified journals and periodicals; and public posting in highway department for not less than 21 days when procuring services for under $1,000,000, and 30 days for procuring services over $1,000,000.
P.R. LAWS tit. 22, § 46 (1964)	Publication of notice in newspapers with largest circulations in Spanish and English languages.		Advertisement in the manner prescribed by Secretary of Public Works, or by federal requirements.

[1] Departmental policy requires advertising four times in newspaper of statewide circulation during the 3 weeks prior to date for receiving bids, and publishing notice at least once in a journal of the construction industry serving New England.

107

Highway Acts, the practice of advertising for competitive bids is followed because federal regulations require it as a condition to the participation of federal funds.

The Attorney General's opinion referred to the fact that federal approval is required before any advertisement for bids or undertaking of bids.[**] In this approval, the Federal Highway Administration (FHWA) requires that a minimum of 3 weeks must be available to bidders before the opening of bids. However, the FHWA Division Engineer is authorized to approve shorter periods in special cases. Ultimately, the question of justification is likely to be a practical one. Longer advertising periods are desirable for large or complex projects that require substantial study and investigation of data before proposals can be developed. In contrast, small, simple problems of construction and main-

[**] Federal Highway Administration, § 6:4:1:6, ¶ 7. *Federal-Aid Highway Program Manual,*

tenance can be prepared and submitted on short notice. The FHWA regulations also realistically recognize that the required "advertising for bids" may include the mailing of notices or other advance information to a suitable list of contractors.[90]

Content of Bid Advertisements

Statutes governing bidding procedure deal variously with the problem of informing prospective bidders of the nature of the work required. A rule of reason suggests that the contracting agency's announcement must be sufficient to indicate the character, quality, location, and timetable of a construction project, or the type, quantity, and delivery requirements for purchases of supplies and construction materials. However, requirements relating to the content of bid advertisements often vary according to the highway system that is involved. Within a State, there usually are separate and different laws regarding State, county, municipal, and turnpike highway systems; and each may have differing provisions regarding the items of information that bid advertisements for its particular highway projects must contain.

Kansas' law relating to contracts of the State highway commission and the county boards of commissioners illustrates the typical differences in mandatory items of information. Kansas law regarding State highway projects requires the notice to

108

> specify with reasonable minuteness the character of the improvement contemplated, the time and place at which the bids will be received, and invite sealed proposals for the same.[91]

For projects undertaken by county boards of commissioners, the Kansas statutes require that the public notice

> specify with reasonable minuteness the character of the improvement contemplated, where it is located, the kind of material to be used, the hour, date and place of letting of such contract, when the work is to be completed, and invite sealed proposals for the same. Such other notice may be given as the board may deem proper.[92]

Similar differences may be seen in the laws of many other States.[93]

In addition to the basic items that are necessary to identify the character and location of the work, some States have added other items in which there is special interest. Examples include notice that prevailing wage rates will be paid to laborers on the job,[94] or that bids

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[90] *Id.*

[91] KAN. STAT. ANN. § 68-408 (Supp. 1975).

[92] KAN. STAT. ANN. § 68-521 (Supp. 1975).

[93] *Compare* S.D. CODE LAWS § 5-18-5 (1974) and § 31-12-14 (1976); NEV. REV. STAT. § 408.865 (1975) and § 403.490 (1973); N.J. STAT. ANN. §§ 27:7-29 (1966), § 52:34-14 (1955), and § 40A:11-23 (Spec. Supp. 1976).

[94] ORE. REV. STAT. § 279.025, referring to § 279.350 (1975).

must lie on the entire project unless the contracting officer formally determines that a separation is necessary,[95] or that bid bonds will be required in specified amounts.[96] It is common, also, for statutes to require that bid invitations reserve to the contracting agency the right to reject all bids if it is deemed appropriate, and to require that the notice include information as to where the project plans, specifications, and other pertinent papers may be inspected. When these additional features are listed in statutes or regulations, they become necessary to the validity of the public notice, and cannot be waived.[97]

Contracts for highway construction in which federal-aid funds are used must comply with certain requirements of federal law or regulations which must be mentioned in the project advertisement.[98] Federal-aid regulations call for specific assurance that State procedures afford all qualified bidders a nondiscriminatory basis for submitting proposals and having such proposals considered. If there are any features of State law which may operate in a manner to prohibit submission of a bid, or prevent consideration of a bid made by a qualified contractor, the project advertisement must state that such features are not applicable to the advertised contract.[99] In addition, all advertisements must advise prospective bidders that, as a condition precedent to federal approval of the contract, the successful contractor must execute and file with the State highway agency a sworn statement that he has not been a party to any collusion or restraint of free competitive bidding in connection with the project.[100] 109

Finally, federal-aid regulations specifically state that bid advertisements shall not be issued until the provisions of regulations and directives covering administration of the Uniform Relocation Assistance Act have been met, and there exists an understanding that satisfactory traffic control devices will be installed before acceptance of the project. In the event these conditions are not met before advertisement of the project, however, federal-aid regulations provide that the advertisement may be issued if it includes appropriate notice that the successful bidder will not be allowed to commence actual construction until these conditions are met.[101]

Beyond these mandatory items of information and specific declara-

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[95] CAL. GOV'T CODE § 14291 (West Supp. 1976).

[96] ARK. STAT. 14-612 (1968).

[97] Ragland v. Commonwealth, 172 Va. 186, 200 S.E. 601 (1939). Plans and specifications placed on file for public inspection or as a reference to bidders become the only authentic and binding specifications. Trinkle v. Commonwealth, 170 Va. 429, 196 S.E. 652 (1938). *See also*, KY. REV. STAT. § 176.070 (1971) and Hall v. Commonwealth *ex rel.* Ferguson, 331 S.W.2d 272 (Ky. 1959).

[98] Federal Highway Administration, *Federal-Aid Highway Program Manual*, § 6:4:1:6, ¶ 7.

[99] *Id.*, ¶ 7(e).

[100] *Id.*, ¶ 7(i).

[101] *Id.*, ¶ 7(h).

tions required by State and Federal law, there is a substantial practical problem regarding how much information can and should be included to describe the specifications of the work to be done. Earlier comparison of language describing requirements for State highway agencies and county governmental bodies suggests that notice of State highway projects is streamlined to avoid construction details. In fact, the prevalent rule for State highway agencies requires that their advertisements tell where plans and specifications for the desired work are available for inspection, or how prospective bidders may acquire copies of these plans by purchase or on loan. As this practice has become accepted, it has had the effect of encouraging advertisements which contain listings of many projects together with standardized items covering matters of general applicability to all the listed jobs. Typically, the items of information for which general declarations can be made include requirements regarding bid bond and federal approval of contracts, notices of predetermination of minimum wage rates and applicability of such rates, notices of the availability and cost of copies of plans and other prebidding information, various affirmative statements required by federal-aid highway regulations, and information about the time and place for filing proposals, with lists of the various documents comprising the proposal package.

110

The practice followed for road and bridge construction supervised directly by the Federal Highway Administration calls for furnishing prospective bidders an official form for submitting their proposals, together with various items of information about the job and the bidding procedure. To the extent possible, the requirements for federal construction are patterned on a comparable set of standards and procedures developed by the State highway agencies,[102] and so have encouraged uniformity and consistency in both the engineering aspects of highway construction and the award and administration of construction contracts. Specifically, the informational requirements of the federal standard bid form are stated as follows:

> Upon request, the Government will furnish the prospective bidder with an Invitation for Bids. This assembly will state the location of the contemplated construction and will include the general requirements and conditions for bidding; the time in which the work must be completed; the amount of the bid guarantee; and the date, time and place of the opening of bids; and any special provisions or requirements which vary from or are not contained in the standard specifications.

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[102] Federal Highway Administration, *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects*, FP-74, (Washington: GPO 1974); Amer. Ass'n of State Highway & Transp. Officials, *Guide Specifications for Highway Construction* (Washington: AASHTO, 3d ed. 1972) [hereinafter cited as *FHWA Standard Specifications*].

> All papers bound with or attached to the bid forms are considered a part thereof and must not be detached or altered when the bid is submitted.
>
> The plans, specifications and other documents designated in the bid forms will be considered a part of the Invitation for Bids whether attached or not.[103]

Identical or substantially similar practices have been adopted in most States for contracts on State highway system projects.

Responsibility for Plans, Specifications, and Technical Information

A common feature of State competitive bidding statutes, and of many municipal charters and ordinances, is the requirement that contracting agencies must prepare plans and specifications for their construction projects, and make these documents available to prospective bidders, along with documentation of other matters capable of assisting bidders in preparing and submitting their proposals. Even without being specifically required by legislation, however, it is generally accepted that the contracting agency's obligation to furnish detailed plans and specifications arises as a necessary implication of the requirement for competitive bidding. The objective of the latter policy, it is argued, cannot be achieved unless bidders are sufficiently well informed of the plans and specifications of the job to permit them to prepare their proposals intelligently.[104] Whether based on statutory language or implication, therefore, the duty to provide plans, specifications, and technical information is strongly rooted in public policy and is consistently enforced by the courts.[105] 111

Understandably, questions arise concerning both the sufficiency of the information supplied by a contracting agency, and the interpretation given to it for planning purposes. The FHWA *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects* warn that quantities appearing in the bid schedule are approximations, prepared to aid the comparison of bids, and may be changed during performance of the work.[106] Special reference is made to geophysical data and information about subsurface conditions at the work site; and prospective bidders are advised to have this information independently evaluated by technically qualified professionals.[107] In explicit language, responsibility for interpretation of subsurface data is placed on the prospective bidder.[108]

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[103] *FHWA Standard Specifications*, FP-74, § 102.02.

[104] COHEN, *supra* note 1, at 10.

[105] *Annot.*, 31 A.L.R.2d 469 (1953).

[106] *FHWA Standard Specifications*, FP-74, § 102.04.

[107] *Id.* § 102.05.

[108] *Id.*, stating "any interpretation of the Government's subsurface investigation record made by the bidder as to the types, characteristics, quantity and quality of any subsurface material or condition shall be at the sole risk of the bidder."

Review of the *Standard Specifications for Road and Bridge Construction*, published by the various State highway and transportation agencies, shows a similar pattern of statements relating to the interpretation of plans, specifications, and technical information, in some instances going so far as to require bidders to examine the site of the proposed work as well as the technical documents describing the work required.[109]

Notwithstanding these disclaimers, State laws and regulations have emphasized the goal of opening up the bidding process to competition among all bidders on equal terms, including information about the job. Most States appear to have approached this matter in the spirit expressed in Alaska's Standard Specifications Manual, namely:

> The Department will prepare full, complete, and accurate plans and specifications giving such directions as will enable any competent mechanic or contractor to carry them out.[110]

When courts have been called on to determine whether this duty has been met, they have appeared to adopt somewhat the same pragmatic approach, and when the situation did not readily permit more precision or detail, they have found that the duty has been met by "substantial compliance." A Texas decision summarizes this view as follows:

112

> The omissions pointed out above constituted mere irregularities to be corrected, at the instance of any particular property owner . . . interested in having the correction made. If the word "complete" . . . be given the meaning and effect contended for here, it would follow that jurisdiction would be lost if the specifications were deficient in the most trivial respect, for they would not be "complete." Such a technical meaning cannot be reasonably ascribed to the term, in the connection in which it is used in said charter provision. Considering the nature of the document called for, it is reasonable to believe that a substantial compliance with said provision is all that was meant to be required as a basis for jurisdiction, even should it be granted that the said provision was meant to be mandatory.[111]

The foregoing remarks were made regarding a set of specifications that omitted measurements for certain parts of an area to be paved by a contractor. In other cases, deficiency of descriptive information has been alleged regarding size or capacity of equipment being purchased.

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[109] *E.g.*, Del. Dep't. of Highways & Transp., *Standard Specifications for Road and Bridge Construction*, § 102.04 (Jan. 1974); Nev. Dep't of Highways, *Standard Specifications for Road and Bridge Construction*, § 102.05 (1968); Wis. Dep't of Transp., *Standard Specifications for Road and Bridge Construction*, § 102.04 (1969); Alaska Dep't of Highways, *Standard Specifications for Road and Bridge Construction*, § 102-1.05 (1972) [hereinafter cited as Alaska, *Standard Specifications*].

[110] Alaska, *Standard Specifications*, § 102-1.05.

[111] Scanlan v. Gulf Bitulithic Co., 44 S.W.2d 967, 970 (Tex. Comm'n App. 1932).

In *Otter Tail Power Co. v. Village of Elbow Lake*, also, the Court was chiefly concerned with the actual effect of the language on the bidder's ability to write his proposal, saying:

> The court has found that the plans and specifications were sufficiently definite and precise to afford a basis for competitive bidding. Witnesses for the respective parties differed as to the range above the minimum of 1200 horsepower which would be reasonable. They all admitted that some range would be reasonable. The question was one of fact, and the evidence sustains the court's finding.[112]

Specifications that do not suffer from vagueness may, at the other extreme, become so restrictive as to preclude effective competition among bidders. This has been charged, for example, where only one bidder could meet the competitive price level set in the project specifications. Yet the Court held that this did not make the specifications too restrictive to permit competition. In adopting specifications for equipment, a highway agency may provide for competition among types of equipment as well as prices.[113] Similarly, in contracts for services, competition may be based on skill and experience for a stated price or price level. The discretion of the contracting agency in drafting specifications for work normally will not be overruled unless it is shown to be arbitrary, oppressive, or fraudulent.[114]

The form and style in which plans, specifications, and technical information are prepared are influenced more by customs of industry and practices of the contracting agency than by conventions and rules of judicial origin. In many cases, each phase of the construction called for in the project—such as earthwork, concrete, structural steel, masonry, carpentry, and the like—is treated in a separate section. Likewise, equipment and machinery used in the work will be described separately; and each category of basic materials will have its own section.[115] Although no fixed rules prescribe the organization of these elements, there is a preference for arranging them as closely as practicable to the sequence of the construction operations. In all cases the draftsman should bear in mind that whatever method is used must present the plans and specifications in a manner that enables any bidder relying on them to determine what is required in all important details of the work.[116]

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[112] Otter Tail Power Co. v. Village of Elbow Lake, 234 Minn. 419, 425, 49 N.W.2d 197, 202 (1951).

[113] *Id.*

[114] Koich v. Cvar, 111 Mont. 463, 110 P.2d 964 (1941); Brener v. City of Philadelphia, 305 Pa. 182, 157 A. 466 (1931).

[115] R. ABBETT, ENGINEERING CONTRACTS AND SPECIFICATIONS, at 397-8 (New York: John Wiley & Sons, 4th ed. 1963) [hereinafter cited as ABBETT].

[116] State *ex rel.* Hoeffler v. Griswold, 35 Ohio App. 354, 172 N.E. 438 (1930); Superior Incinerator Co. v. Tompkins, 37 S.W.2d 391 (Tex. Civ. App. 1931), *aff'd* 59 S.W.2d 102 (Tex. Comm'n App. 1933).

In preparing project plans and specifications, the draftsman must also consider how his description of materials and methods will facilitate the inspection and testing that is required during the construction and prior to acceptance of the finished work. For projects involving major highways or structures, there is no practical way to determine by a single test or series of tests of the finished work whether it will perform its intended function throughout its expected service life. Therefore, it is customary to control the quality of materials and workmanship by testing components as they are assembled and installed. For most types of materials and construction, standard specifications and test procedures have been developed and published by the contracting agencies. In this published form, they are incorporated by reference into project plans and specifications, subject to special provisions or modifications which pertain to the project and are set forth specifically.

For highway and bridge construction undertaken directly by the Federal Government and by State agencies under federal-aid funding programs, standard specifications for materials and workmanship provide accepted criteria for preparation of bids and, subsequently, evaluation of results. However, specifications expressed in terms of over-all performance may still be used for certain items of equipment or machinery which may readily be tested prior to use by the contractor. Various types of heavy equipment, pumps, motors, generators, and other accessories may be considered as being necessary to qualify a contractor for particular work. In such cases, performance specifications for these items are frequently used, sometimes in conjunction with the additional requirement that the equipment or other items be warranted by the contractor or manufacturer to perform as proposed.

114

In somewhat the same manner that performance specifications are used, the contracting agency may designate certain materials, products, or processes by standard brand names. Such designation is feasible where the items are obtainable on the open market and have been standardized by commercial use. In these cases, however, specifications must be drafted carefully because of the competitive aspects of patented or proprietary products and processes.

If care is exercised to assure that clear reference points are provided in the description of materials and workmanship, project specifications are not weakened by authorizing a measure of discretion by the contractor in selection of materials and performance of construction. This generally is done by use of the term "or equal" when describing quality or enumerating materials or methods. It may also be done by stating "or other methods satisfactory to the Engineer," or ". . . commercial grades shown on the plans . . . and acceptable to the Engineer." Although such terms introduce elements of discretion or negotiation into the standards of performance, they are controlled by the context of the language and the nature of the tasks involved; and for certain aspects of construction projects their use is not only feasible but also necessary as a form of expression.

Alternate Bids

Where engineering problems can be solved by alternative means, the contracting agency may face a dilemma in preparing its plans and specifications. The goal of competitive bidding is to achieve economy in construction costs, and engineering judgment may honestly differ on the best way to achieve this goal. Rather than designate one particular method of construction or one list of materials that must be used, contracting agencies may ask for proposals on alternative approaches, specifying only the end result, and leaving it to the bidders to select materials, methods, and other aspects of their bids. In some cases, this approach has official status in directives to the contracting officer to solicit proposals on all feasible methods as a basis for awarding a contract. In others, the highway agency's governing legislation may not mandate the solicitation of alternative bids, but may accord the contracting officer the authority to proceed in this way where circumstances make it desirable.

An illustration of the issues raised by another type of alternate bidding is provided by *L. G. DeFelice & Son, Inc. v. Argraves*,[117] involving contracts for construction of the Connecticut Turnpike. In his notice to prospective bidders, the highway commissioner requested alternate bids, one for construction of reinforced concrete and one for bituminous concrete pavement, stating that the type of pavement to be used would be determined after bids had been received, and all factors, including costs, had been fully investigated. Plaintiff was the low bidder on bituminous concrete, and in this bid was lower than the lowest bidder on reinforced concrete paving. Accordingly, when the highway commissioner awarded the contract to the low bidder for the reinforced concrete paving, plaintiff sought to enjoin the award as being contrary to the legal requirement for award to the lowest responsible bidder. The Court denied the injunction, stating 115

> [T]he great weight of authority supports the proposition that the awarding official may exercise his discretion to determine after the receipt of alternative bids which alternative to select and to select the lowest responsible bidder under that alternative. . . . The court will not interfere with the exercise of discretionary powers vested in a public official in the absence of fraud, corruption, improper motives or influences, plain disregard of duty, gross abuse of power or violation of the law.[118]

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[117] 19 Conn. Supp. 491, 118 A.2d 626 (Super. Ct. 1955).

[118] *Id.* at 496, 118 A.2d 628. *See also:* Automatic Merchandising Corp. v. Nusbaum, 60 Wis. 2d 362, 210 N.W.2d 745 (1973); Mayer Bros. Constr. Co. v. Erie Parking Auth., 187 Pa. Super. 1, 149 A.2d 495 (1959); Leskinen v. Pucelj, 262 Minn. 461, 115 N.W.2d 346 (1962).

The Connecticut court stresses the significance of statutory language granting the contracting agency discretion in calling for bids and selecting the lowest responsible bidder. A California law which required solicitation of alternate bids in certain types of construction work provides a different setting for use of discretion.[119] In mandamus proceedings to compel solicitation of alternate bids,[120] the contracting agency's defense of its call for only one type of pavement brought the following comment:

> They argue that they came to the honest conclusion, as a result of engineering reports, that the physical conditions—adverse soil, hill cuts, and fills, were unsuitable for Portland cement pavement. If that type were used, they say, it would be necessary for the contractor to go to such excessive expense in preparing the subgrade and in overcoming other adverse conditions that he could not possibly do it at a figure which would compete with the contractor using the asphalt type. They concluded that the preparation of alternate plans and specifications would be an idle act, resulting in needless extra expense.[121]

The California Supreme Court was not persuaded by this reasoning, and rejected it as nullifying the clear intention of the legislature. The purpose of the statutory requirement, the Court said, was to eliminate favoritism and artificially maintained equality between producers, and to make the choice of pavements a result of free competitive bidding between two recognized superior materials. Applying this to the facts of the case, the Court continued:

116

> If the department substitutes its own judgment on costs, the benefits of such competition are lost. The judgment of the department may be an entirely honest one. . . . But under the statute, an honest opinion that one type of pavement will cost more than another cannot be the basis of the department's action. Physical conditions alone are committed to the discretion of the respondents.
>
> We may concede that in an exceptional case, where the costs of overcoming adverse conditions would be so unusually high that it would be foolish to expect any competition, the department might be justified in dispensing with alternate bids. . . . In such a case the physical conditions may be said to require one type, since those conditions could not be changed save at unreasonable expense.[122]

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[119] CAL. POL. CODE § 365s½ (1933): "Whenever any highway paving work is to be done by contract under the control and direction of the Department of Public Works . . . and in the judgment of said department the conditions do not require the use of a particular type of pavement, the said department shall cause to be prepared alternate plans and specifications contemplating the use of all such materials as are adopted as standard for high-type paving by the Division of Highways and acceptable to it. The department . . . shall then advertise and call for bids for the doing of such work based on the use of such alternate materials and . . . shall proceed to the award of a contract to the lowest qualified bidder. . . ."

[120] Landsborough v. Kelly, 1 Cal. 2d 739, 37 P.2d 93, 96 A.L.R. 707 (1934).

[121] *Id.* at 745, 37 P.2d at 95–96.

[122] *Id.* at 745–46, 37 P.2d at 96.

Whether or not contracting agencies must prepare for alternate bids thus depends on the statutory or charter provisions governing each particular case. Careful examination of legislative language is warranted since it is evident that courts are strict in their construction of any grants of discretion which appear likely to weaken the vigor of competition among contractors on public construction projects.[123]

Instances of genuine alternate bidding should be distinguished from situations in which plans and specifications give unusually broad discretion to bidders to select construction methods and materials, and so permit differing end products in performance of the contract requirements. For example, where an advertisement for bids to install a public lighting system specified "Westinghouse metallic flame arc lamps or 'any other modern lighting system equally as good,' " the Court rejected the argument that the language constituted an invitation to submit alternate bids. The Court viewed the advertisement as undermining free competition, and increasing the risk that favored contractors might load public improvements with inferior materials at excessive prices.[124] In another instance, descriptions of varying specifications were treated as being issued for public information, and not intended as a basis for bidding. In still another case, an alternate bid call appeared to have been used solely as a device to disclose information about the merits of certain paving materials, after which the contracting office rejected all bids and readvertised the contract under specifications for one particular form of paving.[125] 117

PREPARATION OF BIDS

Eligibility of Bidders

Where eligibility requirements are imposed on bidders by State law, they generally have involved compliance with contractor licensing and prequalification rules. The scope and major characteristics of these laws as they relate to State highway construction are discussed in "Licensing and Qualification of Bidders" (Vol. 3, Ch. VI, p. 1043, *supra*). Application of these rules to the preparation of bids deserves specific notice, however, because such rules may vary depending on whether State or Federal funding is involved.

If federal-aid highway funds are to be used in a project, federal regulations provide that no contractor shall be required by law, regulation, or practice to obtain a license before he may submit a bid or have that bid considered.[126] However, this prohibition is not construed to prevent

[123] Annot., 96 A.L.R. 712 (1935); Annot. 79 A.L.R. 225 (1932).

[124] Jenkins Township v. Public Service Comm'n, 65 Pa. Super. 122 (1916).

[125] Wester v. Belote, 103 Fla. 976, 138 So. 721 (1931); City Street Improvement Co. v. Kroh, 158 Cal. 308, 110 P. 933 (1910).

[126] 23 C.F.R. § 635.108 (1976).

States from requiring the successful bidder to obtain a business or professional license upon or immediately after the award of a contract, if such a requirement is in fact consistent with competitive bidding. The rationale of this rule is rooted both in the constitutional doctrine that States may not subject nonresident contractors to requirements that impede their bidding and so create a barrier to interstate commerce, and in the practical consideration that licensing serves no purpose in the bidding phase of a public works project.

In contrast, State requirements that all bidders must be prequalified by or for the contracting agency as a condition to submission of a bid and award of a contract are recognized as having a direct relationship to determination of the lowest responsible bid; and federal regulations permit States to apply this requirement to both resident and nonresident contractors desiring to bid on a project involving federal-aid highway funds. These regulations emphasize, however, that where prequalification is required, the State must allow sufficient time between the call for bids and the opening of bids to allow all potential bidders an opportunity to be certified after a full and appropriate evaluation of the contractor's experience, personnel, equipment, financial resources, and performance record.[127]

118 Licensing and prequalification requirements may apply to subcontractors as well as prime contractors, and requirements regarding subcontractors may be specified in the advertisement of a project, or incorporated by reference or implication into the rules of bidding. Eligibility of bidders may also be conditioned on maintaining a certain division of work among prime and subcontractors. In projects using federal-aid highway funds, federal regulations require that a prime contractor must perform at least 50 percent of the total contract work with personnel of his own organization.[128]

Another requirement imposed on bidders in federal-aid highway projects is derived from federal legislation designed to eliminate conflicts of interest. This law provides that, as a prerequisite to approval of a State highway contract for participation of federal-aid funds, the successful bidder must submit a sworn statement of his freedom from any conflict of interest, collusion, or restraint of competition in connection with such contract.[129] In practice, this statement is called for at the time bids are submitted, and has become a prerequisite to acceptance of the bid for consideration.

Loss of eligibility to bid on highway construction projects may result from various causes set forth in State laws or regulations relating to

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[127] *Id.*

[128] 23 C.F.R. § 635.113 (1976), providing that "specialty items" of work may be designated in the specifications for subcontract and deducted from the total contract job before computing the amount of work that the prime contractor must perform by his own organization.

[129] 23 U.S.C. § 112 (1970).

licensing, prequalification, and conflict of interest. Suspensions or other forms of withdrawal of eligibility are based entirely on statutory or administrative authority and procedures. Accordingly, they are construed strictly, for not only are they considered as being regulatory in nature, but also disqualification of one or more major contractors may have the practical result of significantly reducing the number of contractors capable of performing certain types of construction, and thus may actually reduce competition for the State's contracts.[130]

Form of Bid

Single or Separate Contracts

Public works agencies customarily have wide discretion as to when to subdivide a project and award separate contracts for each segment or component of the work. Their decision in this matter may directly affect the number and type of bidders for the contract. However, it is recognized that sometimes compelling economic, engineering, and financial reasons influence an agency's decisions regarding advertisement and award of contracts. As long as these considerations are reasonable, courts have tended to uphold the contracting agency's actions.[131]

If, however, the specifications issued by the contracting agency result in biasing the bidding, or otherwise impairing free competition in the selection of public contractors, the award may be enjoined or nullified or the agency may be required to reject all bids and readvertise on more appropriate terms. Accordingly, a project for installation of traffic signals may not be divided arbitrarily into separate contracts for procurement of materials, equipment, and labor where these items are all components of an integrated construction job, and the evident purpose of the separation is to keep each contract under the statutory minimum price for requiring competitive bidding.[132] 119

On the other hand, where these items are not necessarily integrated in the type of construction work called for, they may be provided under separate contracts. Specialty work frequently is sufficiently different from basic construction tasks to warrant separation of contracts; and separate contracts have also been upheld for construction of two similar facilities where the projects were to be paid for from separate fund sources.[133]

In a reverse situation, where statute law provides that street improvements authorized under separate ordinances must be undertaken as

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[130] See reference to effects in Wisconsin of disqualification of several major paving contractors because of conspiracy. See note 15, *supra*.

[131] Annot., 123 A.L.R. 577 (1939).

[132] Nat'l Electr. Contractors Ass'n, Puget Sound Chapter v. City of Bellevue, 1 Wash. App. 81, 459 P.2d 420 (1969).

[133] Daves v. City of Madelia, 205 Minn. 526, 287 N.W. 1, 123 A.L.R. 569 (1939); Gibson v. Owens, 115 Mo. 258, 21 S.W. 1107 (1893).

separate projects, municipal authorities have been allowed to include a series of such projects in a single contract in order to take advantage of economies obtainable in the performance of excavation and grading.

Many of the rulings regarding segmentation of projects for bidding purposes occurred in the late nineteenth century. At this time the beginnings of modern urban growth were accompanied by a rapid evolution of the legal framework for carrying out the new and expanded role of local government in public works. A rich variety of factual situations, and a wide range of statutory and city charter provisions on competitive bidding, assured that most applications of the principle of reasonableness were tested in court. Modern highway construction programs, however, make greater use of standard specifications and procedural manuals, and, as a result, the room for discretionary combining or splitting of projects for bidding is reduced. Standardization of competitive bidding practices along lines that courts and contractors agree are reasonable, feasible, and do not weaken the process of procurement by competition, has also contributed to stabilizing this aspect of bid preparation.

Lump Sum versus Unit Price Bids

120 Another aspect of bidding that is determined by the contracting agency is whether bids shall be submitted in the form of a lump sum for the entire project or a series of prices for units of work or materials. Lump sum bids are favored where construction jobs involve a variety of operations and it is impractical to break down the work into a few basic units of materials and labor. Many kinds of structures fit these criteria and lend themselves to lump sum bidding. Ultimately, however, the success in use of this method requires complete and accurate specifications and detailed work plans. Failure to provide full guidance on these technical matters increases the risk of excessively high bids as bidders hedge risks they cannot evaluate.

Unit price bidding is favored where a project requires large quantities of relatively few standardized materials and construction operations, or where, in addition, the exact quantities of materials and labor are not ascertainable in advance. Moreover, when bidding is on a unit price basis, reasonable variations often may be made in the work without the necessity of executing formal change orders. This flexibility applies only to items originally covered in the contract, however, and if material discrepancies occur between the estimated and actual quantities required for the work it is customary to reconsider the original contract.

Bidding forms issued by State highway agencies use both these methods according to the need for stating the bid fully and firmly. Typically, items covering excavations are listed in terms of a stated number of cubic yards; subgrade preparation is listed in square yards; base

course, subgrade, seal coat, and cement are listed in tons; culvert pipe in linear feet; and so on, as necessary to provide units of measurement to which unit prices can be applied.

Standardization of specifications for modern State highway construction programs has almost entirely eliminated cases in which bidders are asked to furnish their own specifications for the work in question; but it has not entirely eliminated other causes of confusion in preparing bids. One such cause of confusion may be a contracting agency's reservation of the right to award contracts on only a part of the total work described in the bid advertisement. A discussion of this matter is provided by the Massachusetts court in *Devir v. Hastings*,[134] where municipal authorities requested bids for resurfacing four named streets, but reserved the right to award contracts for less than the total number. The bid advertisement specified that bids must be submitted on a per yard basis, and it was argued that the agency's reservation deprived bidders of a common basis for such a unit price bid. The court saw it differently, however, and felt that prospective bidders could determine both the minimum and maximum amounts of material needed, and so could compete on an equal footing.

A variety of conditions raising the same issue may be found in bid advertisements at all levels; however, as long as they do not nullify all bases for competitive bidding and leave it to each bidder to furnish his own specifications, the essential criterion of competitive bidding statutes would seem to be met.[135] 121

Joint Ventures and Subcontractors

Where construction work is carried out under a single contract, unusually large or complex projects may require assembling financial resources and administrative or technical manpower on a scale greater than any single contractor can provide through his own efforts, or through his own staff plus the use of subcontractors. A practical accommodation of the rules of competitive bidding to the needs of contractors and contracting agencies is offered in the practice of accepting bids from several contractors acting in a joint venture. In this type of bid, groups of contractors combine their assets, plant, and personnel in a joint effort to perform the work called for in a specific contract.

In many respects joint ventures are similar to ordinary business partnerships.[136] In both forms of organization the parties share the work, the prospects of profits, and the risks of loss. In both, the terms on

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[134] 277 Mass. 502, 178 N.E. 617 (1931).

[135] Sweezey v. Mayor of Malden, 273 Mass. 536, 174 N.E. 269 (1931); Annot., 79 A.L.R. 225 (1932).

[136] Bradbury v. Nagelhus, 132 Mont. 417, 319 P.2d 503 (1957), stating: "Broadly speaking, a joint adventure may be characterized as a quasi-partnership . . . undertaken for mutual gain."

which the parties share the responsibilities and results of the work are set forth in written agreements. The chief difference between joint ventures and partnerships is that joint ventures are created to perform one specific job, whereas partnerships are continuing arrangements. In the matter of remedies available to the parties in the event of a dispute, contrasting approaches have been used. Among partners, the usual remedy is for the aggrieved partner to sue for an accounting; but among joint venturers, one may sue the others for breach of the contract defining the terms of their cooperative undertaking, or for contribution to the plaintiff's losses.[137]

Although corporations may join with individuals in joint ventures, it is customary to see joint ventures created among corporate contractors, and dealings with individuals handled as subcontracts. Under such arrangements, all details of the subcontractor's work are defined in his agreement with the prime contractor. The prime contractor is responsible to the contracting agency for the performance of the subcontract along with the rest of the contract work except as to those requirements which State or Federal law imposes directly and individually on both the prime contractor and the subcontractor. An example of such a requirement is the Contract Work Hours and Safety Standards Act,[138] which requires both the prime and subcontractors to comply with federal standards for hours of work.

122

Limitations are placed on the extent to which subcontracting may be used in contracts for highway construction involving federal-aid funds. Federal Highway Administration regulations specify that prime contractors must perform at least 50 percent of the total contract price with their own organization personnel. The regulation states, however, that if any of the contract work requires "highly specialized knowledge, craftsmanship or equipment not ordinarily available in the type of contracting organizations qualified and expected to bid on the contract as a whole," such work may be designated as specialty work and may be deducted from the total contract price before computing the proportions designated for prime and subcontractors to perform.[139]

Subcontracts and joint ventures are subject to scrutiny to assure that they are genuine, for either technique can be abused and become a threat to fair competition. It is contrary to public policy for bidders on a public works project to agree that some of them will refrain from bidding in favor of others. Joint venture bidding is permitted under this procedure so long as it is a bona fide cooperative effort among its parties. In judging the acceptability of a joint venture bid it is suggested that

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[137] Alpine Constr. Co. v. Gilliland, 23 Mich. App. 275, 178 N.W.2d 530 (1970); Goss v. Lamm, 170 Ia. 57, 152 N.W. 43 (1915).

[138] 40 U.S.C. §§ 327–333 (1970).

[139] 23 C.F.R. § 635.113 (1970).

> The size of the contract, the financial ability, the 'know-how,' and the experience to perform certain portions of the work, together with the ownership of proper equipment, are reasonable and honest factors to support a voluntary combination of rival contractors.[140]

Joint venture bids must fully disclose the terms of the cooperative effort the parties will undertake. Secret agreements under which several contractors undertake to share the work, risks, and profits of a project are not proper or enforceable, regardless of whether they result in a single bid for the parties to the arrangement or separate bids by all parties according to a prearranged plan.[141]

Federal-aid highway regulations and the laws of several States require disclosure of intended subcontractors as part of a prime contractor's bid on a project covered by those rules. The purpose of these requirements, however, is not so much to assure free competition in bidding as to assure compliance with laws requiring licensing of contractors and subcontractors working on public works projects. Occasionally, the provisions of State laws requiring disclosure of subcontractors specify in detail how disclosure shall be made, and how subcontracting shall be arranged to prevent violation of contractor licensing laws.[142] More often, however, the authority to require disclosure of subcontractor use in bids is considered to be implicit in general provisions of licensing statutes[143] as a countermeasure to the acknowledged evils of bid shopping and bid peddling in public works programs.[144] 123

Joint venture bids have the advantage of pooling the capacity of several contractors and allowing prequalification for projects which no one of them is capable of performing individually. When such bids are filed, therefore, it is customary for the bid to indicate what percentage of the dollar amount of the contract should be debited against the prequalification capacity rating of each joint venturer. Where bidders do not allocate the proportions to be debited, the contracting agency must make this determination as it deems to be in its own best interest. Apportionment of the prequalification capacity rating debit among the parties to a joint venture bid does not in any way divide the responsibility of each for the execution and performance of the project contract if it is awarded to them.[145]

Balanced and Unbalanced Bids

Where project advertisements specify that bids must be expressed in unit prices, contracting agencies must be prepared to deal with unbalanced bids. The distinction between balanced and unbalanced bids

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[140] COHEN, *supra* note 1, at 62.

[141] Hoffman v. McMullen, 83 F. 372 (9th Cir. 1897).

[142] *E.g.*, CAL. GOV'T CODE §§ 4104-4107, 4109.

[143] *See*: ARIZ. OP. ATT'Y GEN. 61-9 (Feb. 21, 1969).

[144] *See*: CAL. GOV'T CODE § 4101.

[145] Fla. Dep't of Transp., *Information for Contractors*, § 9-10 (Jan. 3, 1972).

lies in the extent to which the unit price assigned to each bid item realistically reflects the item's share of the total cost or work. A balanced bid carries its full and correct share of the total price; an unbalanced bid does not, so that some items are overpriced and others are low or only nominally priced. Thus, without changing the total price, a contractor may arrange the unit prices for the specifications of a project so as to achieve unusually favorable, and sometimes unintended, results.

The attractiveness of unbalanced bidding in certain situations is easy to visualize. A contractor who needs to build up or recoup his working capital as soon as possible may unbalance his bid by setting high prices on items of work performed early in the project. In this way the contractor can ease the financial strain incurred in mobilizing his construction plant and equipment, and purchasing materials, and the general costs of starting up the project—all expenses which the contractor otherwise could not expect to liquidate until the work progressed over a substantial period of time. There is, however, a risk to the public if this practice is abused. An unscrupulous or unqualified bidder may unbalance his bid in a way that results in excessively high payments early in the work, only to have the contractor default and leave his surety or the contracting agency to finish the project and pay for those items that were underestimated in the bid.[146]

124

Unbalanced bidding also may be used where a bidder believes that the contracting agency's estimates for quantities of certain items are low, and that these quantities will have to be increased as the work progresses.[147] In such circumstances the contractor can increase his profits by unbalancing his bid in favor of these items without increasing the total price of his proposal. In other instances, inaccurate estimates may work to the disadvantage of a contractor, because any substantial increase or reduction in the quantity of materials or work after construction operations have commenced may distort the factors which determine a contractor's actual cost, so the unit price submitted in his bid is thrown out of balance, with resulting loss of profits.

Because of these possibilities for unanticipated profits or losses, and

[146] ABBOTT, *supra* note 115, at 160; COHEN, *supra* note 1, at 53-58.

[147] Interpretation of estimates used in the contracting agency's specifications is subject not only to unavoidable risks of inaccuracy due to the nature of the project, but also to denials of responsibility by the agency. Many State highway agencies follow the practice of the Federal Highway Administration, which includes the following statement in contract bidding instructions:

> The quantities appearing in the bid schedule are approximate only and are prepared for the comparison of bids. Payment to the contractor will be made only for the actual quantities of work performed in accordance with the contract. The scheduled quantities of work to be done and materials to be furnished may each be increased, decreased, or omitted as hereinafter provided. Bid schedule quantities will be considered the original contract quantities. *FHWA Standard Specifications*, FP-74, § 102.04.

the susceptibility to fraud and collusion, unbalanced bids are not favored, and bidding specifications sometimes provide for permissive rejection of unbalanced bids.[148] In this way, unbalanced bidding may be scrutinized case-by-case, and its effect on the cost to the contracting agency can be analyzed. This approach is to be preferred to outright prohibition of unbalanced bidding, for courts have stated that unbalanced bids are not per se fraudulent, nor are they always evidence of substantial error. The rule appears to be that

> An unbalanced bid that does not materially enhance the aggregate cost of the work cannot be complained of. If there is no deception or mistake as to the quantities, and if the ordinances have fairly been complied with, and the quantity and quality of the work has been estimated as nearly as practical, there is no ground for alleging substantial error merely because of an unbalanced bid under which the contract was let, and if the cost of the work has not thereby been enhanced, there is no ground for alleging fraud.[149]

It is always to be hoped, of course, that cooperation between the contractor and the contracting agency will prevail to eliminate the risk of unfair practice and minimize the area in which inaccuracies exist. Such a policy is sometimes set forth in the State highway agency's own standard specifications, and in this form it serves as a standard of business conduct which may be considered in licensing and prequalifying prospective bidders.[150] 125

Bidding on Alternatives

Where contract specifications call for bidding on alternative materials or methods of work, such specifications sometimes have been challenged as being inadequate for competitive bidding. Where bidding on alternatives is permitted, the contracting officer has the advantage of comparing the bidders on a range of materials and technical aspects, as well as on price; and it is to be expected that greater economy for the contracting agency will result. Bidders may feel, however, that the call for consideration of alternatives introduces unnecessary elements of uncertainty into the preparation and submission of bids. Notwithstanding this, State statutes and local charters and ordinances sometimes require alternate plans and specifications for bidding whenever, in the contracting agency's judgment, the circumstances do not require use of

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[148] Armaniaco v. Borough of Cresskill, 62 N.J. Super. 476, 163 A.2d 379 (App. Div. 1960).

[149] *In re* Anderson, 109 N.Y. 554, 17 N.E. 209 (1888). *See also* Pearlman v. City of Pittsburgh, 304 Pa. 24 155 A. 118 (1931).

[150] *E.g.*, Nev. Dep't of Highways, *Standard Specifications*, § 105.04, (1968) stating: "The Contractor shall take no advantage of any apparent error or omission in the plans or specifications. In the event the Contractor discovers such an error or omission, he shall immediately notify the Engineer. The Engineer will then make such corrections and interpretations as may be deemed necessary. . . ."

a particular type of material, design, or construction process. Where these statutes are clearly and positively stated, they have been held to be reconcilable with the requirement of competitive bidding.[151]

Modification of alternative bidding where a contracting agency deems it desirable to designate certain materials as mandatory for certain types of facilities also has been upheld, as illustrated in *Landsborough v. Kelleu*.[152] There, a statute requiring the State Department of Public Works to prepare alternative plans and specifications for bids on paving projects was held to contemplate use of all materials which are suitable for "high type paving," but was subject to the highway division's engineering judgment as to when a specific highway should have a particular type of highway paving material or treatment. In approving the agency's specification that bituminous concrete and portland cement concrete would be the only materials accepted as "high type paving," the Court stated that the criteria for designating certain alternatives as acceptable for bidding were primarily physical rather than economic. Neither initial costs nor maintenance expenses could be considered proper grounds for limiting the range of materials or methods on which bids are invited.

Whether asking for alternate bids or modified alternatives, the contracting agency's specifications must be full, accurate, and complete as
126 to each of the alternatives; and they must be presented in a manner that allows opportunity for free competitive bidding on each alternative. Meeting these criteria, these methods of calling for bids are reconcilable with the principles of competition.[153] Under the best of circumstances, however, efforts at completeness and accuracy are subject to variances and discrepancies that occur inadvertently in the specifications. Where such discrepancies are discovered, a rule of reason applies. If they fail in some material aspect to inform potential bidders of the terms on which bids will be compared or performance required,[154] the specifications are defective, and any contract awarded on them is subject to cancellation.

Bidding on alternative specifications may be accomplished on separate proposal forms or in a single consolidated form. Instructions on the preparation of bids must be followed fully and exactly. Where a single combined bid form is used, it is customary for the instructions

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[151] Barber Asphalt Paving Co. v. Gaar, 115 Ky. 334, 73 S.W. 1106 (1903); City of Baltimore v. Flack, 104 Md. 107, 64 A. 702 (1906); Johnston v. City of Hartford, 96 Conn. 142, 113 A. 273 (1921); L&M Properties Co. v. Burke, 152 Ohio St. 28, 86 N.E.2d 768 (1949).

[152] 1 Cal. 2d 739, 37 P.2d 93 (1934).

[153] Brener v. City of Philadelphia, 305 Pa. 182, 157 A. 466 (1931); City Street Improvement Co. v. Kroh, 158 Cal. 308, 110 P. 933 (1910); Wester v. Belote, 103 Fla. 976, 138 So. 721 (1931); Vowles v. Town of Kenwood Park, 198 Ia. 517, 199 N.W. 1009 (1924).

[154] State *ex rel.* Hoeffler v. Griswold, 35 Ohio App. 354, 172 N.E. 438 (1930).

to require that all spaces must be filled, and all items of information must be furnished for each alternative. Failure to comply with this requirement exposes the bid to the risk of rejection because of its irregularity.[1]

As with other formal defects in bid preparation, the contracting officer has some discretion in the matter of waiving variances and omissions which do not adversely affect the freedom and genuineness of bid competition. He cannot, however, construe a bid in a manner that is contrary to the bidder's evident intent. Thus, where a contracting agency attempted to accept only part of an offer which the bidder intended to be a single combination bid, it was held that the bidder's intention to submit a combined bid should prevail despite his use of a form which could be construed differently.[156]

Mandatory Provisions

Where statutes, regulations, or policies of the contracting agency require that certain provisions must be included in all the agency's construction contracts, they generally are incorporated into standard forms which all bidders must use. Typically, some of these provisions are concerned with procedures to be followed during performance of the contract so that administrative processing will be facilitated; others impose positive duties on the contractor in the performance of the contract which may affect his methods of operation, and therefore must be reflected in his bid. 127

Examples of both types occur in the required provisions for federal-aid highway construction contracts.[157] Requirements for keeping records and making reports on acquisition of materials, supplies, and labor illustrate the type of provisions dealing with contract administration.[158] Requirements that contractors comply with provisions of federal environmental protection laws [159] and federal labor standards [160] illustrate factors which must be considered in calculating bid prices. Contracts for direct federal construction projects require compliance with the Buy American Act [161] and the Walsh-Healy Act.[162]

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[1] COHEN, *supra* note 1, at 60.

[156] Consolidated School Dist., No. 22 v. Frey, 11 Wis. 2d 434, 105 N.W.2d 841 (1960).

[157] FHWA Form PR-1273 (Rev. 9-75) "Required Contract Provisions: Federal-Aid Construction Contracts."

[158] *Id.*, § VI

[159] *Id.*, § X, referring to the Clean Air Act, 42 U.S.C. § 1857, as amended by Pub. L. No. 91-604, the Federal Water Pollution Control Act, 33 U.S.C. § 1251, as amended by Pub. L. No. 92-500, and Executive Order 11738, 40 C.F.R. pt. 15.

[160] *Id.*, §§ II, III, and IV, concerning equal opportunity, nonsegregated facilities, and payment of predetermined minimum wages.

[161] 41 U.S.C. §§ 10a-10d (1970); Executive Order No. 10582.

[162] 41 U.S.C. §§ 35-45 (1970).

State legislation has occasionally imposed limitations on the preparation of bids which raise questions regarding unconstitutional interference with interstate commerce. Early consideration of State laws requiring contractors to give preference to local construction material usually took the view that such laws were discriminatory against material produced outside the State, and therefore a restraint of trade. The New York Court of Appeals explained this view:

> It is a regulation of commerce between the states which the legislature had no power to make. The citizens of other states have the right to resort to the markets of this state for the sale of their products, whether it be cut stone, or any other article which is the subject of commerce. . . . Under the Constitution of the United States, business or commercial transactions cannot be hampered or circumscribed by state boundary lines, and that is the effect of the statute in question.[163]

The cases that have raised this issue have presented a wide range of situations, and factual differences have distinguished permissible preferences from prohibited practices.[164] Arizona's law relating to award of public works contracts illustrates a type of preference that has been upheld. With respect to contractors, it provides:

128

> Bids of contractors who have satisfactorily performed prior public contracts, and who have paid state and county taxes within the state for not less than two successive years immediately prior to submitting a bid . . . shall be deemed a better bid than the bid of a competing contractor who has not paid such taxes, whenever the bid of the competing contractor is less than five per cent lower, and the contractor making a bid, as provided in this section, which is deemed the better bid, shall be awarded the contract.[165]

The constitutionality of this act was upheld in *Schrey v. Allison Steel Manufacturing Co.*,[166] with the Arizona Supreme Court speaking as follows:

> All discrimination or inequality is not forbidden. Certain privileges may be granted some and denied others under some circumstances, if they be granted or denied upon the same terms, and if there exists a reasonable basis therefor. . . . The principle involved is not that legislation may not impose special burdens or grant special privileges not imposed on or granted to others; it is that no law may do so without

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[163] People *ex rel.* Treat v. Coler, 166 N.Y. 144, 59 N.E. 776 (1901).

[164] *See*, Allen v. Labsap, 188 Mo. 692, 87 S.W. 926 (1905), holding there was no objectionable restraint of trade where State law requiring that stone for public buildings be cut and dressed within the State.

[165] ARIZ. REV. STAT. § 34-241 (1974). *See also*, ARIZ. REV. STAT. §§ 34-242, 243 (1974), applying 5 percent preference to locally manufactured materials and local dealers. See ARIZ. OP. ATT'Y GEN. 62-36 (R-67) (Oct. 31, 1962) and ARIZ. OP. ATT'Y GEN. 67-24 (R-110) (Oct. 16, 1967).

[166] 75 Ariz. 282, 255 P.2d 604 (1953).

> good reason. . . . [A] statute may be allowed to operate unequally between classes if it operates uniformly upon all members of a class, provided the classification is founded upon reason and is not whimsical, capricious, or arbitrary.[167]

This decision has been interpreted as allowing State legislatures to regulate public construction contracts so as to protect or promote legitimate public interests, provided constitutional standards of reasonableness and equal treatment are satisfied.[168] In the *Schrey* case, the question of unreasonable burdens on interstate commerce appeared to be secondary to the question of whether the State law could be reconciled with constitutional requirements that public contracts must be awarded to the lowest responsible bidder. In other instances, this same issue has been raised by language that had the effect of restricting performance of the work in question to unionized employees. Whether the legitimate public interest in avoiding strikes and labor disputes in public works construction projects can lawfully be protected by this means may depend on when the limitation is applied in the bidding process. If it is used to screen out bidders after there has been a general open competitive bidding, it would seem to violate the principles of contract competition.[169]

Required Use of Patented Materials and Exclusive Sources 129

The principles of fair competition are subjected to further tension where contracting agencies specify in their bid invitations that the work must be performed with certain designated materials or processes. Where specifications require use of materials or processes that are patented or otherwise obtainable only from exclusive sources, it is arguable that monopolistic control over one element of the contract's specifications could easily lead to rigging of the bids.

No question is raised over the right of the contracting agency to prescribe the terms of the contract's performance, or the right of federal agencies to insist on the inclusion of particular terms in construction contracts paid for in part by federal grants-in-aid.[170] The problem is with the risk of misuse of these privileges. Early State court decisions generally aligned with the "Wisconsin view" or the

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[167] *Id.* at 286; 255 P.2d at 606.

[168] COHEN, *supra* note 1, at 16. *See also:* Del. Dep't of Highways, *Policy Implement* § 6914, Re: Use of Delaware Labor.

[169] *See, however:* Pallas v. Johnson, 100 Colo. 449, 68 P.2d 559, 110 A.L.R. 1403 (1937); Burland Printing Co. v. LaGuardia, 9 N.Y.S.2d 616 (Sup. Ct. 1938); State *ex rel.* United Dist. Heating, Inc. v. State Office Building Comm'n, 124 Ohio St. 413, 179 N.E. 138 (1931). See, also: Annot., 3 A.L.R.3d 864 (1965).

[170] Campbell v. School District, 328 Pa. 197, 195 A. 53 (1937); Eckerle v. Ferris, 175 Okla. 107, 51 P.2d 766 (1935).

"Michigan view" of this question. The difference in these two approaches was explained thus:

> The keystone of the argument in support of the Wisconsin line of cases is that where the statute requires competitive bidding, after advertising, as a condition precedent to the power of the municipality to contract for street improvements, the statute is violated when the . . . contract specifications require the use of a patented or monopolized article, because there can be no real competition when the bidding is practically restricted to the individual or corporation controlling the patent: on the other hand, the fundamental reason supporting the Michigan line of cases is that, even where the statute requires competitive bidding, it . . . does not apply, when all the competition is allowed which the situation permits, that a municipality should not be denied the right, for the benefit of its citizens, to avail itself of useful inventions and discoveries, even though protected by patents; and that, when a city exercising its power to make the public improvements in good faith decides to contract for the use of patented articles, there is created no monopoly and no abatement in competition beyond what necessarily results from the rights and privileges given the patentee by the federal government.[171]

In the field of highway construction, contracts for paving and procurement of paving supplies have furnished a large proportion of the
130 examples of patent and monopoly problems. The period 1920 to 1960 was one of noteworthy progress in this aspect of engineering; numerous patentable improvements were developed, and highway agencies naturally sought to obtain the benefits of their use. The weight of authority gradually swung to a position of approving the specification of patented or exclusive source items, provided there is no intent thereby to restrict the competition among bidders.[172] In addition, practical safeguards against hardships in preparing bids often are provided by the contracting agency through advance agreements with owners of patented products or exclusive sources to allow their use by all bidders on equal terms.[173]

Bid Security Deposits

Official bid forms customarily advise bidders of requirements for furnishing a security deposit at the time their bid is submitted. The purpose of such deposit is to assure that the bidder is acting in good faith, and that if his bid is successful he will enter into the contract offered to him and furnish the necessary bonds for performance and payment for labor and materials.

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[171] Dillingham v. Mayor, Etc., of City of Spartanburg, 75 S.C. 549, 56 S.E. 381 (1907).

[172] Hoffman v. City of Muscatine, 212 Ia. 867, 232 N.W. 430 (1930); Eckerle v. Ferris, 175 Okla. 107, 51 P.2d 766 (1935); Taylor v. County Board, 189 Va. 472, 53 S.E.2d 34 (1949).

[173] Annot., 77 A.L.R. 702 (1932).

As it relates to highway construction contracts, the requirement for bid security often is set forth in statutory terms; in other instances, it is contained in the State highway agency's standard specifications for road and bridge construction. These sources typically specify the amount of the deposit, either as a percentage of the total amount of the bid, or a fixed dollar amount determined by the contracting agency, and the acceptable method or methods of providing the security. In most instances, the statutes and regulations also specify how security deposits will be released or returned to the unsuccessful bidders.

A comparative summary of State statutes and regulations relating to bid security deposits is given in Table 3, p. 1191, *infra*.

Where security requirements are satisfied by furnishing a surety bond, the surety's obligation typically covers the difference between the amount of the bid and the amount the contracting agency must pay to another contractor to perform the work covered by the bid.[174] Where security requirements are met by deposit of check or bank draft, a specific dollar sum is posted, and is subject to forfeiture in the event the bidder fails to execute the contract awarded to him.[175]

Whether bid security deposits are penalties or liquidated damages has frequently been questioned. Language used in the formal instruments describes these security deposits in various ways. Sometimes deposits are described as liquidated damages defraying added costs to the contracting agency due to delay and other inconveniences;[176] in other instances the instructions simply state that the deposit will be "forfeited" if the bidder fails to enter into a contract.[177] The language of these forms has not, however, been considered conclusive proof of their intention or effect. When questions of enforcement have arisen, courts have tended to allow the circumstances to govern each case; and forfeiture of security deposits have been avoided where unusual hardship or inequity would result.[178]

Although much of the reported litigation over interpretation of bid security requirements arises from circumstances where mistakes are

131

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[174] *E.g.*, Conn. Dep't of Transp., Form CLA 6, Ed. 6/72 "Standard Bid Bond"; Va. Dep't of Highways, Form C-24 (Rev. 1-6-71) "Proposal Bond."

[175] *E.g.*, Tex. Dep't of Highways, Form 419A, Rev. 9-69 "Proposal to State Highway Comm'n."

[176] *Id.*, stating that if the successful bidder fails to execute a contract "the check shall become the property of the Commission, and shall be considered as payment of damages due to delay and other inconveniences suffered by the Commission on account of failure to execute contract."

[177] *E.g.*, Minn. Dep't of Highways, Form 21126D (Rev. 1-72) "Proposal Guaranty"; N.H. Dep't of Public Works & Highways, "Proposal Form," (9-20-74).

[178] *Compare:* Brendese v. City of Schenectady, 194 Misc. 150, 85 N.Y.S.2d 856 (Sup. Ct. 1947), *aff'd*, 273 App. Div. 831, 75 N.Y.S.2d 884, *aff'd*, 297 N.Y. 965, 80 N.E.2d 355 (1948); Frank W. O'Connell, Inc. v. County of Broome, 198 Misc. 402, 98 N.Y.S.2d 1009 (Sup. Ct. 1950).

claimed, some involve deliberate refusal to execute a contract because of alleged failure of contracting agencies to initiate certain actions necessary to permit performance. Thus, where a successful bidder had cause to believe the contracting agency would not be able to furnish the right-of-way needed, he delayed executing a contract on the project. Ultimately, he was obliged to forfeit his deposit, however, when the Court took the position that the contracting authority had ample legal authority to obtain the right-of-way through condemnation, and was under no obligation to actually acquire the land in advance of the contract.[179] The Court's ruling was consistent with the generally held view that, unless conditional terms are set forth and accepted in the bid, the bidder is not relieved of his contractual duty under the bid merely because he may believe that the contracting agency will not be able to perform its part of the contract.[180]

SUBMISSION OF BIDS AND AWARD OF CONTRACT

Authority of Contracting Agencies

Procedures for submission of bids and award of contracts for public works projects are based on statutory provisions or, for local agencies, on provisions of charters and ordinances. The validity of a contract award depends on strict compliance with these legislative directives. In some instances, legislation has described in detail the steps that bidders and agencies must take in moving from bid filing to contract award; but normally these procedural requirements are promulgated as administrative regulations under authority delegated by the legislature.[181] Where this latter approach is used, the delegated authority is subject to the explicit condition that the award must be made to the "lowest responsible bidder," and an implicit requirement that all rules should be designed to strengthen free and open competition among qualified bidders. Where administrative rules show reasonable compliance with these standards, they have withstood challenge as unconstitutional delegations of rulemaking authority.[182]

132

The process of receiving, recording and accepting bids, determining the lowest responsible bidder and awarding a contract on the basis of such determination has been characterized as being judicial or quasi-judicial in nature, and not merely a ministerial function. Accordingly,

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[179] Coonan v. City of Cape Girardeau, 149 Mo. App. 609, 129 S.W. 745 (1910).

[180] COHEN, *supra* note 1, at 35-36.

[181] *Compare:* KAN. STAT. ANN. § 68-410 (Supp. 1975) authorizing the State Highway Commission to make all necessary rules and regulations covering the making and receiving of bids and letting of contracts, and TEX. CIV. CODE, art. 6674i (1969), with TENN. CODE § 54-516 (1968).

[182] If the opportunity for genuine competitive bidding is provided it is immaterial that many bidders may fail to submit bids. Hunt v. Fenlon, 313 Mich. 644, 21 N.W.2d 906 (1946).

TABLE 3

SECURITY REQUIRED FOR BIDS ON HIGHWAY CONSTRUCTION CONTRACTS

STATE & CITATION	AMOUNT OF SECURITY	FORM OF SECURITY	TERMS FOR RETURN OF SECURITY
ALA. CODE tit. 50, § 15 [illegible] 15-4 (1958)	5% of awarding authority's estimate of cost, to $1[illegible]	Certified check or surety bond	All guaranties, except three lowest bona fide bids, returned "immediately after proposals have been checked, tabulated, and the relation of the proposals established." Guaranties of lowest three bidders returned as soon as contract and contract bond executed.
ALASKA Std. Specs §§ 101-2.07 103-1.04	Contracts of $10[illegible] or less: 10% of bid; contracts of more than $100,000: 5% of bid, or, amount specified in bid invitation.	Surety bond, postal money order, certified check, or cashier's check	Guaranties, other than bid bonds, returned to all bidders except the two low bidders "as soon as practicable" after bid opening. Guaranties of two lowest bidders returned "immediately after" execution of contract and contract bonds
ARIZ. REV. STAT. § 34-201 (1974)	5% of amount of bid	Certified check or cashier's check.	Checks returned to unsuccessful bidders following opening of bids.
ARK. STAT § 14-612 (1968) Dep't Regs	Amount specified in bid invitation	Surety bond, or bank draft, certified check or cashier's check drawn on a solvent bank.	All guaranties, except two lowest bidders, returned "immediately" after opening and checking of bids. Guaranties of two lowest bidders returned within 10 days after award completed.
CALIF. GOV'T CODE §§ 14314, 14334 (West 1963)	10% of amount of bid	Certified check, cashier's check, cash or surety bond.	Returned to unsuccessful bidders within 10 days following award, except second and third lowest bidders' guaranties retained until contract executed.
COLO. REV. STAT. §§ 43-1-105, 43-1-106 Std. Specs § 102.08, 103.04	Guaranty in an amount specified in bid invitation, or 5% of engineers' estimate	Surety bond, certified check, or cashier's check	Returned to unsuccessful bidders "immediately" following opening and verification of bids.

133

NOTE: Table deleted except for representative sample.

TABLE 3—Continued

STATE & CITATION	AMOUNT OF SECURITY	FORM OF SECURITY	TERMS FOR RETURN OF SECURITY
§§ 102.08, 103.03	dicated in bid invitation.	State Highway Department's form	
VA. CODE § 33.1-186 (1970); Std. Specs §§ 102.08, 103.04	6% of bid amount if surety bond is used, 5% of bid amount if certified or cashier's check is used.	Certified check, cashier's check, or surety bond.	Returned to unsuccessful bidders immediately after opening and checking bids, except two lowest bidders, whose security returned within 5 days after execution of contract and issuance of contract bonds.
WASH. Std. Specs.	5% of bid amount.	Certified check, cashier's check, surety bond, or cash.	Returned to unsuccessful bidders after contract award.
W. VA. CODE § 17-4-19 Std. Specs. §§ 102.8, 103.4	Amount specified in bid invitation, but not less than $2,000 nor more than 5% of bid.	Certified check, cashier's check, or surety bond.	Returned to unsuccessful bidders immediately following opening and checking of bids, except security of two lowest bidders returned within 10 days after award.
WIS. Std. Specs. §§ 102.8, 103.4	Amount specified in bid invitation.	Certified check, bank draft, cashier's check, postal money order.	Returned to unsuccessful bidders promptly after bids checked, except two lowest bidders whose security retained until contract executed by contractor.
WYO. Std. Specs. §§ 102.08, 103.04	Amount specified in bid invitation.	Certified check, cashier's check, or bank money order.	Returned to unsuccessful bidders immediately following bid opening, except security of second lowest bidder is returned after check of bids. Security of low bidder returned after execution of contract.
D.C. Std. Contr. Provisions, art. 12	Not less than 5% of bid amount.	Certified check, surety bond, or negotiable securities (United States bonds)	Returned to unsuccessful bidders after award of contract.
P.R. Dep't Instr.	5% of total bid amount.	Certified check, postal money order, cashier's check, or surety bond.	Returned to unsuccessful bidders immediately after opening and checking bids, except security of two lowest bidders returned within 10 days after contract award.

[1] Although GA. CODE ANN. § 95A-809, uses the terminology shown here the actual practice in Georgia is to return the security to unsuccessful bidders upon award of contract to the low bidder. Letter, State Transportation Office Engineer, August 11, 1976.

[2] Certificate of deposit, cashier's check, or certified check may be used only to maximum deposit of $40,000. HAWAII REV. STAT. § 103-28.

courts have been cautious about overruling contracting authorities in the exercise of discretion; and as a rule such decisions are not upset except where it is shown that fraud, deceit, or flagrant abuse of discretion has prejudiced the competitive bidding.[153] Within a wide range of lawful methods of implementing applicable statutory standards, administrative discretion is permitted to control selection of the lowest responsible bid, just as it is accepted in determining the prequalification of bidders. As in the case of prequalification of bidders for highway construction projects, courts reserve the right to intervene where it appears that abuse of discretion may threaten the policy of competitive award of public contracts.

Submission, Opening, and Acceptance of Bids

Requirements designating the time and place for filing bids, and the form of the bid, are set forth in the contracting agency's regulations or "standard specifications" and in the instructions issued with the proposal form. Full compliance with these formal requirements is essential; and contracting agencies, either by statute or by their own rules, generally reserve the right to reject any bid which fails to adhere to these requirements. Courts have upheld these technical requirements as mandatory for both bidders and contracting agencies, and have taken the position that such requirements may not be waived for one bidder unless other bidders receive the benefit of similar modification of rules.[154] It is customary for State highway agencies to require that proposals be submitted on official bid forms which include specific instructions as to the time and place for submission of bids, and warn that proposals received after the time and date designated will be returned to the bidder unopened.[155] 135

Bidding statutes and regulations normally specify that bids shall be opened in a public session which all bidders may attend. The rule on opening of bids in accordance with the terms set forth in the advertisement of the project and bidding instructions, together with a corollary requirement that the award will be announced at that time or within a specified or a reasonable time thereafter, are mandatory duties which contracting agencies owe to bidders.[156] Postponement of scheduled bid openings and contract awards without strong justification, therefore, may be challenged as abuse of administrative discre-

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[153] Annot., 80 A.L.R. 1382 (1932).

[154] Hawaii Corp. v. Kim, 53 Hawaii 659, 500 P.2d 1165 (1972).

[155] *However, see:* Gostovich v. City of West Richland, 75 Wash. 2d 583, 452 P.2d 737 (1969), holding that where a bid was mailed more than 24 hours before the time for bid opening, and there was no suggestion of fraud or undue competitive advantage, the bid could be accepted despite its late arrival.

[156] The time for execution of a contract may be specified by statute, as in TENN. CODE § 54-516 (1968).

tion. Generally, the need to introduce changes in project specifications, or to enable bidders to evaluate and reflect such changes in their bids, has been the most readily accepted justification for postponement.[187]

The rules regarding acceptance of bids which do not fully and precisely meet all formal requirements set forth in regulations and instructions are positive and explicit: bids that are technically defective or deficient must be considered "irregular" or "informal," and may be rejected. The rules calling for rejection of irregular bids are generally stated in permissive terms. As a result, the possibility of waiver of technical defects always is present. However, the courts recognize a distinction between nonmandatory bidding requirements that can be waived and mandatory requirements that cannot be waived without impairing the essential competitive nature of the contract award.

The distinction between waivable and nonwaivable bidding requirements sometimes may be spelled out in the language of applicable statutes; but frequently such distinction must be discerned through a careful evaluation of the actual impact of the irregularity.[188] Commentators have noted that sound adjudication of these cases, like sound administrative practice, recognizes that frequently bids are prepared under circumstances that increase the chance of innocent error. It is common for bidders to wait as long as possible before the filing deadline to complete their bids, for by so doing they may be able to take advantage of late price changes for materials. In other instances, this longer time also may be used beneficially to analyze the project specifications and verify the technical data upon which the contracting agency has based its estimates. Preparation and submission of bids under pressure increases the danger of many types of error. Typical of the irregularities that may have to be evaluated by contracting agencies are the following:[189]

136

- Bid is not signed or is not dated.
- Bid papers do not acknowledge the bidder's receipt of changes in plans, or additions to specifications.
- Bidder does not include lists of his current equipment, or a description of previous experience, or an updated financial statement.
- Arithmetical errors occur in estimating materials, or extending unit prices to derive total prices.
- Bid papers are not submitted in the required number of copies.
- Prices are not quoted for all items of a lot where specifications indicate that bids will be considered only for all items of a lot.

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[187] Yonkers Contracting Co. v. Tallamy, 283 App. Div. 749, 127 N.Y.S.2d 646 (1954).

[188] Coleman *ex rel.* State v. Munger, 84 Ohio App. 148, 83 N.E.2d 809 (1948); A. A. B. Electr., Inc. v. Stevenson Public School Dist., 5 Wash. App. 887, 491 P.2d 684 (1971)

[189] ABBETT, *supra* note 115, at 158.

- Prices submitted are for an alternate item in lieu of an item specified.
- Bidder does not include his plan of operating with his bid.

Many of these irregularities cannot adversely affect the competitive bidding process. Others, such as failure to submit a plan of operation or an updated financial statement, might affect a contract award under prevailing circumstances. A positive approach is indicated in Cohen's review of the decisions on this matter; he advises:

> In the reasonable exercise of the power of determining to waive an inconsequential informality and to accept the bid, or to reject it because of the informality, the public official who is clothed with that power must first explore the importance of the informality, and then give consideration to the rights of the public whom he represents, and the effect of his action upon the other bidders. Experience has disclosed that sound administrative policy is implemented in a practical manner, by reliance upon inflexible standards in the bidding procedure that are invoked with uniformity and assurance.[190]

More serious difficulties may arise when bids do not conform fully or precisely to the plans, terms, or specifications in the project announcement. When bids are at variance with these aspects of the project announcement it is unlikely that the contracting agency will receive the end product it desires, and also it is not possible to compare all bidders on a common set of work standards. Thus, when bids do not coincide with advertised plans, terms, and specifications, but still offer an acceptable end product, the logic of the law would seem to require that such bids be treated as counterproposals which are not responsive to the advertisement.[191] 137

Although logic argues for rejection of all bids that vary from the terms of the project advertisement, in practice the character and consequences of a bid's variance influence the disposition of the bid. Where the variances are minor, and the bid conforms substantially to the specifications, courts have held that acceptance of the bid as originally submitted does not destroy the competitive character of the bidding.[192] Rejection appears to be required only where the bid variance would create a substantial difference between the terms of the bid and the announced specifications of the project.

The reasonableness of this accommodation makes it readily acceptable in theory; but difficulties arise in practical application of the rule to individual cases, for variances may be produced in a wide range of fact situations. The reported cases have concerned all major types of specifications—quantity, quality, and condition of materials; schedules

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[190] COHEN, *supra* note 1, at 46.

[191] Maryland Pavement Co. v. Mahool, 110 Md. 397, 72 A. 833 (1909).

[192] Pascoe v. Barlum, 247 Mich. 343, 225 N.W. 506, 65 A.L.R. 833 (1929); Bader v. Sharp, 36 Del. Ch. 89, 125 A.2d 499 (1955).

for work and deliveries; geometric and structural design, organization of work—and numerous special provisions;[193] and they have disclosed a wide variety of language used in both bids and specifications.[194]

The courts have approached these cases with a pragmatic objective of preventing situations in which any bidder is allowed to bid in a way that gives his proposal an advantage that is not also enjoyed by the other bidders.[195] The impact on bid prices is, therefore, the pivotal point in distinguishing allowable and prohibited variances; and those which have minimal effect or no effect on price are permitted to remain in the competition for contract award. It is not important to the rule that the variant bid might provide an additional benefit to the contracting agency; if it contemplates a material change, and thus departs from the basis on which the other bids are evaluated, the variance must be rejected.[196]

Change of Specifications Following Advertisement

It is customary for the contracting agency to reserve the right to change its plans or specifications for a project whenever the public interest requires it. If such changes are made after the execution of a contract, alteration of the contract's terms must be accomplished by issuance of a formal "change order," and, if necessary, the contract price must be adjusted. Procedures for negotiation and issuance of such changes are set forth in published standard specifications for road and bridge construction in all States, and for direct federal construction projects.[197]

138

This same rule does not, however, apply to changes of plans or specifications announced before a contract is awarded and signed. The project announcement and bidders' proposals are considered to be only invitations and offers, either of which may be changed or withdrawn without penalty prior to the opening of bids and contract award.

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[193] Annot., 65 A.L.R. 835 (1930); Annot., 69 A.L.R. 697 (1930); Annot., 114 A.L.R. 1437 (1938).

[194] *E.g.*, Miller v. City of Oelwein, 155 Ia. 706, 136 N.W. 1045 (1912), wherein the bid was for using bitulithic (or its equal) pavement. Also, in Lupfer v. Board of Chosen Freeholders, 87 N.J. Eq. 491, 100 A. 927 (1917), specification merely called for a bridge with a bascule span in the center.

[195] Duffy v. Village of Princeton, 240 Minn. 9, 60 N.W.2d 27 (1953); Pascoe v. Barlum, 247 Mich. 343, 225 N.W. 506 (1929); Orr v. Mann, 208 Ky. 46, 270 S.W. 491 (1925).

[196] Inge v. Board of Public Works, 135 Ala. 187, 33 So. 678 (1903), contractor assumption of legal liability for damages resulting from work; Miller v. Incorporated Town of Milford, 224 Ia. 753, 276 N.W. 826 (1937), extended schedule for work.

[197] *FHWA Standard Specifications*, FP-74, § 109.03. *See also:* Wis. Div. of Highways, *Standard Specifications*, §§ 104.2-5 (1969 ed.); Nev. Dep't of Highways, *Standard Specifications*, § 104.02, 104.03 (1968 ed.); Del. Dep't of Highways, *Standard Specifications*, §§ 104.02-3 (1974 ed.).

Certain limits, however, are placed on an agency's reserved right to make changes during the bidding process. A change announced unilaterally by the contracting agency after advertisement of a project must not give any bidder or group of bidders an unfair advantage; nor may the contracting agency include in the contract any provision benefiting the contractor that was not within the terms or specifications that were the basis for the bidding.[199] Extensions of time for performance, and agreement to accept substitute materials or modified designs are common types of changes that test the application of this rule.[199] Where the change made in the originally announced terms or specifications is substantial, the validity of the competitive award can be preserved best by readvertising the project for bids giving consideration to the changed terms.

Determination of Lowest Responsible Bidder

Almost without exception State statutes specify that highway construction contracts shall be awarded to the "lowest responsible bidder."[200] Generally, also, this term is used without any qualification or language reserving the contracting agency's right to exercise its discretion.[201] A few State statutes contain criteria for selection of successful bidders, and typically have referred to consideration of "conformity with specifications, terms of delivery, quality and serviceability."[202] In addition, an extensive series of court decisions provide a working definition of "lowest responsible bidder" which fits the pattern formed by these statutes and reflects the interests of the public and the capabilities of contract administration techniques.[203]

Judicial interpretations of "lowest responsible bidder" emphasize the equal importance of each element of the phrase. One frequently

139

[199] Miller v. Incorporated Town of Milford, 224 Ia. 753, 276 N.W. 826, 114 A.L.R. 1423 (1937); Robert G. Lassiter & Co. v. Taylor, 99 Fla. 819, 128 So. 14, 69 A.L.R. 689 (1930); Jonathan Clark & Sons Co. v. City of Pittsburgh, 217 Pa. 46, 66 A. 154 (1907).

[199] Annot., 69 A.L.R. 697 (1930); Annot., 114 A.L.R. 1437 (1938).

[200] States which do not have this provision are Michigan, COMP. LAWS ANN. § 123.501 (discretion of Highway Commission) and Iowa, IOWA CODE ANN. § 314.1 (Supp. 1976) (bid price considered with experience, equipment, and performance of similar work).

[201] *But see*, ALA. CODE tit. 50, § 15(5) (1958); S.D. COMP. LAWS § 31-5-10 (1976); DEL. CODE tit. 29, § 6907 (1974).

[202] ILL. ANN. STAT. ch. 127, § 132.6 (Supp. 1976). *See also:* IOWA CODE ANN. § 314.1 (Supp. 1976); MINN. STAT. ANN. § 16.07 (Supp. 1976); N.H. REV. STAT. ANN. § 228:4 (Supp. 1975); N.Y. HIGHWAY LAW § 38 (McKinney Supp. 1976); N.D. CENT. CODE § 24-02-23 (1970); IND. STAT. ANN. § 8-13-5-6 (Supp. 1976), requires that bid be not more than 5 percent of estimated cost.

[203] COHEN, *supra* note 1, at 80-84. *See also:* Netherton, "Licensing and Prequalification of Bidders" (Vol. 3, Ch. VI, p. 1043, *supra*).

cited case, *Ingr v. Board of Public Works*,[204] explains the criteria for contract award as follows:

> In deciding upon the responsibility of bidders, it is the duty of the board or officers not only to take into consideration the pecuniary ability of bidders to perform the contract, but also to ascertain which ones, in point of skill, ability, and integrity, would be most likely to do faithful, conscientious work, and to fulfill the terms of the contract. The determination of who is the lowest bidder, with the qualification of responsibility, rests not in the exercise of an arbitrary, unlimited discretion of the officer or board awarding the contract, but upon the exercise of a bona fide judgment, based upon facts tending reasonably to the support of such determination.[205]

Bidder responsibility thus includes a wide range of factors beyond the capacity to supply labor and materials, and may involve business morality,[206] the relative merits of a proposed piece of work as a prudent investment of public funds,[207] or the bidder's previous performance on similar contracts.[208]

Most of these factors bearing on a contractor's ability to perform satisfactorily can be (and generally are) discovered in the processes of licensing and prequalification. Thus, instances in which a contracting agency rejects the lowest-priced bid in favor of a higher-priced offer occur because the rejected bid fails to meet some technical specifications of the project. Responsiveness to the advertised specifications is an essential element of the competitive bidding process, and the contracting agency's duty to assure compliance with this requirement may be enforced either by a bidder who is passed over or by a taxpayer having standing to challenge the agency's action.[209]

140

A contracting agency may, of course, reject all bids received for a particular project, and readvertise the contract. Although it is arguable that this authority is implicit in the agency's general power to select the lowest responsible bidder, the authority of State highway agencies to reject all bids generally is set forth in statute law.[210] Therefore, actions challenging the use of such authority tend to look for violations of agency procedures or actions that exceed the scope of the

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[204] 135 Ala. 187, 33 So. 678 (1903).

[205] *Id.* at 198, 33 So. at 681.

[206] Trap Rock Industries, Inc. v. Kohl, 59 N.J. 471, 284 A.2d 161 (1971).

[207] Clayton v. Salt Lake City, 15 Utah 2d 57, 387 P.2d 93 (1963).

[208] Hanson v. Mosser, 247 Ore. 1, 427 P.2d 97 (1967); Board of Comm'rs v. Davis, 92 Kan. 672, 141 P. 555 (1914).

[209] Robert G. Lassiter & Co. v. Taylor, 99 Fla. 819, 128 So. 14 (1930), variance in paving material. *See also*, Annot., 65 A.L.R. 835 (1930); Annot., 69 A.L.R. 697 (1930); Annot., 114 A.L.R. 1437 (1938); Annot., 27 A.L.R.2d 917 (1953).

[210] In the absence of a legislative reservation of the right to reject all bids, courts have recognized that public authorities have this right implicit in their contracting authority. *See*, Annot., 31 A.L.R.2d 469 (1953).

contracting officer's lawful discretion. Both of these issues were present in *Charles L. Harney, Inc. v. Durkee*[211] which arose out of bidding on construction of San Francisco's Bayshore Freeway. Three competent, reputable, and prequalified contracting firms bid on the freeway project, and plaintiff was the low bidder of the three. His bid was, however, substantially in excess of the State's own estimate of the costs; and it led the State to revise its estimate, relying in part on plaintiff's own working papers. As a result, the State's engineers concluded that their original estimate had been too low, that plaintiff's low bid was reasonable, and that a lower bid would not be secured through readvertisement. Nevertheless, the Director of Public Works rejected all bids and directed that the work be readvertised. Before the new bids were opened, however, further processing by the State was enjoined pending determination of whether plaintiff was entitled to a writ of mandate to compel award of the contract on the basis of the original bidding.

The trial court granted the writ of mandate, finding that the Director had failed to make "any independent determination as to the best interests of the State of California, or to consider and weigh the . . . evidence, facts, reports and recommendations available to him." In addition, it was charged that the Director knew of the errors in his staff's initial estimate, and was in a position to determine that plaintiff's proposal was in the best interest of the State. 141

On appeal, the California Court of Appeals reversed the trial court, and sustained the rejection of all bids. It explained its view thus:

> This conclusion may seem a harsh one so far as Harney Co. is concerned. Admittedly, its bid was honestly and fairly prepared. But competitive bidding statutes are not passed for the benefit of bidders, but for the benefit and protection of the public. No right exists in the lowest bidder to have his bid accepted where the statute confers the power to reject all bids. While it is unfortunate that all bids were rejected because the department engineers made mistakes in the original estimate, public policy requires that the director have this power and protection or grave abuses may arise.[212]

Expanding on this latter point, the Court noted the statutory requirement that plans, specifications, and cost estimates shall be prepared and approved by the Director before contracts for a project are executed.[213] It also noted that in this instance the Director knew when and how his department's estimates had been developed; and it agreed with his action under the circumstances, saying:

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[211] 107 Cal. App. 2d. 570, 237 P.2d 561, 31 A.L.R.2d 457 (1951).

[212] *Id.* at 580, 237 P.2d at 567–68.

[213] CAL. GOV'T CODE §§ 14270–71 (West 1963).

> [O]ne of the purposes of requiring an estimate is to protect the public and the director, and to give him an objective and accurate yardstick to measure the fairness of the bid. The law does not contemplate that estimates shall be prepared after examining the bids and the bidders' work sheets. Such an estimate would be valueless and such a practice would lend itself to the very abuses that the statute, by requiring prior estimates, was intended to prevent. Durkee considered these matters. He had grave . . . doubts as to whether a new estimate so prepared would constitute substantial compliance with the provisions of the statute. . . . Under such circumstances, even if new bids might be in excess of the old ones, Durkee acted well within the discretion conferred upon him by law in rejecting all bids. . . .[214]

Although the circumstances of this case may seem to validate the decision to reject all bids and readvertise, not all reported cases on this issue have been as clear. In some cases it has been held that public authorities claiming the right to reject all bids must show they acted in good faith;[215] others have considered the motives for rejection immaterial.[216] Disagreement has occurred concerning the time limit for exercising bid rejection power. If bids are to be rejected, fairness requires that determination and notification be prompt, but no standard for measurement of promptness fits all cases.[217] Neither is there any touchstone for distinguishing the circumstances in which a contracting authority may be denied the right to exercise its authority because of its own mistakes or procedural errors. Such questions have been raised when inadequate or defective bid advertisements were issued,[218] illegal bids were accepted,[219] bids exceeded estimated costs or appropriated funds for the contract,[220] errors were committed in official estimates,[221] and acceptance of a bid was withdrawn prior to notification of the bidder.[222]

142

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[214] *Id.* at 579–80, 237 P.2d at 567.

[215] Marshall Constr. Co. v. Bigelow, 29 Hawaii 641, (1927); Arensmeyer-Warnock-Zarndt, Inc. v. Wray, 118 Misc. 619 194 N.Y.S. 398 (Sup. Ct. 1922).

[216] People *ex rel.* Shay v. McCormack, 167 App. Div. 854, 153 N.Y.S. 808 (1915); Fulton Iron Co. v. Larson, 84 U.S. App. D.C. 39, 171 F.2d 994 (1948), *cert. den.* 336 U.S. 903, 93 L.Ed. 1068, 69 S.Ct. 489 (1949).

[217] *See:* Pennell v. Mayor, Etc., of City of New York, 17 App. Div. 455, 45 N.Y.S. 229 (1897), suggesting that delay in notifying the low bidder might be so great as to have the effect of extinguishing the right to reject all bids.

[218] Titgen v. Smith, 68 Pa. D.&C. 207 (1949).

[219] Hankins v. Police Jury, 152 La. 1000, 95 So. 102 (1922).

[220] Williams v. City of New York, 118 App. Div. 756, 104 N.Y.S. 14 (1907), *aff'd mem.* 192 N.Y. 541, 84 N.E. 1123 (1908); Marshall Constr. Co. v. Bigelow, 29 Hawaii 641 (1927).

[221] Charles L. Harney, Inc. v. Durkee, 107 Cal. App. 2d 570, 237 P.2d 561 (1951).

[222] State *ex rel.* Cleveland Trinidad Paving Co. v. Board of Public Service, 81 Ohio St. 218, 90 N.E. 389 (1909); McIntosh Road Materials Co. v. Woolworth, 365 Pa. 190, 74 A.2d 384 (1950); Schull Constr. Co. v. Board of Regents of Educ., 79 S.D. 487, 113 N.W.2d 663, 3 A.L.R.3d 857 (1962)

Preferential selection of local resident contractors has previously been referred to in discussion of the preparation of bids. When considered in connection with determination of the contract award, such preferential selection inevitably raises constitutional questions. Arizona's law authorizing a 5-percent preference for contractors who had previously performed public contracts satisfactorily and who had paid county and State taxes for 2 years immediately prior to bidding was reviewed in *Schreg v. Allison Steel Mfg. Co.*[223] The issues raised in this case dealt with equal protection of law and the establishment of reasonable classifications of bidders, the granting of special privileges and enactment of special legislation, and the certainty of the language of the law as it affected the law's enforceability. On all of these issues, however, the validity of the Arizona Legislature's action was sustained.[224] The conditions imposed by the Legislature were clearly within its prerogative, and the enforcement of the terms of the law would not impair the essential quality of openness and competition in the award of public works contracts.

THE EFFECT OF BID MISTAKES IN CONTRACT AWARDS

Withdrawal of Erroneous Bids Prior to Opening

143

The series of steps from submission of bids to award of contract described in the foregoing sections moves smoothly when bidders and contracting agencies are fully in accord regarding the contract's requirements and details of the bid, and the cost estimates of the bidder are correctly computed and presented. When errors creep into cost calculations, or the terms of the project advertisement or bid are not correctly construed, the resulting confusion may seriously delay or jeopardize the contract award. In the case of contracts for large and complex highway construction projects this risk is increased by the sheer size of the task of checking the plans, specifications, and estimates to detect mistakes. It may also be complicated by the fact that State codes and administrative regulations rarely provide comprehensive procedures for correcting mistakes. Thus, where controversies cannot be settled administratively by the contracting agency, the parties must adjudicate their claims in court. Mistakes discovered prior to the opening of bids are easily handled. Standard specifications published by State highway and transportation agencies typically provide for withdrawal and revision of proposals, or filing of new ones, prior to the time and date scheduled for opening the bids.[225] In some instances the right to correct the mistake and file a revised bid or new proposal

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[223] 75 Ariz. 282, 255 P.2d 604 (1953).

[224] ARIZ. REV. CODE § 34-241 (1974). *See also*, ARK. STAT. § 14-622 (1968) providing a 3 percent preference for local bidders.

[225] *E.g.*, Nev. Dep't of Highways, *Standard Specifications*, § 102.10 (1968).

is denied in order to avoid any appearance of collusion.[226] In others, the contracting agency requires that if a bidder is granted the privilege of withdrawing his bid because of an alleged mistake, he may not file a revised bid or substitute a new bid in any subsequent round of bidding on that same contract.[227]

Essentially, all procedures established for handling bid mistakes discovered before bid opening are designed to facilitate the withdrawal of erroneous bids, and thereafter, depending on the contracting agency's policy, to facilitate correction of the mistake or substitution of a new bid. In this process the main concern of the law is to maintain the integrity of the competitive bidding process and avoid the appearance of collusion or unfair advantage in any form.

Correction of Bid Mistakes After Opening of Bids

When a mistake is not discovered until bids have been opened, or where, for other reasons, a bid containing an error is not withdrawn prior to opening, the consequences are more serious. When bids are opened they are considered to be formally tendered offers, and each bidder is obligated to accept and perform a contract if he should be selected as the lowest responsible bidder.[228] Moreover, the bid forms used by most public highway agencies contain specific statements by the bidder that he will accept a contract and execute it within a specified time if one is offered. Both by law and by contract, therefore, the bidder is obligated to stand by the offer he has made in his bid; and except in rare instances, neither the law nor the contract provides for the contingency of mistakes in the preparation and submission of bids. Where relief is available to prevent excessive hardship from forcing a bidder to perform a contract based on a mistake, it comes through the courts' application of equitable principles and remedies to the claims of the parties involved.

144

In a few instances, special legislative procedures facilitate this recourse to equity. One illustration is provided by Wisconsin legislation relating to municipal public works contracting.[229] Under this legislation if a mistake is discovered and the contracting officer is notified prior to the bid opening, the erroneous bid is returned unopened to the bidder, with the restriction that he is not entitled to bid again on that contract unless it is readvertised. If, on the other hand, the mistake is discovered afer bids are opened, the bidder who desires to withdraw must give notice of this fact without delay, and must produce evidence

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[226] *E.g.*, WIS. Dep't of Transp., *Standard Specifications*, § 102.09 (1969), stating that ". . . if such withdrawal is made, such prospective bidder shall not be entitled to bid on the contract at hand unless the same is readvertised and proposals are again requested upon such advertisement."

[227] COHEN, *supra* note 1, at 65.

[228] ABBETT, *supra*, note 115, at 159.

[229] WIS. STAT. ANN. § 66.29(5) (1965).

that his mistake was not caused by carelessness or lack of care in examining the project plans and specifications. In the event his bid bond or security deposit is forfeited, the statute provides that it may be recovered by proving to a court of competent jurisdiction that the mistake was not due to "carelessness, negligence, or inexcusable neglect."

Application of these provisions to a municipal public works project was tested in *Krasin v. Village of Almond*,[230] where figures on an adding machine tape were misread because of a worn ribbon, and the resulting error in cost estimates was only discovered at the bid opening. Here the Court found that the bidder's error was excusable, as contemplated by the statute, and the bid deposit should be recovered by the bidder. The constitutionality of the statute was not questioned in this case, nor was the correctness of the legislature's decision to make forfeiture of the bid security turn on such ill-defined criteria as "excusable" and "inexcusable" neglect.[231]

California legislation for the relief of bid mistakes is similar to Wisconsin's law in its essential features and design. It denies the bidder any direct relief for an erroneous bid, and prohibits the bidder from any further bidding on the project on which the erroneous bid was made.[232] But it authorizes court action for the recovery of forfeited security deposits upon proof that (1) a mistake was in fact made; (2) the contracting agency was notified in writing within 5 days after the opening of bids, with a detailed description of how the mistake occurred; (3) the mistake makes the bid materially different than was intended by the bidder; and (4) the mistake was made in preparing the bid form, and was not due to bad judgment, or carelessness in inspecting the work site, or in reading the plans and specifications.[233] 145

Equitable Relief for Bid Mistakes

The prerequisites for recovery of bid security under the California statute previously described generally are parallel to the proof required to secure equitable relief through the courts. In litigation involving bid mistakes, the bidder's purpose generally is rescission of the bid, or the contract, if it has been awarded, or recovery of a forfeited bid security. Where action is brought by the contracting authority, it generally is for recovery on a surety bond posted as bid security. In these cases, the rights of the public agencies and private contractors are determined by the same principles of equity that apply to analogous situations involving private parties.

It is a general rule that the remedy of *reformation* of a bid or contract, frequently given to relieve against the consequences of a mutual

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[230] 233 Wis. 513, 290 N.W. 152 (1940).

[231] *Id.* at 519, 290 N.W. at 155.

[232] CAL. GOV'T CODE §§ 14350–54 (West 1963, as amended Supp. 1976).

[233] CAL. GOV'T CODE § 14352 (1963).

mistake, will not be given to relieve against a unilateral mistake. The distinction between the two situations is said to be in the danger that in the latter case one of the parties would be forced into an agreement that was foreign to his intention.[234] Similar objections sometimes have been made concerning application of the remedy of *rescission* or cancellation of a bid where a unilateral mistake has occurred, particularly if knowledge of the mistake is limited to only one party. This view is associated with the so-called "objective theory of contracts,"[235] and has prevailed in numerous cases in which carelessness, poor judgment, or undue haste is evident in explaining the cause of the error,[236] or the bidder has failed to use his opportunities to prevent unwitting action by others in reliance on the error.[237]

A significant number of cases in which relief has been granted for a unilateral mistake in bidding have, however, evolved a general rule regarding the criteria for successful recourse to equity in such cases. The Maryland court in *City of Baltimore v. De Luca-Davis Constr. Co.* discussed this matter as follows:

> The general rule as to the conditions precedent to rescission for unilateral mistakes may be summarized thus: 1, the mistake must be of such grave consequences that to enforce the contract as made or offered would be unconscionable; 2, the mistake must relate to a material feature of the contract; 3, the mistake must not have come about because of the violation of a positive legal duty or from culpable negligence; 4, the other party must be put in status quo to the extent that he suffers no serious prejudice except the loss of his bargain.[238]

146

In *De Luca-Davis*, the erroneous cost estimate resulted from copying unit prices incorrectly on the bidder's worksheets, and the contracting agency was notified of the mistake as soon as it was discovered at the bid opening. In addition, 5 days after the bid opening, a complete written explanation of the mistake was presented to the proper agencies of the city in support of a request for rescission of the bid and return of the bid deposit. Such prompt action by the bidder strengthened his claim for relief by forestalling action on the part of the contracting agency which would have been irreparable, and similar instances of early notification have been noted in other cases where rescission has been allowed.[239]

Determination that the cause of an error in bidding is not due to

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[234] Annot., 52 A.L.R.2d 792 (1957).

[235] 13 WILLISTON ON CONTRACTS, § 1578 (3d ed. W. Jaeger 1970).

[236] Daddario v. Town of Milford, 296 Mass. 92, 5 N.E.2d 23, 107 A.L.R. 1447 (1936).

[237] Annot., 107 A.L.R. 1451 (1937).

[238] 210 Md. 518, 527, 124 A.2d 557, 562 (1956).

[239] M. F. Kemper Constr. Co. v. City of Los Angeles, 37 Cal. 2d 696, 235 P.2d 7 (1951); James T. Taylor & Son, Inc. v. Arlington Independent School Dist., 160 Tex. 617, 335 S.W.2d 371 (1960); Townsend v. McCall, 262 Ala. 554, 80 So.2d 262 (1955).

"culpable negligence" or a violation of a legal duty may be substantially more difficult than determining whether notification of the mistake was given promptly. In a leading California case,[240] a majority of the court took the position that clerical errors in bid preparation did not come within the scope of the equitable rule denying relief. The Court said:

> It has been recognized numerous times that not all carelessness constitutes a "neglect of a legal duty" within the meaning of the section. . . . On facts very similar to those in the present case, courts of other jurisdictions have stated that there was no culpable negligence and have granted relief from erroneous bids. . . . The type of error here involved is one which will sometimes occur in the conduct of reasonable and cautious businessmen, and, under all the circumstances, we cannot say as a matter of law that it constitutes a neglect of legal duty such as would bar the right to equitable relief. . . .
>
> . . . There is a difference between mere mechanical or clerical errors made in tabulating or transcribing figures and errors of judgment, as, for example, understanding the cost of labor or materials. The distinction between the two types of error is recognized in the cases allowing rescission and in the procedures provided by the state and federal governments for relieving contractors from mistakes in bids on public work. . . . Generally relief is refused for error in judgment and allowed only for clerical or mathematical mistakes. . . . Where a person is denied relief because of an error in judgment, the agreement which is enforced is the one he intended to make, whereas if he is denied relief from a clerical error, he is forced to perform an agreement he had no intention of making.[241]

147

A dissenting opinion in this case presented the opposing view of the effects of mistakes in this way:

> When it is necessary for a person to make calculations or estimates, in order to determine the sum which he will bid for an offered contract, or to determine the cost to him of a proposed contract, or whether or not it will be advantageous to him to enter into it, he must assume the risk of any error or oversight in his computations, and cannot have relief in equity on the ground of mistake, if he reaches a wrong conclusion through inadvertance, misunderstanding of that which is plain on its face, or mathematical error. . . . So, where plaintiff makes an offer to erect a building for a certain amount, and defendant accepts it, there is a consummated and binding agreement, although the plaintiff, in adding up the items of his estimates, makes a mistake of a very large sum, provided defendant is not in any way responsible for it.[242]

The dissent cited the statement in the bid form advising the bidder

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[240] M. F. Kemper Constr. Co. City of Los Angeles, 37 Cal. 2d 696, 235 P.2d 7 (1951).

[241] *Id.* at 702–703, 235 P.2d at 10–12.

[242] *Id.* at 708, 235 P.2d at 14, citing BLACK ON RESCISSION & CANCELLATION, § 142.

that his bid was an irrevocable offer and would "not be released on account of error," and argued strongly for giving this statement its full effect. The Court replied:

> The term "error" has a broad meaning and is not confined to those of judgment. It means the same as mistake. To narrow its meaning is to alter the contract of the parties. The phrase was used to avoid the precise claim now made by the bidder. It was contemplated by the parties that the risk of any mistakes was to be borne by the bidder. Pertinent rules are stated: "Where the parties treat upon the basis that the fact is doubtful, and the consequent risk each is to encounter is taken into consideration in the stipulations assented to, the contract will be valid, notwithstanding any mistake of one of the parties."[243]

Among the other criteria for granting equitable relief from the penalties of a unilateral bid mistake, the courts have frequently stressed the requirement that the error must relate to a material feature of the contract, and must be of such magnitude or character as to make enforcement of the offer or contract unconscionable. This requirement generally is found in conjunction with the corollary rule that equity will not allow withdrawal of an erroneous bid or return a forfeited security deposit unless it appears that reasonable diligence and care were used in preparing the bid, and that the contracting agency will suffer no serious injury, except the loss of its original contract.[244]

148

These propositions reflect the concern of equity for the essential qualities of fairness and realism in judging the bidder's claim for relief. What is material to the contract is likely to be determined according to its influence on the parties' acceptance or rejection of the contract rather than according to any particular dollar amount of the profit or loss.[245] Diligence and care in preparing bids are essential to success in claiming equitable relief; but they are requirements which must be applied in the light of each bidder's circumstances. Thus, accidental errors in transcribing figures were forgiven where the bidder's engineer was nearsighted and had to make his cost estimates under heavy pressures of time.[246] Errors in calculating the expenses of excavation were considered in the light of evidence that when the bidder visited the construction site he was misled by old right-of-way stakes and flags which suggested the highway was to be built through loose dirt rather

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[243] *Id.* at 709, 235 P.2d at 15, citing 2 POMEROY ON EQUITY JURISPRUDENCE § 855.

[244] COHEN, *supra* note 1, at 65.

[245] Western Sand & Gravel Co. v. Town of Cornwall, 2 Ill. 2d 560, 119 N.E.2d 261 (1954).

[246] Moffett, Hodgkins & Clarke Co. v. City of Rochester, 178 U.S. 373, 44 L.Ed. 1108, 20 S.Ct. 957 (1900), where forms to be used by bidders for filing on December 23d were not available until December 15th. *See also:* Conduit & Foundation Corp. v. Atlantic City, 2 N.J. Super. 433, 64 A.2d 382 (Ch. 1949); Rushlight Automatic Sprinkler Co. v. City of Portland, 189 Ore. 194, 219 P.2d 732 (1950).

than through a rocky area which was the correct route.[247] Clerical errors, such as omitting digits or decimal points, are recognized as likely to occur in spite of diligent efforts to prevent such errors, and so are not automatically equated with negligence which will defeat a claim. If the circumstances include factors which reasonable men would expect to make the bidding process more difficult or increase the chance of error, the standard of care to which bidders must conform reflects this fact.[248]

"Negligence" or its equivalent lack of care in bid preparation, as this concept is applied to claims for equitable relief for bid mistakes, means carelessness which exceeds the tolerances that the business and governmental community typically allow themselves in carrying on their own affairs. Reasonably understandable failure to calculate or present bid information correctly and completely will not bar equitable relief unless obvious carelessness or lack of good faith are present. When claims of mistake suggest that either carelessness or lack of good faith are present, the bidder is considered as having violated his duty to compete in good faith, and his claim to equitable relief generally is fatally weakened.[249]

The duty to deal in good faith is, of course, as binding on the contracting agency as on the bidder. Where a bid clearly discloses that in all probability it contains a mistake, the contracting agency is charged with that knowledge; and later, if it is shown that a mistake in fact has occurred, the agency may not take advantage of the bidder by acting in reliance on a bid when there is evidence or suspicion of error.[250] Warning that a mistake has been made often is given by the unusually great disparity of one bid in comparison with others, but it may be given by any evidence that, under the circumstances, is recognizable by the bidder or contracting agency.[251]

149

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[247] State by and through its Road Comm'n v. Union Constr. Co., 9 Utah 2d 107, 339 P.2d 421 (1959). *See also:* Puget Sound Painters, Inc. v. State, 45 Wash. 2d 819, 278 P.2d 302 (1954) and Greene v. City of New York, 283 App. Div. 485, 128 N.Y.S.2d 715 (1954).

[248] M. F. Kemper Constr. Co. v. City of Los Angeles, 37 Cal. 2d 696, 235 P.2d 7 (1951); State by and through its Highway Comm'n v. State Constr. Co., 203 Ore. 414, 280 P.2d 370 (1955); State Highway Comm'n v. Canion, 250 S.W.2d 439 (Tex. Civ. App., 1952); Levine v. Parsons, 258 App. Div. 1003, 16 N.Y.S.2d 722, *motion for leave to appeal den'd*, 18 N.Y.S.2d 749 (1940).

[249] Annot., 52 A.L.R.2d 792 (1957).

[250] Rushlight Automatic Sprinkler Co. v. City of Portland, 189 Ore. 194, 219 P.2d 732 (1950), Ex parte Perusini Constr. Co., 242 Ala. 632, 7 So. 2d 576 (1942).

[251] *E.g.*, City of Baltimore v. De Luca-Davis Constr. Co., 210 Md. 518, 124 A.2d 557 (1956) noting that "There was testimony that there was a general perceptible reaction in the room when the appellee's bid was opened and announced—a realization that something was wrong, that there was an error in the bid." 124 A.2d at 559. *See also*, Annot., 52 A.L.R.2d 792 (1957).

Disposition of Bid Security

Just as bidding instructions which purport to prohibit or restrict withdrawal of bids have been construed as inapplicable to situations involving an honest unilateral mistake, equity courts have given similar construction to statements providing for forfeiture of deposits or surety bonds serving as security to assure execution of contracts. Because State laws and regulations require bid security in terms of a percentage of the total amount of the bid, the security deposit may represent a substantial amount of money, which a bidder cannot afford to lose. Much of the litigation over bid mistakes, therefore, is concerned with imposition of forfeiture of defaulted deposits, or attempted return of a security deposit following bid withdrawal.

Where a bid mistake is remediable by withdrawal of the bid, and the contracting agency is promptly notified of the error, equity will order return of the security deposit or cancellation of the bid bond. These results are based partly on the precept that once the contracting agency is aware of a bid error it is unjust to take advantage of this situation and impose a forfeiture, and partly because after the bid is withdrawn the reason for the security ceases to exist.

In a typical case where this reasoning supports equitable recovery
150 or cancellation of bid security, notice of the mistake is received by the contracting agency before it accepts the erroneous bid.[252] Frequently the discovery is made and notice given before the bid opening. Failure to give notice to the contracting agency before acceptance of an erroneous bid weakens the case for return of bid security, but forfeiture of security is not always the result in these situations. If a bidder notifies the agency after its acceptance of his offer, but before a contract has been signed, and before there is any change in position in reliance on the erroneous bid, he may be successful in obtaining return of his deposit or cancellation of his bid bond.[253]

Often a decisive factor in determining recovery of bid security is whether the contracting party has acted in reliance on the bidder's mistake. In the great majority of cases where equitable relief was requested, bid security was not recovered if the mistake was not discovered or reported until after the agency had made a contract award.[254] Yet, occasionally there are circumstances in which bid mistakes are not discovered and reported until after contract award, and because no culpable negligence is chargeable to him, the bidder is permitted to recover his bid security. A Kentucky case illustrates the required combination of circumstances. Here the agency queried the bidder about

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[252] Annot., 60 A.L.R. 586 (1932); Annot., 52 A.L.R.2d 792 (1957).

[253] Board of Regents of Murray State Normal School v. Cole, 209 Ky. 761, 273 S.W. 508 (1925); Kutsche v. Ford, 222 Mich. 442, 192 N.W. 714 (1923).

[254] 64 AM. JUR. 2d, *Public Works and Contracts*, § 85 (1972).

possible mistake at the time of bid opening, and the bidder verified his bid as correct. Relying on this assurance, the contract award was made, only to have the bidder discover his mistake shortly thereafter.[255] The Court granted relief; but instead of applying the doctrine that an executory contract can be cancelled when it is entered into with a unilateral mistake on a material point and without culpable negligence, the Court chose to treat the matter as a rescission of the contract. The parties were restored to their original positions as nearly as possible by the return of the bidder's deposit, and payment by the bidder of the contracting agency's actual expenses of readvertising the project for new bids.

CONCLUSION

The requirement that public construction contracts must be awarded to the lowest responsible bidder as determined in open competition reflects a long-standing policy and deeply-rooted conviction regarding protection of the public interest. There is no dissent from the principle underlying this policy, but, as with many other fields of contemporary law, there are evident difficulties in giving full effect to this principle in the day-to-day business of roadbuilding.

The body of statutory and administrative law that prescribes the competitive bidding procedures of the States in contracting for construction of State and Federal-aid highways has become extensive, and may seem to be excessively complex because of the provisions that reflect the responsibilities of both State and Federal highway agencies in connection with the funding of highway projects. Yet the record of the past 20 years is impressive in documenting the success of government and the construction industry in putting more than a billion dollars to work on highway projects annually through these competitive bidding procedures. 151

By this pragmatic test, the body of law providing a framework for competitive bidding on construction contracts has served the public well. Has the present system served the public as well regarding the long-range interest in developing a broad, vigorous, and financially sound construction industry? If it is conceded that this is a legitimate (although perhaps secondary) interest that is affected by the rules for competitive bidding, any critical evaluation of this body of law must include this aspect.

Traditionally it has been accepted that competition for highway construction contracts is vigorous, open, and subject to more than the ordinary scrutiny for protection of the public interest because of the involvement of both Federal and State agencies. Although construction

[255] Board of Regents of Murray State Normal School v. Cole, 209 Ky. 761, 273 S.W. 508 (1925).

has the reputation of a high risk activity, it appears to attract and support a mobile mix of large and small firms, which, logic suggests, is a guarantee against the growth of oligopoly. As a consequence there has been little study of the economic impact of the competitive bidding system on the construction industry or the public investment in highways. Federal anti-trust investigation of highway contracting patterns has not been undertaken on any significant scale.

Some economic analysts believe that many of the traditional assumptions about highway construction contracts are not warranted if the contracting process is examined closely.[258] Upon such an examination, it is said, the effect of current construction contracting laws—competitive bidding rules, bonding requirements, labor standards, and other features—may be seen as encouraging barriers to the full competitive functioning of market processes. If so, a case for revision of competitive bidding rules may well be developed on the basis of the system's secondary or long-range effects. It is, however, a matter that is dependent upon future analysis of the economics of competition in the construction industry, future evolution of attitudes regarding transportation investment priorities, and future leadership of lawyers in the process of constructive law revision.

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[258] J. J. Coleman, *An Empirical Analysis of the Structure and Performance of the Federal-Aid Highway Construction Contracting Industry* (Unpublished DBA dissertation, School of Government & Business Administration, George Washington University, Washington, D.C., 1974) 3–4.

MALAWI GOVERNMENT

MINISTRY OF WORKS AND SUPPLIES

DESIGN DEPARTMENT

STANDARD SPECIFICATION FOR ROAD AND BRIDGE WORKS

(METRIC EDITION)

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CONTENTS

Series No.	Series Title	Clause No.	Clause Title	Page No.
** 100	GENERAL	101	Land available	2
		102	Compensation	2
		103	Graves and tombs	2
		104	Housing, stores and workshop areas	2
		105	First-aid facilities	3
		106	Accommodation for Engineer ..	3
		107	Security services for Engineer ..	3
		108	Assistance to Engineer ..	3
		109	Survey equipment	3
		110	Transport for Engineer ..	3
		111	Photographs	4
		112	Proposed levels	4
		113	Agreement of surface levels ..	4
		114	Traffic safety and control ..	4
		115	Temporary diversion of traffic ..	4
		116	Temporary traffic signs ..	4
		117	Water supply	4
		118	Services	5
		119	Protection of mains and services ..	5
		120	Quarries and borrow pits ..	5
		121	Copies of orders	5
		122	Other Works	5
		123	Possession of the Site	5
		124	Trial pit information	6
		125	Weather conditions	6
		126	Programme	6
		127	Facilities for Engineer's staff ..	6
		128	Drawings	6
		129	Preservation of survey markers ..	6
		130	Dimensions and levels	6
		131	Engineer's clerical and technical staff	6
		132	Amenity and access	6
		133	Units of measurement	7
		134	Works during period of maintenance	7
		135	Clearing of site on completion ..	7
** 200	SITE CLEARANCE AND EARTHWORKS	201	Clearing	9
		202	Topsoil	9
		203	Definitions	9
		204	Classification of excavated material	9
		205	General use	10
		206	Excavation of cuttings	10
		207	Explosives and blasting ..	11
		208	Excavation of foundation pits and trenches	11

CONTENTS—*continued*

Series No.	Series Title	Clause No.	Clause Title	Page No.
		209	Backfilling of foundation pits and trenches	11
		210	Earthworks to be kept free of water	12
		211	Benching	12
		212	Excavation below embankments and below formation level in cuttings	12
		213	Slips	12
		214	Suitable material for filling ..	12
		215	Rock fill	13
		216	Forming of embankments and other areas of fill	13
		217	Preparation of material for compaction	13
		218	Watering and mixing	14
		219	Compaction of fill	14
		220	Compaction trials	14
		221	Compaction equipment ..	15
		222	Testing	15
		223	Compaction under embankments and in cuttings	15
		224	Compaction of rock fill ..	15
		225	Borrow pits	15
		226	Settlement of embankments on soft foundations	16
		227	Anthills	16
		228	Trimming of slopes	16
		229	Soiling and grassing	16
		230	Watercourses	16
		231	Filling existing watercourses ..	16
		232	Clearing existing ditches and streams	16
300	DRAINAGE	301	General	17
		302	Side drains	17
		303	Cut off drains	17
		304	Mitre drains	17
		305	Inlet and outlet drains	17
		306	Mitre banks, earth berms and check dams	17
		307	Excavation for open drains ..	17
		308	Excavation for pipelines ..	18
		309	Subsoil drains	18
		310	Types of pipe	18
		311	Pipe culverts, bedding ..	19
		312	Pipe culverts, laying and jointing	19
		313	Inlet and outlet structures ..	20
		314	Pipe culverts, backfilling ..	20

CONTENTS—*continued*

Series No.	Series Title	Clause No.	Clause Title	Page No.
		315	Existing culverts	20
		316	Cleaning and maintenance ..	21
		317	Drainage control kerbs ..	21
		318	Brick-lined drainage channels ..	21
		319	Rubble drains in slopes of cuttings	21
		320	Gabion protection to permanent works	21
		321	Settlement of culverts	21
400	SUBGRADES, SUB-BASES AND BASES	401	Definitions	23
		402	Approval of methods	23
		403	Prevention of damage to partially completed subgrade and pavement	23
		404	Tolerances	23
		405	Subgrades	24
		406	Commencement of pavement construction	24
		407	Selection of materials	24
		408	Sub-base and shoulder material ..	25
		409	Base material	26
		410	Laying and compaction, general..	28
		411	Laying and compaction of Type 1 Base Material	29
		412	Laying and compaction of Type 2 Base Material	29
		413	Laying and compaction of Type 3 Base Material	29
		414	Trial length of stabilised Type 4 Material	29
		415	Preparation of layer for stabilisation	30
		416	Watering	30
		417	Application of stabilising agent ..	30
		418	Mixing of stabilising agent ..	30
		419	Compaction of stabilised material	31
		420	Adjoining sections	31
		421	Curing of stabilised layers ..	31
		422	Testing of stabilised layers ..	32
500	SURFACING	501	Materials for surface dressing ..	33
		502	Bitumen heaters and distributors	34
		503	Application of prime coat ..	34
		504	Application of surface dressing, general	34
		505	Stone seal	35
		506	Slurry seal	36
		507	Premixed surfacing	37

CONTENTS—*continued*

Series No.	Series Title	Clause No.	Clause Title	Page No.
		508	Transporting, laying and compacting of premixed surfacing ..	37
600	PILING FOR STRUCTURES	601	General	39
		602	Tolerances	39
		603	Precast concrete piles	39
		604	Cast-in-place piles	40
		605	Timber piles	40
		606	Steel sheet piling . ..	41
		607	Pile tests	41
		608	Pile records	41
700	FORMWORK AND SURFACE FINISH FOR STRUCTURES	701	Construction	43
		702	Formed surfaces, classes of finish	43
		703	Preparation of formwork before concreting	43
		704	Removal of formwork	43
800	STEEL REINFORCEMENT FOR STRUCTURES	801	General	45
		802	Bending of reinforcement ..	45
		803	Placing of reinforcement ..	45
		804	Cover blocks	45
		805	Welding of reinforcement ..	45
900	CONCRETE FOR STRUCTURES	901	Concrete mix design	47
		902	Concrete for ancillary purposes (class E)	47
		903	Trial mixes	47
		904	Admixtures	48
		905	Delivery and storage of materials	48
		906	Mixing concrete	48
		907	Sampling concrete	49
		908	Frequency of testing	49
		909	Transport and placing	50
		910	Compaction of concrete ..	51
		911	Unformed surfaces, classes of finish	51
		912	Construction joints	51
		913	Construction details	52
		914	Curing of concrete	52
		915	Remedial treatment of surfaces ..	52
		916	Early loading	52
1000	PRESTRESSING FOR STRUCTURES	1001	General	53
		1002	Prestressing components ..	53
		1003	Prestressing tendons	53
		1004	Sheaths and extractable cores ..	53
		1005	Anchorages	53

CONTENTS—*continued*

Series No.	Series Title	Clause No.	Clause Title	Page No.
		1006	Jacks for prestressing	53
		1007	Post-tensioning procedure ..	54
		1008	Grouting of ducts	54
		1009	Plant for grouting of ducts ..	55
		1010	Grout for ducts	55
		1011	Storage of prestressed members ..	55
		1012	Handling and placing of prestressed members	56
		1013	Composite slab bridges ..	56
		1014	Pretensioned members	56
		1015	Manufacture of prestressed members off the site	56
1100	STRUCTURAL STEELWORK	1101	General requirements, workmanship, fabrication and erection ..	59
		1102	Working drawings	59
		1103	Welding and flame cutting procedure trials	59
		1104	Qualification and testing of welders	60
		1105	Supervision of welding	60
		1106	Welding plant	60
		1107	Welding	60
		1108	High strength friction grip bolts..	62
1200	PROTECTION OF STEELWORK AGAINST ATMOSPHERIC CORROSION	1201	Preparation of surfaces to receive paint	63
		1202	Treatment of surfaces	63
		1203	Storage of paint	63
		1204	Application of paint	64
		1205	Storage of painted steelwork ..	64
		1206	Repairs to damaged surfaces ..	65
1300	MISCELLANEOUS FOR STRUCTURES	1301	Backfilling to structures ..	67
		1302	Dry stone pitching	67
		1303	Mortar stone pitching	67
		1304	Grouted stone pitching ..	67
		1305	Random rubble masonry coursed or uncoursed	67
		1306	Bearings	67
		1307	Expansion joints	68
		1308	Parapets	69
		1309	Gabion protection	69
1400	MISCELLANEOUS FOR ROADWORKS	1401	Traffic signs	71
		1402	Road markings	71
		1403	Guard rails	71
		1404	Milestones	71
		1405	Marker posts	71
		1406	Kerbs	71

CONTENTS—*continued*

Series No.	Series Title	Clause No.	Clause Title	Page No.
1500	MATERIALS	1501	Submission of samples and test certificates	73
		1502	Aggregates for concrete	73
		1503	Bolts, nuts and washers	74
		1504	Cement	74
		1505	Cement grout for general use	74
		1506	Electrodes for welding	74
		1507	Joint sealing compound	74
		1508	Mortar	75
		1509	Paint for road marking	75
		1510	Paint for steelwork	75
		1511	Pipes and pipe bedding material	75
		1512	Preformed joint filler	76
		1513	Rubber bearings for bridges	77
		1514	Sheaths for prestressed concrete	77
		1515	Stainless steel	77
		1516	Steel castings	77
		1517	Steel forgings	77
		1518	Steel reinforcement	77
		1519	Steel tendons for prestressed concrete	77
		1520	Steel wire mesh and expanded metal	78
		1521	Structural steel	78
		1522	Timber for general purposes	78
		1523	Water for use with cement	78
1600	TESTING OF MATERIALS AND WORKMANSHIP	1601	Provision of testing equipment	79
		1602	Assistance in sampling and testing	79
		1603	Testing of moisture content of timber	79
		1604	Testing of pipe bedding material	79
		1605	Testing of stabilised material	79
		1606	Testing of bituminous mixtures and their component materials	80
		1607	Testing of slurry sealing material	80
		1608	Testing of concrete for structures	82
		1609	Testing of pretensioned beams	82
		1610	Inspection and testing of precast concrete units	82
		1611	Testing of steel for structures	82
		1612	Testing of welding	83
		1613	Testing of rubber bearings for bridges	84
APPENDICES		1	List of British Standards	85
		2	List of other references	89

Notes

(i) The Standard Specification is to be read in conjunction with the Particular Specification for individual contracts which deletes, amends or adds to the provisions of the Standard Specification

(ii) The Standard Specification is divided into parts for convenience only and shall be read as a single document. The preambles and descriptions of labour, materials and general requirements appearing in any section or part of the Specification apply equally to other sections or parts and shall be read as though reported therein.

(iii) The term "Malaŵi Standard" shall refer to those documents published or issued by the Malaŵi Bureau of Standards, P.O Box 946, Blantyre.

The term "British Standards" and "British Standard Codes of Practice" shall refer to those documents published or issued by the British Standards Institution, 2 Park Street, London W1A 2BS.

The term "AASHO Standards" shall refer to those documents published or issued by the American Association of State Highway Officials.

(iv) All Malaŵi Standards, British Standards, British Standard Codes of Practice (henceforth abbreviated to MBS, BS and BSCP respectively) and AASHO Standards referred to in the Contract shall refer to the latest editions, including all amendments published thereto.

(v) The terms referred to in this Specification shall have the meanings assigned to them as defined in the "Glossary of Highway Engineering Terms" BS 892.

(vi) Any clauses in this Specification which relate to work or materials not required by the Contract shall be deemed not to apply.

GENERAL

Land available

101 The land available to the Contractor free of charge shall be as follows:

(i) The land occupied by the Permanent Works.

(ii) The land occupied by approved temporary diversion routes.

(iii) The land indicated on the Drawings or subsequently approved by the Engineer as borrow areas for materials for pavement construction or as quarries for stone.

(iv) The land occupied by approved access roads to (iii) above.

(v) The land required for housing, plant-yards, workshops and offices after approval has been given for the locations and layouts of such installations.

(vi) Subject to the approval of the Engineer, any land lying within the boundaries of the road reserve (such width depending upon road classification) may also be made available to the Contractor as working space or borrow areas for fill material.

Before giving such approval the Engineer will give particular attention to the temporary and permanent effects of the proposed activities on land use and on the drainage of the area. The Contractor's proposals for reinstatement will also be carefully considered.

In forest plantations the width of clearing will generally be 17.5 m on either side of the centreline and land outside the clearing will not normally be available to the Contractor.

The Contractor shall make all negotiations and pay all necessary compensation fees for any additional land he may require, including, inter alia, borrow areas for fill material outside the road reserve. 161

Compensation

102 The costs of agreed compensation for disturbance of buildings, crops, etc., within the land available free of charge shall be paid by the Contractor through the Contract and he shall be reimbursed nett under the relevant item in the Bill of Quantities. The cost of all other compensation shall be borne by the Contractor.

Construction of the Works shall not commence until the compensation has been agreed.

Graves and tombs

103 Areas which contain graves and/or tombs within the Site shall be cleared by the Contractor who shall obtain from the District Commissioner written authority to enter into each of such areas before commencing work.

A copy of each letter of authority shall be submitted to the Engineer, who shall, when he is satisfied that the removal of corpses has been completed, give authority to the Contractor to proceed with the Works within the limits of the Site so affected.

Housing, stores and workshop areas

104 The location and layout of housing, stores and workshop areas together with usage and detailed dimensions shall be approved by the Engineer. The Contractor shall not erect any structures on the Site without the approval of the Engineer.

At the beginning of the Contract the Contractor shall fence off all areas designated for housing, plant-yards, workshops, offices and the like. By the end of the Period of Maintenance or at such earlier time as the Engineer may instruct or approve the Contractor shall clear all structures, plant and rubble from these areas and leave them in a condition acceptable to the Engineer.

105 The first-aid, welfare and safety standards to be provided and observed shall be at least equal to those laid down in the Factories Act. **First-aid facilities**

106 The Contractor shall provide, maintain and remove on completion of the Works, any houses, offices or testing laboratories as shown on the Drawings or scheduled in the Particular Specification for the sole use of the Engineer. The buildings shall have at least the floor area stated and shall contain the equipment, supplies and furnishings scheduled. **Accommodation for Engineer**

Testing equipment supplied in accordance with the Particular Specification shall be located in the testing laboratories as required by the Engineer.

All buildings shall be ready for occupation and use by the Engineer within 4 weeks of the order in writing from the Engineer to commence the Works.

All offices and testing laboratories shall be regularly and properly cleaned and maintained for as long as they remain erected.

The Engineer may require any of the buildings scheduled with any or all of the equipment, supplies and furnishings to remain for occupation and normal use during the period of maintenance.

The Contractor shall make all arrangements and pay all necessary charges for the provision and maintenance of the following services to each building to the satisfaction of the Engineer:

1. Continuous supply of electricity for power and light.
2. Constant supply of fresh potable water
3. Disposal of sewage and waste water.

162

107 The Contractor shall provide adequate security for the offices, vehicles and houses of the Engineer and two watchmen shall be employed at all times on each site for offices and houses from sunset to sunrise. **Security services for Engineer**

108 The Contractor shall provide at all times during the period of the Contract, for the exclusive use of the Engineer, all such workmen as the Engineer may deem to be necessary for the carrying out of his duties in connection with the Contract. **Assistance to Engineer**

The workmen shall be selected for their intelligence and knowledge of the English language and so far as possible the same workmen shall be provided throughout the period of the Contract.

109 The Contractor shall provide and maintain during the period of the Contract for the exclusive use of the Engineer for any purpose in connection with the Contract new surveying equipment as scheduled in the Particular Specification. **Survey equipment**

110 The Contractor shall provide and maintain in roadworthy condition for the exclusive use of the Engineer, for the period of the Contract, new vehicles as scheduled in the Particular Specification. **Transport for Engineer**

The vehicles shall be taxed, comprehensively insured, fuelled, repaired, serviced and maintained by the Contractor for the duration of the Contract and an acceptable temporary replacement for any vehicle not in a roadworthy condition shall be provided until such vehicle is repaired and returned for use. The Contractor shall provide a driver for each vehicle supplied to the Engineer.

The ownership of vehicles shall revert to the Contractor at the end of the Contract or at such earlier date as the Engineer may instruct.

Photographs 111 The Contractor shall obtain a photographic record of the execution of the Works by taking photographs from such points and at such times as the Engineer may specify. The Contractor shall supply six black and white prints, together with the negative of each photograph, to the Engineer. Two of the aforementioned prints shall be dated and signed by the Contractor and the Engineer and one copy retained by the Contractor.

All prints shall be on glossy paper, 215 mm × 165 mm (full plate size).

Proposed levels 112 The Contractor shall be responsible for calculation of all the levels necessary for the setting out of the Work and shall furnish the Engineer with a schedule of these levels prior to setting out.

Agreement of surface levels 113 The Engineer shall take and record levels of any portion of the Site before the surface of any such portion is interfered with or the works thereon begun. Such levels when checked and agreed with the Contractor shall be recorded on drawings which shall be signed by the Engineer and the Contractor and shall form the basis of the measurements for the Engineer's Certificates.

Traffic safety and control 114 The Contractor shall be responsible for making provision for maintaining safe traffic flow through or round any part of the Works at all times, and for proper direction of traffic.

No road shall be closed by the Contractor to the public except by permission in writing from the Engineer. When the road under construction is being used by the travelling public, the Contractor shall ensure that the public can travel over the same in comfort and safety.

Temporary diversion of traffic 115 No work that will in any way inconvenience the travelling public shall commence until adequate provision has been made to deviate or by-pass traffic in comfort and safety to the satisfaction of the Engineer.

The standard of construction of all deviations shall be suitable in all respects for the class or classes of traffic using the existing way and the width of the diversion shall not be less than that of the existing way unless otherwise agreed by the Engineer.

All deviations and existing public and private roads used as detours shall be maintained in good condition at all times by the Contractor to the satisfaction of the Engineer.

The Contractor shall render assistance to any traffic unable to negotiate diversions due to unfavourable conditions.

On completion of the Contract such roads shall be left in a condition approved by the Engineer.

Temporary traffic signs 116 The Contractor shall provide, erect and maintain all barricades, warning lights, danger signals, reflectors, signs and watchmen as may be necessary to the satisfaction of the Engineer.

Barricades and signs shall be constructed and used in accordance with the requirements of the Engineer.

Water supply 117 The Contractor shall make his own arrangements for the provision from approved sources of adequate clear water for use in construction of the Works or otherwise. Quantities of water withdrawn from the approved sources shall be such that the requirements of the local population in respect of water for irrigation, drinking purposes, etc., are not interfered with. The Contractor shall have

obtained permission from the Ministry of Agriculture and Natural Resources for the abstraction of water from any natural source before the use of such source will be approved by the Engineer.

118 The Contractor shall make his own arrangements for the supply of electricity for power and light, and of any other services required in order to carry out the Works and he shall make his own arrangements, subject to the approval of the Engineer, for the disposal of sewage and all waste materials during the execution of the Works. **Services**

119 The Contractor shall protect and support during the construction of the Works all pipes, mains, cables, overhead lines and other apparatus which might be endangered by his operations. **Protection of mains and services**

In the event of any pipes, mains or cables being exposed at any time, the Contractor shall immediately notify the authority or proprietor concerned and shall not cover the exposed pipe, main or cable until it has been examined and approved by the appropriate authority or proprietor.

Before commencing any section of the Works the Contractor shall obtain full information with regard to the position and depth of all pipes, mains and cables.

120 The location of sites for proposed quarries and borrow pits for the provision of materials necessary for the construction of the Works will be indicated on the Quarries and Borrow Pits drawings. The Contractor shall be responsible for opening up all quarries and borrow pits and shall organize his methods of operation so that only material of a type and quality approved by the Engineer shall be selected for use in the Works. The Contractor shall provide, erect, operate and maintain all plant necessary for their proper operation, together with any access roads, temporary bridges or the like necessary for the supply to the Works of the aforementioned and pay all charges incurred. **Quarries and borrow pits**

164

The Contractor may, with the approval of the Engineer, locate and open up quarries and borrow pits in addition to those indicated on the Drawings in accordance with sections 29 and 31 of the Public Roads Act.

At the completion of the Contract the ownership of all quarries and borrow pits shall remain with the Government unless otherwise directed by the Engineer.

121 The Contractor shall provide the Engineer with copies of all orders for the supply of materials and goods required in connection with the Works as the Engineer may require. **Copies of orders**

122 During the continuance of the Contract the Government may cause other Works such as the installation or removal or resiting of services to be carried out, on, through or adjacent to the site. **Other Works**

The Contractor shall at all times comply with the requirements of Clause 31 of the Conditions of Contract in respect of these and any other Works not included in the Contract and shall allow reasonable access as approved by the Engineer on and through the Site of the Works to any other contractor or workmen who may be working on or near the Site.

123 Possession of the Site will be in accordance with Clause 42 (1) of the Conditions of Contract. Possession will be granted on the Contractor's written application to the Engineer and the length to be handed over at any particular time shall be generally in accordance with the Contractor's programme referred to in Clause 14 of the Conditions of Contract and approved by the Engineer. **Possession of the Site**

Trial pit information

124 Information regarding the position of trial pits and the results of tests carried out on various samples of materials will be provided by the Engineer. The Contractor shall be deemed to have considered this information carefully during the preparation of his tender, to assure himself of the characteristics of the materials and the suitability of the plant and methods of working on which he has based his rates.

Weather conditions

125 The Contractor shall not be entitled to extra payment by reason of the occurrence or effect of high winds, excessive rainfall, temperature, humidity or any other meteorological phenomena.

Programme

126 Further to Clause 14 of the Conditions of Contract the Contractor shall furnish to the Engineer within 15 days of the date of the acceptance of his tender a detailed programme of the order in which he proposes to carry out the Works. The programme shall include time and progress charts so that actual progress on each operation can be shown against anticipated progress. Due allowance should be made for the seasonal rains. Indication of requirements for possession of the Site should also be given.

Facilities for Engineer's staff

127 Construction of houses, offices and laboratory facilities for the use of the Engineer's Representative and his staff shall commence as soon as practicable after receipt of the Engineer's order to commence the Works. Pending completion of these facilities the Contractor shall provide alternative temporary facilities on or near the Site. Such facilities shall be acceptable to the Engineer and payment for them will be made as set out in the preamble to the Bill of Quantities.

Drawings

128 The Contractor shall be issued with two copies of each of the Drawings listed in the Contract Documents. When necessary the Contractor shall also be supplied with two copies of any further drawings which may be issued in accordance with the Conditions of Contract. Any additional copies of Drawings required by the Contractor may be prepared by the Engineer.

165

Preservation of survey markers

129 The Contractor shall locate and where possible preserve or else relocate all survey markers established for the construction of the road. Where such survey markers will be destroyed, the Contractor shall accurately reference these to permanent concrete markers before work is commenced.

Where it is likely that any survey marker which is the property of the Survey Department will be disturbed the Contractor shall inform the Commissioner for Surveys at least 14 days before the marker will be endangered.

Dimensions and levels

130 All dimensions and levels shown on the Drawings or mentioned in documents forming part of or issued under the Contract shall be verified by the Contractor on the Site and he shall immediately inform the Engineer of any apparent errors or discrepancies in such dimensions or levels.

Engineer's clerical and technical staff

131 The Engineer will engage and employ his own clerical and technical staff. A provisional sum has been included in the Bill of Quantities to cover the salaries of such personnel.

When the Engineer's Representative so requires the Contractor shall provide him with cash of suitable denomination to make up pay packets.

Amenity and access

132 The Contractor shall ensure that, in carrying out the Works, he causes no damage by plant, workmen, flooding, subsidence or otherwise to property. He shall take all precautions to the satisfaction of the Engineer to ensure that such hazards are avoided and public amenity maintained.

The Contractor shall be responsible for providing and maintaining access to and along the Site for his own purposes, including whatever temporary river crossings he may require.

133 Unless specifically stated to the contrary the units of measurement to be used throughout the Contract shall be based on the S.I. system. **Units of measurement**

Abbreviations, whether singular or plural, shall be as follows:

Kilometre	km
Metre	m
Millimetre	mm
Hectare	ha
Square metre	m^2
Cubic metre	m^3
Litre	l
Millilitre	ml
Tonne	t
Kilogramme	kg
Gramme	g

134 Certificates of completion will be issued by the Engineer in respect of the substantial completion of each length in which possession of the Site was initially given. The period of maintenance for each such length shall commence on issue of the applicable Certificate of Completion. **Works during period of maintenance**

166 After the Commencement of the Period of Maintenance, which shall normally be 12 months, the Contractor shall do nothing which might endanger the safety of the public and he shall obey all instructions of the Engineer or other duly authorized person or authority.

Throughout the Period of Maintenance the Contractor shall notify the Engineer of the work or operations he intends to carry out on the Site and he shall obey any instructions which the Engineer may give as to the times and manner of working so that any inconvenience to the public is kept to a minimum.

Provision is made elsewhere in these documents for an adjustment to the Tender Sum should the Engineer direct that the Contractor's obligations for maintenance on any section of the Works terminate on the issue of the Certificate of Completion in respect of the final length.

135 On completion of the Works the Contractor shall leave the Site in a tidy condition to the satisfaction of the Engineer. **Clearing of site on completion**

SITE CLEARANCE AND EARTHWORKS

201 The Contractor shall remove all anthills, ants' nests, grass, bushes, clearing trees, stumps, roots and other vegetation, boulders, buildings, walls, fences, spoil from the existing road or similar obstructions occurring within the boundaries of the permanent Works as defined by the Engineer. He shall clear each part of the Site to the approval of the Engineer, after complying with Clauses 102 and 103. Unless excavation is to be carried out, cavities left by clearing operations shall be properly cleaned out and backfilled with suitable material as defined in Clause 214 and compacted in compliance with Clause 223. Clearing

Cleared materials shall be burned or disposed of by the Contractor in a manner acceptable to the Engineer. Such materials shall be the property of the Contractor except in the case of materials classed as forest produce under the Laws of Malawi. The Contractor shall dispose of such forest produce as stated above but must hold a Forest Licence if he proposes to remove any forest produce for his own use or sale.

202 Topsoil shall not be removed from any area unless the Engineer so instructs and then not until excavation or filling operations are about to commence in that area. Where the Engineer instructs the removal of topsoil on the sites of cuttings and embankments it shall be excavated to the average depth and over such widths as the Engineer shall direct. Such topsoil as will be required in the Works shall be stockpiled within the road reserve. Excavated topsoil surplus to requirements shall be spread within the road reserve to an even depth not exceeding 250 mm. Topsoil

203 Earthworks shall include all excavations, filling, embankment and cut forming, and all other work, operations and processes contingent upon or related to excavation as required by the nature of the Contract. Definitions 167

In relation to earthworks the following words and expressions shall have the meaning hereby assigned to them:

(i) "Existing ground level" means the ground level existing before the commencement of the Works.

(ii) "Stripped ground level" means the level calculated by subtracting the thickness of topsoil directed by the Engineer for removal on any section of the Works from existing ground level.

(iii) "Finished excavation level" means the level of completed excavation after any trimming, compacting and preparation of the excavation as calculated from the Drawings or as instructed by the Engineer.

(iv) "Construction width" shall mean the width of the Permanent Works measured between the outer extremities of the side drains, cutting or embankment slope as the case may be.

(v) "Formation level" shall mean the level of completed earthworks ready for pavement construction and shall be synonymous with "Subgrade Level".

(vi) "Formation width" shall mean the width of the earthworks measured between the points of intersection of side drain or embankment slopes at formation level.

204 The following definitions of earthworks material shall apply to this and other Clauses of the Specification in which reference is made to the defined materials: Classification of excavated material

(i) "Topsoil" shall mean the top layer of soil that can support vegetation.

(ii) "Suitable material" shall comprise all material that is acceptable in accordance with Clause 214 for use in the Works and which is capable of compaction to the standards specified in Clause 219 to form a stable fill having side slopes as shown on the Drawings.

(iii) "Unsuitable material" shall mean other than suitable material and shall include—

(*a*) material from swamps and marshes;

(*b*) logs, stumps, roots, vegetable matter and perishable material;

(*c*) slurry and mud;

(*d*) anthill material.

(iv) "Rock" shall mean solid material found in ledges or masses in its original position which can only be broken down by blasting or by the use of pneumatic tools. Solid boulders exceeding 0.40 m^3 in volume encountered in general excavation shall be regarded as rock.

General use

205 The use of topsoil shall be restricted to surface layers in positions not subject to loading by pavements or structures.

No excavated suitable material other than surplus to requirements of the Contract shall be removed from the Site except on the direction or with the permission of the Engineer.

If any suitable material excavated from the Site is, with the permission of the Engineer, taken by the Contractor for purposes other than the forming of embankments and other area of fill, sufficient suitable material to occupy, after full compaction, a volume equal to that which the excavated material occupied shall, unless otherwise directed by the Engineer, be provided by the Contractor from his own resources.

168

Before commencing work on any section of the road, the Contractor shall ensure that he has adequate instructions concerning the use of suitable excavated material.

Suitable material and topsoil surplus to the total requirements of the Works and all unsuitable material shall, unless the Engineer permits otherwise, be run to spoil in tips provided by the Contractor.

Where excavation reveals a combination of suitable and unsuitable materials, the Contractor shall, unless otherwise agreed by the Engineer, carry out the excavation in such a manner that the suitable materials are excavated separately for use in the Works without contamination by the unsuitable materials.

The contractor shall make his own arrangements for the stockpiling of topsoil and/or suitable material, and for the provision of sites for this purpose.

No excavation for any purpose whatever shall be made on the site, except as shown on the Drawings, without the permission of the Engineer.

Excavation of cuttings

206 Hauling of material from cuttings or borrow pits to embankments or other areas of fill shall proceed only when sufficient compaction plant is operating at the place of deposition to ensure compliance with Clause 219. Any excess depth excavated below the formation level tolerance specified in Clause 404 shall be made good by scarifying and backfilling with suitable material of similar characteristics to that removed, and compacted in accordance with Clause 223. The slopes of cuttings shall be cleared of all rock fragments which move when prised by a crow-bar. Where in the slopes of cuttings layers of rock and softer

material alternate and the Engineer considers that the slope immediately after dressing will not permanently withstand the effect of weather, the Contractor shall excavate any insecure material to an approved depth and build up the resulting spaces with Class E concrete or masonry using rock similar to the adjoining natural rock so as to ensure a solid face.

207 Blasting shall be carried out in strict accordance with the latest Government Regulations, and at all times shall be carried out and supervised by fully qualified persons in terms of these Regulations. If in any situation blasting is considered dangerous, the Engineer's decision in this respect shall be final. Should any damage of any kind occur, the Contractor shall be solely responsible for such damage or any claims that may arise therefrom, and shall, at his own expense, carry out repairs or restoration as the Engineer may direct. **Explosives and blasting**

Care shall be taken that no undischarged cartridges are allowed to remain in the excavation. Careless or indiscriminate use of explosives will result in the Engineer withdrawing permission for their use and under such circumstances the Contractor shall resort to other methods of excavation.

The Contractor shall obtain the written permission of the Engineer for each location where the Contractor requires to use explosives.

208 The sides of pits and trenches shall be adequately supported at all times. Alternatively, except where the Contract expressly requires otherwise, they may be suitably battered. **Excavation of foundation pits and trenches**

Trenches and pits shall be kept free of water in accordance with Clause 210. The bottom of all excavations shall be levelled carefully and stepped or benched horizontally as shown on the Drawings or as directed by the Engineer. Any pockets of soft material or loose rock in the bottoms of pits and trenches shall be removed and the resulting cavities and any large fissures filled with Class E concrete. 169

Immediately after the base of the excavation has been completed, and approved by the Engineer, blinding concrete to Class E shall be laid as shown on the Drawings or as instructed by the Engineer.

After the placing of any blinding concrete required by the Contract, no trimming of the side faces shall be carried out for 24 hours.

All excavated materials from such excavations not required for refilling shall be disposed of in accordance with the requirements of Clause 205.

The Contractor shall make good with suitable material as defined in Clause 214 or concrete as directed by the Engineer—

(i) Any excavation greater than the net volume required for the works as described in the Contract.

(ii) Any additional excavation at or below the bottom of foundations to remove material which the Contractor allows to become unsuitable.

209 Unless otherwise shown on the Drawings or directed by the Engineer all filling for this purpose shall consist of suitable material as defined in Clause 214 deposited and compacted by approved plant. Timber sheeting and other excavation supports shall be carefully removed as the filling proceeds except where they are required by the Contract to be left in position, but the removal of such supports will not relieve the Contractor of his responsibilities for the stability of the works. **Backfilling of foundation pits and trenches**

Earthworks to be kept free of water

210 Water shall not be allowed to accumulate at any point in the earthworks. The Contractor shall arrange for the rapid disposal of all water from the Works, whatever the source may be, and shall at his own expense effectively drain and keep dry the whole of the Works during the period of the construction.

Such provision shall include carrying out the work of forming the cuttings and embankments in such a manner that their surfaces have at all times a sufficient minimum crossfall and longitudinal gradient to enable them to shed water and prevent ponding.

Benching

211 In accordance with the Drawings or where directed by the Engineer the Contractor shall excavate benching in natural ground prior to the construction of embankments. Excavated material from benching shall be placed to fill or disposed of to the Contractor's tip as the Engineer directs.

Excavation below embankments and below formation level in cuttings

212 Where any material below the natural ground level under embankments or below formation level in cuttings is required to be excavated, it shall be removed to such a depth and over such an area as shown on the Drawings or directed by the Engineer and disposed of to the Contractor's tip.

The resultant excavation shall be backfilled with suitable material as defined in Clause 214 and compacted as specified in Clause 223.

Nevertheless, where in these circumstances such material has to be deposited below standing water the Contractor shall use approved granular material and such material may be deposited below water without the associated use of compaction plant.

170

Where directed by the Engineer approved rock fill material in accordance with Clause 215 shall be placed directly on the naturally occurring unsuitable material and compacted in accordance with Clause 224.

If after the removal of material as specified in the first paragraph of this Clause the Contractor allows the material so exposed to reach a condition where compaction of backfilling is impracticable he shall make good at his own expense either by additional excavation and filling in the manner specified in this Clause or by waiting until the condition of the exposed material is fit to receive the approved backfill.

Slips

213 During the excavation the Contractor shall limit vertical and other temporary faces to such heights as are suitable to the nature of the soil exposed. If in the course of the Works any slips, slides or subsidences extend below the line and slopes or below the levels shown on the Drawings, the excess excavation shall be at the Contractor's own expense and he shall make good in a manner satisfactory to the Engineer unless the Contractor can show that the slip, slide or subsidence was not due to his failure to comply with the Specification.

Suitable material for filling

214 Soils for fill shall be obtained from areas of cut, including side drains, or from approved borrow pits. Subject to the approval of the Engineer side drains may be widened to provide additional suitable fill.

Suitable fill material shall meet the following requirements:

(i) The Plasticity Index (PI) shall not exceed 30%.

(ii) The percentage passing a .075 mm sieve shall not exceed 40%.

(iii) The CBR swell shall not exceed 1% after soaking for 48 hours.

(iv) The maximum laboratory dry density as determined by the BS (Heavy) Compaction Test shall not be less than 1,500 kg/m³.

(v) The material shall not contain particles with a maximum dimension exceeding 100 mm except in the case of rock fill.

Where suitable materials with differing characteristics occur in the same area the Contractor shall be responsible for selecting those materials with the better engineering characteristics and reserving those for use in the upper layers of the fill.

215 Rock fill shall be of such a size that it can be deposited in horizontal layers not exceeding 450 mm loose depth extending over the full width of the embankment. **Rock fill**

No stone exceeding 300 mm in any one direction or 0.15 m³ in volume shall be used in rock fill embankments. The Engineer may however allow the incorporation of isolated boulders measuring not more than 900 mm in any one direction in embankments other than rock fills at depths exceeding 1.50 m below formation level.

216 Embankments and other areas of fill shall be formed of material defined as "suitable material" in Clause 214 or where directed by the Engineer, rock fill in accordance with Clause 215. **Forming of embankments and other areas of fill**

All earthworks material placed in or below embankments, below formation level in cuttings or elsewhere in the Works shall be deposited and compacted as soon as practicable after excavation in layers not exceeding 250 mm thickness before compaction. Subject to the Engineer's approval the loose depth of these layers may be altered following the results of compaction trials. 171

Embankments shall be built up evenly over the full width. During the construction of embankments the Contractor shall control and direct constructional traffic uniformly over the full width. Damage to compacted layers of material by constructional traffic shall be made good by the Contractor to the satisfaction of the Engineer.

The Contractor shall provide adequate supervision and ensure that only approved materials are incorporated in the embankment. If any unsuitable or oversize material, or material which has not been approved, is included it shall be removed from the embankment and replaced with approved material at the Contractor's expense.

217 The material to be compacted shall be thoroughly broken up over the full width and depth of the layer and all stones, clods and lumps shall be broken down to comply with Clause 214. **Preparation of material for compaction**

If the material deposited as fill subsequently reaches a condition such that it cannot be compacted in accordance with the requirements of the Contract the Contractor shall either—

(i) make good by removing the material off the embankment either to tip or elsewhere until it is in a suitable physical condition for re-use, and replacing it with suitable material; or

(ii) make good the material by mechanical or chemical means to improve its stability; or

(iii) cease work on the material until its physical condition is again such that it can be compacted as described in the Contract

Watering and mixing

218 The Contractor shall take advantage of the natural moisture content of the material and add water as necessary in successive applications, evenly and uniformly over the area to be compacted.

The water shall be thoroughly mixed with the material to be compacted by means of suitable equipment.

The material shall be compacted at the optimum moisture content of the material for the compaction plant to be used, with an allowable tolerance of plus one per cent and minus two per cent of moisture by weight of dry material.

Following approval by the Engineer the Contractor shall not vary his plant or methods without previously obtaining the Engineer's approval of such variation.

Compaction of fill

219 The level of compaction to be obtained in any part of the earthworks shall be expressed as a percentage of the maximum dry density (MDD) of the soil at optimum moisture content as measured in the BS (Heavy) Compaction Test.

The minimum standards of compaction to be achieved in fill shall be as follows:

Depth below finished road level	*Minimum permissible percentage of MDD*
150 mm–600 mm	95
Over 600 mm	93

Compaction shall be carried out evenly in a series of orderly and continuous operations over the width of the layer concerned and the length being compacted shall, where possible, be at least 300 m.

The provision, trimming and disposal of additional material to ensure proper compaction in side slopes shall be the Contractor's responsibility.

The Contractor shall obtain the approval of the Engineer's Representative to each layer of fill before spreading a further layer on top.

Testing will be carried out in accordance with Clause 222, although the Engineer may at any time carry out tests on compacted fill. If the test results when compared with the results of similar tests made on adjacent approved work show the compaction to be inadequate, the Contractor shall at his own expense carry out such further work as is necessary to bring the compacted fill within the specification.

Compaction trials

220 At the beginning of the Works, and from time to time as may be necessary in the opinion of the Engineer, the Contractor shall carry out to the satisfaction of the Engineer field trials to determine types of compaction equipment, suitable layer thicknesses and moisture contents, all within the requirements of the Specification, for the placing and compaction of the various materials to be used in the earthworks. The sites of the trials shall be agreed between the Contractor and the Engineer's Representative.

If compaction trial fill is placed as part of the Permanent Work, such fill shall conform to the requirements of the Specification and if it does not comply it shall be removed or reworked until it conforms.

The Contractor shall submit to the Engineer his proposals based on the results of the trials, for the placing and compaction of each variety of material to be used in the earthworks, including proposals in relation to types of plant, number of passes and loose depth of layers. Apart from the compaction trial, work shall not start on any particular variety of material until the Engineer has signified in writing his agreement to the Contractor's proposals for that material.

Following approval by the Engineer the Contractor shall not vary his plant or methods without previously obtaining the Engineer's approval of such variation.

221 Each type of fill material shall be compacted by plant which is suitable for the purpose. Suitable means shall be provided for compacting fill adjacent to structures and in other places where heavy plant cannot operate. The distribution of the wheels on any roller shall be such that the whole of the ground surface within the width of the roller is loaded during each pass. Rollers or other heavy plant may be used in the vicinity of concrete structures only after the concrete has been sufficiently cured and when the Engineer has given permission. **Compaction equipment**

222 The Contractor shall make such tests in advance of excavation as are considered necessary by the Engineer to determine the suitability of materials to be excavated for use as fill. Tests may include gradings, Atterberg Limits, compaction and CBR tests and shall normally be carried out not less than once for every 2,000 m^3 of material to be excavated. **Testing**

In situ density tests shall be carried out at a frequency of one per 100 m per layer or as directed by the Engineer.

223 Before the placing of any fill, or after the removal of unsuitable material, the surface of the ground over the width of the carriageway and shoulders, or over the bottom width of the embankment if the Engineer so instructs, shall be compacted to a depth of 150 mm to 90% of the maximum dry density (MDD) of the soil at optimum moisture content as measured in the BS (Heavy) Compaction Test. **Compaction under embankments and in cuttings**

Where the depth of construction below finished road level is less than 600 mm on embankment, or where the road is in cutting, the Engineer may, following the results of tests, instruct the Contractor to excavate below ground level, or below formation level, over such areas and to such depths as the Engineer may consider necessary. The surface exposed by this operation shall be compacted to 93% of MDD to a depth of 150 mm and the void refilled with suitable material compacted to 95% of MDD. The rates of these operations shall be deemed to allow for any additional compacted fill which may be required to make up the compacted surfaces to the original levels or the levels as reduced by the removal of unsuitable material.

224 Embankments formed with rock fill as defined in Clause 215 shall have all voids filled with approved fill material, and each layer shall be systematically compacted by at least eight passes of a towed vibrating roller weighing not less than 3 tonnes, or a grid roller weighing not less than 13 tonnes dead weight, or other compaction plant approved by the Engineer. **Compaction of rock fill**

225 Fill material which is required in addition to that provided by excavation for Permanent Works, including side drains, shall be obtained from borrow pits which shall be located by the Contractor and approved by the Engineer. The Contractor shall at his own expense provide all accesses, clear and remove all anthills, ants' nests, vegetation, topsoil, rock, boulders and unsuitable or oversize material and shall provide adequate supervision to ensure that approved material is not contaminated with unapproved or unsuitable material. **Borrow pits**

Borrow pits shall be excavated to regular width and shape and shall be cleared upon completion so that the sides are neatly trimmed, topsoil replaced and the bottom levelled and drained away from the Works in such a manner that no water will collect or stand in them.

Settlement of embankments on soft foundations

226 Where, in the opinion of the Engineer, foundation conditions below embankments may result in significant settlement he may instruct the Contractor to construct the embankments in stages. In such cases sufficient time shall elapse between the placing of successive stages to permit consolidation of the foundation to take place to a condition where, in the opinion of the Engineer, the addition of a further stage will not adversely affect the stability of the embankment.

Anthills

227 Where anthill material is encountered on the site of new embankments the Contractor shall excavate to a depth of 0.60 m below existing ground level over an area as directed by the Engineer. The excavated area shall be treated with an approved pesticide and backfilled with suitable material as defined in Clause 214 and compacted in accordance with Clause 219.

Trimming of slopes

228 The slopes of cuttings and embankments shall be trimmed to the slopes shown on the Drawings, or as directed by the Engineer. Any rock or boulder appearing in the face of a cutting or embankment shall be trimmed back to the correct slope and in addition any such rock or boulder which in the opinion of the Engineer is unstable shall be completely removed and the resulting void filled with compacted material to the approval of the Engineer.

Soiling and grassing

229 Where shown on the Drawings or directed by the Engineer the slopes of cuttings, embankments and verges shall be covered with topsoil and lightly rolled to the compacted thickness stated in the Contract.

All surfaces to be grassed shall immediately before grassing be reduced to a tilth and be free from stones.

Grass of the "Kapinga" species or other approved species shall be planted by the Contractor at 250 mm centres and watered at frequent intervals to ensure a quick and regular growth.

The Contractor shall be responsible for the watering, cutting and maintenance of all grassed areas during the period of the Contract.

Water-courses

230 Excavations carried out in the diversion, enlargement, deepening and straightening of existing watercourses shall include the operations of any necessary trimming of slopes, grading of beds, disposal of excavated materials and pumping, timbering works and materials necessary for dealing with the flow of water.

Filling existing water-courses

231 Where watercourses have to be diverted from the sites of embankments or other works, the original channels shall be cleared of all vegetable growths and soft deposits and carefully filled with suitable material as specified in Clause 214 and compacted in accordance with Clause 219.

Clearing existing ditches and streams

232 Existing ditches and streams shall where shown on the Drawings be cleared by removing vegetable growths and deposits. The sides shall be trimmed throughout and the bottoms uniformly graded and the ditches and streams kept clean and maintained for the period of the Works. Material removed from existing ditches and streams shall be disposed of in the Contractor's tips.

FIELD SUPERVISORS DUTIES AND RESPONSIBILITIES

Volume I

Contract Roadworks

Sydney
NATIONAL ASSOCIATION OF AUSTRALIAN
STATE ROAD AUTHORITIES
1975

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CONTENTS

		Page
** **Section 1—General**		
1.1	General	1
1.2	Public Relations	2
1.3	Documents and Records	2
1.4	Preliminary Works	6
1.5	Order of Work	6
1.6	Materials	6
1.7	Emergencies	8
1.8	Contract Payments	8
1.9	Cleaning Up	8
** **Section 2—Sampling and Testing**		
2.1	General	9
2.2	Soils and Pavement Materials	9
2.3	Tars and Bituminous Materials	10
2.4	Precast Concrete Drainage Structures	11
2.5	Concrete Constituents	11
2.6	Concrete Mix	11
2.7	Reinforcing Steel	12
2.8	Paint	13
2.9	Despatch of Samples	13
** **Section 3—Site Tests**		
3.1	General	14
3.2	Aggregate Tests	14
3.3	Concrete Tests	15
** **Section 4—Inspection Guide**		
4.1	General	16
4.2	Matters for Inspection	16
* **Appendices**		
** A	Equipment	19
B	Safety Measures on Works	21

Section 1 — GENERAL

1.1 GENERAL

Definition. The Field Supervisor is the man responsible for the direct supervision of the whole or any portion of the contract work carried out within a defined area or on a particular length of road. He is the representative of, and is responsible to, the Engineer supervising the work on behalf of the Principal.

This man may be called by such other names as Superintending Officer, Clerk of Works, Works Inspector, etc.

Authority. The authority of the Field Supervisor shall be that delegated to him, from time to time, by the Engineer.

Hours of Duty. The Field Supervisor shall remain on duty continuously while the work is in progress, unless otherwise instructed by the Engineer.

Prior approval shall be obtained for work outside normal working hours, except in case of emergency. Where such an emergency arises covering approval shall be sought for the additional hours worked.

Address. The Field Supervisor shall at all times keep the Engineer and the Contractor informed of his place of residence, postal address and both job and private telephone numbers.

Safety of Workmen. Compliance with the requirements of health and safety laws and regulations or industrial awards is the Contractor's responsibility, but any shortcomings shall be reported promptly to the Engineer. 177

Commonwealth and state acts, regulations, ordinances, codes and state road authorities' instructions relating to safety measures on works are listed in Appendix B.

Relations with the Contractor. The Field Supervisor shall be firm and prompt in his decisions and provide, as quickly as possible, any information sought by the Contractor. He shall at no time delay the work un-

necessarily. He shall inspect all materials and works promptly. He shall not place himself under any obligation to the Contractor or any of his workmen and shall not accept any favours from them. He shall deal directly with the Contractor or his representatives on the work (see appropriate clause of the General Conditions of Contract), and shall not issue instructions to the Contractor's workmen.

The Field Supervisor shall notify the Contractor promptly of any departure from the drawings or specifications. Any dispute between the Contractor and any failure by the Contractor to adhere to the drawings and specifications after his attention has been directed to a departure therefrom shall be referred promptly to the Engineer. All instructions to the Contractor shall be given in writing, one copy being retained and one forwarded to the Engineer. Any instruction given orally to the Contractor must be confirmed in writing as soon as practicable.

Equipment. The Field Supervisor shall check that all equipment required for the proper supervision of the work is available to him, and shall ensure that it is properly maintained during the work and is returned to the Engineer (other than expendable items) when the work is complete. A list of some items which may be needed is given in Appendix A.

1.2 PUBLIC RELATIONS

General. In all dealings with the public the Field Supervisor shall be courteous and co-operative. He shall on no account issue any statements concerning the work. Any request for information about the work shall be referred to the Engineer.

178 **Right of Entry and Resumption.** The Field Supervisor shall ensure that satisfactory side-tracks and detours are available, where necessary, and that traffic using private vehicle entrances and side roads is restricted as little as practicable.

1.3 DOCUMENTS AND RECORDS

Plans and Specifications. The Field Supervisor shall make himself thoroughly familiar with the drawings and specifications for the work and the requirements of the General Conditions of Contract. He shall report immediately to the Engineer any discrepancy or ambiguity he may discover in these documents. The Field Supervisor's copy of the drawings and specification shall not be altered unless authorised in writing by the Engineer. Any doubt as the interpretation of the drawings, specification or other matters connected with the work shall be referred to the Engineer for direction.

Wherever the specification states that a matter is to be determined 'by the Engineer', the Field Supervisor shall give the Engineer ample notice as to when his attendance is required.

Progress and Work-as-Executed Drawings. Each week the Field Supervisor shall plot details of the work done during the previous week upon his copy of the drawings or progress charts. The locations and dimensions of all additional works and amendments shall be carefully recorded. Upon completion of the work these drawings or charts shall be forwarded to the Engineer as a record of the work as executed.

Progress Reports. The Field Supervisor shall at regular intervals, as directed by the Engineer, make out a progress report in the required number of copies on the appropriate form. He shall retain one copy and forward the remaining copies to the Engineer.

For bridges this may be reduced scale drawings of the side elevation and plan of the bridge, coloured to show the work done to date; for roads this may be a suitable bar chart or line diagram. See Fig. 1.

An alternative method is to chart on the plans the completed work and the partially completed work. Charts of this type are necessary to assess positively the position at any time against the approved programme of works.

The charts should be available for inspection by the Principal or his representative at all times. Copies should also be submitted to support the periodic written progress reports as required.

Diary. The Field Supervisor shall keep a diary which shall be written up daily and which shall provide a permanent detailed record of the progress of the work. The following information is to be recorded:

- number and classification of men and plant engaged and their locations on the work;
- materials supplied to the Contractor and received by him and materials on hand (see also Measurement Book);
- delivery, installation and removal of Contractor's plant and details of major plant breakdowns and return to service;
- location and description of operations carried on each day;
- dates of commencing and finishing various sections of the work;
- dates of opening sections of the road to traffic;
- details and dates of notification of authorised amendments to the drawings or specification;
- details of any instructions or warnings given to, or important conversations held with, the Contractor or his representative;
- results of field tests on materials;
- date and method of despatch of test samples;
- particulars of detours including their condition and the date of opening or closing;

PROGRESS DIAGRAM

Period Ending: 30-11-75

Description of Work: Reconstruction S.H.2.2. 4km to 7.8km from Hopetown

Date Commenced: 25-11-75

Expected Date of Completion: 24-5-76

Distance from: Hopetown

(kilometres) 2 3 4 5 6 7 8

Clearing	XXXXXXXXXXXXXXXX //////
Fencing	XXXXXXXXXXXXXXXXXXXXXX
Earthworks	XXXXXXXXXXX //////////////
Culverts	XXXXXXXXXXXXXXXXXX
Gravel Pavements	XXXXXXXX
Bitumen Surface	XXXX///

Work in hand shown / / / / / / /

Work Completed shown x x x x x x x

C.O. Works. Superintending Officer

1-12-75 Date

Fig. 1—Typical Progress Diagram

- weather conditions, including approximate rainfall and temperature readings and their effect on the progress of the work;
- particulars of any delays which occur on the work and the reasons for them;
- remarks concerning any unusual features of the work or associated incidents;
- dates of visits to the site by the Engineer and important members of the Contractor's company;
- instructions received from the Engineer;
- where similar materials are drawn from different sources the locations of these materials in the work

On completion of the work the Field Supervisor shall forward his diary to the Engineer.

Measurement Book. The Field Supervisor shall make all necessary measurements and shall keep such records of the receipt and use of materials as will enable him to certify that the specified amounts of the various materials have been incorporated in the work.

For this purpose he shall keep an interleaved measurement book to record in duplicate:

- all measurements of completed work;
- quantities and types of materials as they are received;
- details of duly authorised deductions and extras;
- details of any work being carried out by the Contractor on an actual cost basis, with a reference to the authority for the work;
- details of the materials rejected or work condemned and disposal of rejected materials (this information should also be recorded in the Field Supervisor's diary).

181

In recording in his measurement book details of work carried out by the Contractor on an actual cost basis the Field Supervisor shall separately show for each job:

- the number of men engaged, the hours worked by each and the classification and the rate of pay for each;
- the amounts of materials used and their cost to the Contractor at the site of the works;
- the make, class and other relevant particulars of each plant item used and the time worked by it;
- a description and final measurement of the work completed.

The Field Supervisor shall indicate the source of his information for the above four items and shall check the items with the Contractor, or his

representative, who is required to acknowledge the correctness of the information by signing this record of work done.

On the first day of each costing period, the Field Supervisor shall forward the original entries for the previous period to the Engineer retaining the carbon copy for his own use.

Tally Sheets. The Field Supervisor shall ensure that, where applicable, all tally sheets for material delivered are duly certified and signed both by the Contractor and himself.

Correspondence. The Field Supervisor shall keep copies of his outgoing correspondence in an interleaved correspondence book.

Correspondence received shall be kept on a file and copies of any correspondence, other than that received from his employer, shall be referred to the Engineer.

Security. Generally, the project diary, all contract correspondence and copies of any reports to the Engineer should be treated as confidential and be kept in locked drawers or cabinets when not in use and when the office is unoccupied for any length of time.

1.4 PRELIMINARY WORKS

Setting Out. It is the Contractor's responsibility to set out works, the Field Supervisor shall not set out any work, but shall make checks continually or arrange for such checks to be made. The position, alignment, grading and dimensions of the work as set out by the Contractor shall be compared with the drawings. Permission for work to proceed shall only be
182 given when the Field Supervisor is satisfied with its correctness. In general, such permission does not absolve the Contractor from his responsibility for the correct setting out of the work.

Location of Services. The Field Supervisor shall ascertain the location of all public utility services in the vicinity of the work and, if it appears that they will be affected by the Contractor's operations, shall draw the Contractor's attention to their presence. He shall report immediately to the Engineer any damage to the services resulting from the operations of the Contractor.

1.5 ORDER OF WORK

The Field Supervisor shall ensure that the order of works as decided by the Engineer is maintained.

1.6 MATERIALS

General. The Field Supervisor shall, where applicable, measure the capacity of the Contractor's vehicles and plant, check the loading or charg-

ing thereof, carry out all necessary tests or measurements and keep such records of the receipt and use of materials as shall enable him to certify that the specified amounts of the various materials have been delivered to and used in the work.

Before any part of the work is commenced the Field Supervisor shall check that adequate quantities of all materials required are on hand or will be available when required to complete that stage of the work.

The Field Supervisor shall ensure that all materials used in the completed work have been tested or inspected and accepted as required by the specification or directed by the Engineer. He shall report to the Engineer any material received on the work which, as far as he knows, has not been tested or inspected and shall arrange for inspection, sampling and testing to be carried out as directed by the Engineer.

Materials Supplied to the Contractor. All material supplied to the Contractor by the Principal shall be checked for quantity and condition by the Field Supervisor as soon as possible after its arrival in the presence of the Contractor or his representative.

The Field Supervisor shall obtain receipts (or copies) for all such material supplied to the Contractor and shall ensure that any damage or deficiency in the material is entered on the receipts.

The Field Supervisor shall forward the receipts to the Engineer and report any damage or deficiency without delay.

Sampling and Testing. The object in sampling and testing is to ensure that the various materials used in the works comply with the specifications governing the works.

The procedure to be adopted in sampling and testing various materials, together with the number and size of samples, are detailed in Section 2. The requirements to be met in the tests are set out in detail in the specification governing each particular class of work. A record of all field tests is to be kept (see Diary, Clause 1.3).

It is important that samples be forwarded for testing in time for the necessary tests to be carried out, e.g. 28-day concrete tests.

Site Tests. Certain tests need to be carried out at the site of the work by the Field Supervisor, who shall make himself thoroughly familiar with the procedures for them. (For details see Sections 2 and 3.) Other tests will be arranged by the Engineer.

The Field Supervisor shall draw the Engineer's attention to the need for these tests in ample time for the Engineer to make such arrangements as are necessary.

Faulty Materials or Work. The Field Supervisor shall:

- forbid the use of materials and procedures which do not comply with the drawings and specifications;
- require the removal or repair of faulty construction.

Whenever practicable, reference is to be made to the Engineer prior to taking such action.

1.7 EMERGENCIES

The Field Supervisor shall notify the Engineer immediately any emergency or unusual conditions arises in the course of the work such as accidents, industrial dispute, serious scour, slips, fire, storms, and imminent floods.

The Field Supervisor shall note the high water level of any floods occurring during the progress of the work. Should a flood higher than that shown on the drawings occur it shall be reported immediately and the level reached recorded for future reference.

1.8 CONTRACT PAYMENTS

Progress Payments. The Field Supervisor shall obtain from the Contractor, if required by the Engineer, a copy of the quantities which the Contractor proposes to insert in each progress payment claim. The Field Supervisor shall check and, if necessary, correct the quantities and hand a copy of the corrected list to the Contractor and also forward a copy to the Engineer. The copy forwarded to the Engineer shall bear the certificate

> 'I certify that I have measured up the work done and materials on hand as at ..... and the quantities shown above are correct.
>
> (Signature) .....
>
> (Date) .....'

184

Variations. All extras and deductions on the contract will be ordered by the Engineer and measured by the Field Supervisor.

Extras shall be measured as directed by the Engineer to enable payment to be made. This payment may be on the basis of one of the following:

- In accordance with the existing schedule of rates, where applicable.
- In accordance with a new schedule of rates for work not covered by the existing schedule.
- By day work or actual cost basis.

Extras must be recorded separately in the measurement book and the date of the order by the Engineer recorded in the diary.

Work shall not be commenced until the basis of payment is agreed to by the Contractor and the Engineer.

1.9 CLEANING UP

The Field Supervisor shall ensure that the Contractor cleans, tidies and trims the area before vacating the site.

Section 2 — SAMPLING AND TESTING

2.1 GENERAL

The object in sampling and testing is to ensure that the various materials used, or proposed for use, in the works comply with the relevant specification.

Sampling is to be carried out in a manner which will ensure that the sample represents as nearly as practicable the material under consideration. Set out in the following clauses are abbreviated instructions for sampling materials normally encountered in roadworks. These should be supplemented by detailed instructions from the Engineer.

2.2 SOILS AND PAVEMENT MATERIALS

General. For soils with a particular specified minimum quality and all pavement materials testing will be required to ensure they meet the specification. For this purpose, sampling of materials may be required when in a loose, blended or compacted state.

Sample Size. 7-10 kg.

Method of Sampling.

(a) *Sub-grade Materials*: Without disturbing the sub-grade, remove any overlying pavement, sweep the exposed sub-grade surface and take sufficient material to provide the sample. For each type of soil classed as *essentially similar*, a minimum of one sample for each 300 m of road is required. The point each sample is taken from must be carefully selected to truly represent the range of variations in each soil classed as *essentially similar*.

(b) *Pavement Materials*: Pavement materials may be sampled and tested for control purposes in their loose state or, where several materials are to be combined, after blending has taken place. However, as the pavement material may break down during compaction, it must be tested for compliance with specification requirements after final compaction.

Loose Materials: To secure representative samples a much larger portion than the final sample size must be taken in the first instance. This must then be carefully coned and quartered to the required size on a clean impervious surface.

A sample to represent a rail truck or lorry load is taken as follows:

- Remove the surface material at the centre and near each corner of the truck to a depth of 300 mm. From the exposed surface at each of these five sampling points take about 10 kg for large gauge stone or 5 kg for fine aggregate. That is a total of 50 kg for large gauge stone and 25 kg for fine aggregate.
- Combine this material and quarter to the required sample size. Return the remainder to the rail truck or lorry.

Completed or Existing Pavements: Prior to sampling, the surface is swept, and thoroughly dampened if it is dry and friable. A square hole is dug to the full depth of the layer to be sampled and the sample taken from the material removed. The minimum number of samples is one per kilometre where the material is similar; if the material varies more will be required. It is essential to select the location of the sample hole so as to represent the material. Samples should not be merely taken at regular intervals.

(c) *Compaction*: Compaction is tested during the progress of the work. The maximum thickness of the loose layer before rolling is usually specified. The standard of compaction is measured in-place either by the sand replacement method or proof rolling or other method as directed by the Engineer.

2.3 TARS AND BITUMINOUS MATERIALS

Sample Size. One litre.

Method of Sampling and Testing. All tars, bitumen, bitumen emulsions and asphalts shall be sampled and tested in accordance with the requirements of the following appropriate Australian standard:

A10, Residual bitumen and fluxed native asphalt for roadmaking purposes

A63, Road tars

A131, Cutback bitumen

186 A156, Bitumen emulsion (anionic) for roadmaking purposes.

NOTE: The above standards are currently being revised in metric units.

An abbreviated description of the sampling procedure is given below:

(a) *Road or Rail Tankers and Portable Tanks*: The material must be made fluid by heating. Separate portions are taken from the top, middle and bottom of the tank by lowering a closed metal container carrying a litre sample tin. This container is lowered to the required depth, opened by remote control to allow the tin to fill, then closed and withdrawn from the tank. The three portions are mixed thoroughly and the sample is then taken from the mixture.

(b) *Drums*: Treat each batch or lot of similar material as the unit for sampling. From each unit a portion of the contents shall be taken from a number of drums which shall not be less than the cube root of the number of drums in the unit.

The contents of each drum sampled must be thoroughly mixed before pouring off a portion of the contents. Approximately equal quantities are taken from each drum sampled, these are then mixed and the sample required poured off from this mixture.

2.4 PRECAST CONCRETE DRAINAGE STRUCTURES

Generally concrete pipes, culvert sections and earthenware pipes are tested before despatch. The Field Supervisor is required to check that all such items have been accepted by or on behalf of the Principal, reach the works undamaged and are properly stacked after receipt.

2.5 CONCRETE CONSTITUENTS

Aggregates.

(a) *Sample Size*: Coarse aggregate greater than 9·5 mm—45 kg.

(b) *Method of Sampling*: All concrete aggregates shall be sampled in accordance with the requirements of AS 1141, Methods for sampling and testing aggregates. An abbreviated description of the procedure is given below:

Road or Rail Trucks: The sampling procedure for each rail truck or road lorry is as described in Clause 2.2(b), Pavement Materials.

Stockpiles: From each stockpile one sample is taken to represent each 200 m³ or part thereof.

The sample is taken by digging down to the mid-height of the stockpile at five places, one at the centre and one near each corner, and taking a sample portion as previously described (see 'Loose Materials' under Clause 2.2(b)). These are combined as before to represent each small stockpile or each section of a large stockpile which contains approximately 200 m³. Corner samples from adjacent sections must be a reasonable distance apart.

Cement: One unopened bag (40 kg) for each 100 bags or small lot received is to be forwarded for testing unless directed to the contrary by the Engineer. 187

Mixing Water:

- *Sample Size*: Two litres.
- *Method of Sampling*: When a sample is obtained from a stream or lake the sample must be taken by dipping from below the surface well out from the stream bank or lake edge.

  The container, a glass stoppered jar, and the utensils for taking samples must be clean and should preferably be washed in the water to be sampled. The container should be securely sealed before despatch.

2.6 CONCRETE MIX

Sample Size. Approximately 70 kg, sufficient for a slump test and two 150 mm dia. × 300 mm long test cylinders.

Method of Sampling. Fresh concrete shall be sampled in accordance with the requirements of AS 1012—Part 1, Method for sampling fresh concrete. One concrete sample, representing a batch, is usually taken from the mixer.

Preparing Test Cylinders. Concrete test cylinders shall be prepared in accordance with the requirements of AS 1012—Part 8, Method for making and curing concrete compression, indirect tensile and flexure test specimens in the laboratory or in the field. An abbreviated description of the procedure follows.

The steel base plate of the concrete test cylinder mould is placed on a suitable level surface, the mould is then placed on and clamped to the plate.

The mould is filled in three (3) approximately equal layers each layer being compacted by tamping with at least 25 strokes of a 15 mm diameter steel rod 600 mm long tapered for a distance of 25 mm to a spherically shaped end having a radius of approximately 5 mm. The surplus concrete is struck off, the surface smoothed and the mould covered with a cap plate.

The moulded samples are kept on site for a period not less than 18 hours nor more than 72 hours in a store where they are not subject to temperatures outside the limits set out in the following table.

Climatic Zone	28 day test		7 day test	
	max. °C	min. °C	max. °C	min. °C
Standard Temperate Climate	33	13	28	18
Standard Tropical Climate	35	19	31	23

NOTE: The standard tropical climate includes Queensland, the Northern Territory and that portion of Western Australia north of latitude 25° South and the standard temperate climate includes Tasmania, Victoria, South Australia, A.C.T., New South Wales and that portion of Western Australia south of latitude 25° South.

188

2.7 REINFORCING STEEL

Sample Size. Round or deformed mild steel bars—two samples 750 mm long.

Method of Sampling. Reinforcing steel is generally tested before despatch to the works, but if samples are required the Engineer will direct the method of sampling to be adopted.

2.8 PAINT

Sample Size.

Paint—500 ml

Unmixed Pain: Material—oil—500 ml

pigment—200 g

Method of Sampling.

(a) *Paint*: The paint is mixed thoroughly then the required volume poured off.

(b) *Unmixed Paint Material*: For the oil and each pigment the required volume is taken from the separate containers.

2.9 DESPATCH OF SAMPLES

General. The method of labelling, packaging, identifying and despatch of samples taken in accordance with an Australian standard is specified in the standard and these requirements should be followed. The following clauses briefly summarise the minimum requirements necessary.

Labelling and Identification. A label, with the forwarding address on one side and the sender's name, location of the work, distinguishing mark of the sample and the date it was taken, clearly shown on the reverse side, is to be securely attached to each sample.

Packaging.

- Glass containers are to be securely sealed and crated to prevent damage during transit.
- Bagged materials must be despatched in clean canvas bags (not sugar bags) strong enough to prevent damage during transit or loss of fine particles.
- Concrete cylinders are to be packed so that they are kept damp during transit.

Advice of Despatch. Advice of despatch must be forwarded separately direct to the consignee stating the method of transport and the terminal to which the samples have been sent.

Time of Despatch. Samples must always be despatched to reach their destination in time to enable testing to be completed within the specified period, e.g. 28-day concrete compression tests.

Section 3 — SITE TESTS

3.1 GENERAL

Site tests are those necessary to control day-to-day operations on contract roadworks. They are usually simple in nature but do not replace the more detailed laboratory tests which may be necessary for complete quality control.

Site tests do not replace acceptance tests that may be required for materials at their source of supply.

3.2 AGGREGATE TESTS

Mechanical Analysis—Fine and Coarse Aggregates. The mechanical analysis of all aggregates for compliance with the specification should be done in accordance with the requirements of AS 1141, Methods for sampling and testing aggregates. The following abbreviated description is suitable only for control tests.

A weighed quantity of dry aggregate (see Table 1) is passed through the specified set of sieves by continuing the action of sieving until less than one per cent of the weight retained on each sieve is passed through that sieve during the last minute of sieving.

The weight of aggregate passing each sieve is expressed as percentages of the weight of the whole sample.

TABLE 1

190 Minimum Sample Sizes

Maximum Size of Material Present in Substantial Proportions mm	Minimum Size of Sample kg
40	25
28	10
20	5
14	2·5
10	1·0
7	0·5

Tests for Impurities in Fine Aggregate for Concrete. Tests for impurities in aggregate should be done in accordance with the requirements of AS 1141, Methods for sampling and testing aggregates. The following abbreviated description is only suitable for control tests.

A graduated bottle capable of holding more than 350 ml is usually used for this test. First place 125 grams of fine aggregate in the bottle and then add a three per cent solution of sodium hydroxide until the total volume amounts to 350 ml. Shake the bottle and if necessary add more solution to bring the total volume to 350 ml. Insert the stopper in the bottle, shake it again and allow to stand.

The existence of organic impurities is indicated by the colour of the liquid after 24 hours. If the colour is deeper than light amber there is an excess of organic impurities in the aggregate.

Tests for Bulking of Fine Aggregate for Concrete. The test to determine bulking of aggregate should be done in accordance with the requirements of AS 1141, Methods for sampling and testing aggregates. The following brief description of the test is only suitable for control purposes.

The fine aggregate is placed loosely into a suitable container, levelled, the height H measured and the aggregate emptied into a second container. The first container is half filled with water and half the fine aggregate poured back and rodded until its volume is a minimum.

The remainder of the fine aggregate from the second container is then added and also rodded. The top surface of the inundated fine aggregate is levelled and the height H_1 measured.

The percentage of bulking is then equal to:

$$\left(\frac{H-H_1}{H_1}\right) \times 100$$

3.3 CONCRETE TESTS

191

Slump Test. The slump test for concrete shall be performed in accordance with the requirements of AS 1012—Part 3, Determination of the consistency of concrete (slump test). The following brief description of the test is only suitable for control tests.

A slump cone is placed on a level surface and is filled in three (3) approximately equal layers with freshly mixed concrete, each layer should be approximately one-third of the volume of the cone. Each layer is tamped evenly over the surface with 25 strokes of the tamping rod (see Clause 2.6).

After the top layer has been tamped the surface is struck off level with the top of the cone so that it is exactly filled. The cone is then removed by raising it slowly and carefully in a vertical direction allowing the concrete to subside. The raising of the cone is to be completed in approximately 1½ seconds without causing any lateral or torsional displacement of the concrete.

The slump is the difference in millimetres between the height of the cone and the height of the vertical axis of the subsided concrete.

Section 4 — INSPECTION GUIDE

4.1 GENERAL

The Field Supervisor should always bear in mind that both he and the Contractor are employed by the Principal to achieve a satisfactory completion of the Contract and that they should work together to this end.

All inspections should be carried out promptly and all decisions sought by the Contractor should be available in sufficient time to maintain progress.

4.2 MATTERS FOR INSPECTION

General. The following matters are usually common to all road construction works but each job may have additional features which are peculiar to that job and which should be considered.

Although they are the Contractor's responsibility, the Field Supervisor is required to ensure the Contractor complies with the specification, and other requirements, on the following matters.

Provision for Traffic. Ensure that the Contractor meets the specification on:

- safety, adequacy and maintenance of side-tracks or detours, as well as the provision for traffic through the works under all weather conditions;
- proper maintenance and location of signs and lighting;
- stability of temporary barricades under all weather conditions;
- provision for safe guidance of traffic through or around construction operations.

Protection of the Public and Property. Ensure that the Contractor meets the specification on:

- protection of the public from the construction operations;
- adequacy of warning to, and control of, the public when explosives are being used;
- control of construction operations to prevent damage to adjacent property;
- security of plant and equipment when unattended, and parking plant clear of travelled ways when unattended;
- adequate protection for the public at all excavations especially adjacent to public thoroughfares.

Safe Construction Practices. Ensure that the Contractor meets the specification on all specified safety regulations and requirements. (The requirements of the relevant statutory authority must be met at all times.)

Access to and Security of Abutting Properties. Ensure that reasonable access to abutting properties is maintained as required by owners.
When fences are breached ensure that adequate arrangements are made to protect and secure the property.

Public Utilities. Ensure that adequate provision is made to protect public utilities within the works site.

Setting Out. Ensure that the works set out by the Contractor are in accordance with the plans and specifications.

Earthworks. Check whether the following comply with the specified requirements or, if not specified, comply with good practice.

- Suitability of soils for embankments.
- Clearing of embankment foundations and removal of all soft spots and unsuitable materials.
- The depth of loose layers being placed and suitability for compaction and final compaction.
- All plant necessary is available, suitable, and in good order.
- The dimensions of cuttings and embankments.
- The line and level of completed work.
- The trimming of batters, slopes, drains.

Drainage. Ascertain whether the following comply with the specified requirements or, if not specified, comply with good practice.

- The position, level and line of culverts, kerbs and gutters, gully pits, etc.
- Foundation and suitability of bedding.
- Laying, jointing and type of drainage units.
- Back filling material and compaction.
- Head walls and cut-off walls.
- Formwork, formwork stability, reinforcement, construction joints and dimensions of cast-in-place structures.
- The adequacy of inlet and outlet drains.
- Disposal of subsoil water.

Pavements.

- Ensure that the pavement material is acceptable.
- Check that the compaction, pavement depth, width, finish, line and level is acceptable.

Surfacing.

- Ensure that the surface of the gravel pavement is sound, swept, and ready for treatment.
- Check that the primer, aggregate and binder have been approved, are available and that the road temperature is satisfactory.
- Check rates of application and details required for surfacing treatment, including road and binder temperatures.
- Ensure that all plant necessary is available, suitable, and in good order.
- If premix surfacing material is to be used ensure that:
  (1) the mix has been approved;
  (2) paving and compaction plant is available, suitable, and in good order;
  (3) the compaction, rolling and finish is satisfactory.

Roadside Furniture.

- Inspect guideposts for dimensions, delineators, location and fixing.
- Inspect safety fencing for dimensions, location and fixing.

Closing of Works. Ensure that:

- all commitments to property owners in respect of fences, gravel pits, access roads and similar matters have been finalised;
- all rubbish, fallen timber, temporary buildings and the like have been satisfactorily disposed of and the job left clean and tidy;
- all detours, side-tracks, signs, etc. have been removed;
- all job records are complete and handed over to the Engineer.

APPENDIX A

EQUIPMENT

Field Supervisors should ensure that they have available suitable equipment for the proper supervision of the work. This will include appropriate items from the following check lists.

A1. Plans

Drawings and specifications for the work—at least two copies (one full size to the scale drawn, and half size copies as required).

A2. Stationery

Diary (A5 size) with one day to each page
Correspondence book (A4 size with carbon paper)
Envelopes
Measurement book (A5 size)
Field pocket notebook
Pens (red and black)
Pencils
Timber crayons
Level book
Supply of labels (for samples)

A3. Tools

Steel tape 30 m
Metallic tape 30 m
Dumpy level (or equivalent) and staff
Spirit level
String line and line level
Two plumbobs

Mason's trowel
Hand scoop
Prospector's pick
Carpenter's rule
Claw hammer
Axe
Round mouth shovel
Mud pick
Straight edge 3 m long
Pavement cross section template

A4. Testing Apparatus

Set of sieves
Scales and weights
Concrete test cylinder moulds (in sets of two)
Base plates not less than 9 mm thick complying with the requirements of AS 1012—Part 8, Method for making and curing concrete compression, indirect tensile and flexure test specimens in the laboratory or in the field
Steel rod 15 mm dia., 600 mm long and tapered for a distance of 25 mm to a spherically shaped end having a radius of approximately 5 mm
Slump cone
Three graduated sample bottles of at least 350 ml capacity for fine aggregate impurity tests
Graduated glass jar for sand bulking test
Litre of 3 per cent sodium hydroxide solution
One dozen press lid tins of 2 litre capacity
Spring balance 15 kg capacity
Whisk broom
Scale graduated in millimetres
One dozen approved sample bags
Compaction test equipment
Thermometer—maximum-minimum and recording special type for measuring concrete temperature
Graduated glass cylinder—1 litre capacity

A5. Safety Equipment

First-aid kit
Safety helmet
Suitable working gloves
Safety glasses
Safety boots

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CONTENTS

GOLDEN JUBILEE PAPERS

Foreword from Construction Division Executive Committee
by M. D. Morris, Chairman 235
by Emanuel T. Jensen, Vice Chairman 235

Message from Golden Jubilee Committee
by Robert F. Borg, Chairman 237

Fifty-Year Development—Construction of Steel Truss Bridges
by Lawrence N. Bigelow 239

An Introduction to Fifty Years of Tunneling
by Robert S. Mayo 259

Fifty-Year Highlights of Tunneling Equipment
by David A. Day and Bradford P. Boisen 265

Half Century of USBR Arch Dam Construction
by James R. Graham, James Legas, and Ernest A. Lindholm . . . 281

Fifty Years of Construction Cost-Reducing Analyses
by Robert L. Peurifoy . . . Abst. in HRIS . . . 299

Past and Future of Construction Equipment—Part I
by Franklin J. Larkin and Stuart Wood, Jr. 309

198

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The New Montreal International Airport
by G. Y. Sebastyan 317

Construction Helmet Response under Severe Impact
by Werner Goldsmith 335

In-Place Evaluation of Concrete
by V. Mohan Malhotra 345

** **Recommended Standards for the Responsibility, Authority, and Behavior of the Inspector**
by the Committee on Inspection of the Construction Division 359

Rigid and Flexible Bracing Systems on Adjacent Sites
by Richard G. Tait and Henry T. Taylor 365

OSHA Trenching and Shoring Standards
by George E. Mason and Steven Shimp 377

Fort St. Vrain PCRV Bottom Head Construction
by Hughas M. G. Nerses and Clyde B. Tatum 391

Some Applications of Prestressing in Foundation Construction
by Ingvar Schousboe . . ABST. . IN. HRIS 403

Job Dissatisfactions in Construction Work
by John D. Borcherding and Clarkson H. Oglesby 415

199

DISCUSSION

Proc. Paper 11336

Masonry Construction Operations, by Clayford T. Grimm (June, 1974).
errata 437

Engineering Services for Construction,* by Altaf Hussain (Sept., 1974).
by S. M. Saleem Moini 437
by Mohammad Mushtaq 438
by Roland S. Jary 440

Network Analysis and Construction Planning,* by Shlomo Peer (Sept., 1974).
by Abraham Solnick 442

*Discussion period closed for this paper. Any other discussion received during this discussion period will be published in subsequent Journals.

Vibrations during Construction Operations,* by John F. Wiss (Sept., 1974).
by Ramzi H. Ferahian 443

Some Construction Aspects of Tarbela Dam,* by Morgan H. Thompson (Sept., 1974).
by S. M. Saleem Moini 443

Recent Results in French Research on Reinforced Earth,* by François Schlosser and Nguyen-Thang Long (Sept., 1974).
by Noel E. Simons 444

Polymer-Cement Concretes for Field Construction,* by Sandor Popovics (Sept., 1974).
by Krishnaiyengar Rajagopalan 446

Model Form of 'Notice to Bidders',* by the Committee on Contract Administration of the Construction Division (Sept., 1974).
by S. M. Saleem Moini 448

Repair of Earthquake Damaged Underground Reservoir,* by Daniel J. Smith, Jr. (Sept., 1974)
by Norman B. Jones 449

Construction Solid Waste,* by David A. Spivey (Dec., 1974).
by William B. Culham 451

Stability of Trenches Filled with Fluids,* by Kevin L. Nash (Dec., 1974).
by A. L. Little 453

Labor Cost Control,* by Paul Teicholz (Dec., 1974).
by Sol E. Mester 453

Diaphragm Wall Construction Techniques,* by Kevin L. Nash (Dec., 1974).
by A. L. Little 455

Hardinge Bridge Span Repair, by Amitabha Ghoshal, Jagadish C. Ganguly, Himangsu K. Banerjee, and Mahesh P. Kapoor (Dec., 1974).
errata 456

*Discussion period closed for this paper. Any other discussion received during this discussion period will be published in subsequent Journals.

11384 JUNE 1975 CO2

JOURNAL OF THE
CONSTRUCTION DIVISION

Recommended Standards for the Responsibility, Authority, and Behavior of the Inspector

By the Committee on Inspection
of the Construction Division

Introduction

Constructors, owners, designers, and independent inspection agencies have all expressed dissatisfaction with present day inspection practices and with the qualifications of the inspector. It has been estimated that the situation of inexperienced inspectors plus overzealous inspection practices is adding about $500,000,000 annually to the cost of construction nationally.

The Committee on Inspection recently completed a comprehensive questionnaire project in which all segments of the construction industry were given an opportunity to express their views on the subject of inspection, its problems, and their solutions. The information received was evaluated, summarized, and published in the September, 1972, *Journal of the Construction Division* (1). Many areas requiring needed improvement were identified, among them being: (1) Responsibility; (2) authority; (3) behavior; (4) fees for inspection services; (5) salaries; (6) training; and (7) certification. 201

The Committee chose the areas of responsibility, authority, and behavior of the inspector for its first project of recommended standards. These standards are applicable to construction projects, in which the owner is represented on the site by an inspection team headed by a resident engineer and including a chief inspector to supervise a group of inspectors. Many of these standards can also be applied to projects having only one or two inspectors.

The standards presented are the Committee's recommendations on what the responsibilities, authority, and behavior of a qualified inspector should be. They also reflect the thinking of those members of the construction industry who participated in the questionnaire project.

As a prerequisite to any consideration of standards for establishing responsibility, authority, and code of ethics of the inspector, certain conditions have to be assumed or established. These relate to qualifications and other matters having to do with the capability of the inspector to assume responsibility, exercise

Note.—Discussion open until November 1, 1975. To extend the closing date one month, a written request must be filed with the Editor of Technical Publications, ASCE. This paper is part of the copyrighted Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Vol. 101, No. CO2, June, 1975. Manuscript was submitted for review for possible publication on December 11, 1974.

authority, and behave in an appropriate and effective manner.

The contract documents require the contractor to furnish experienced personnel. The same should apply to the owner's inspection team; it should be staffed with knowledgeable qualified people.

Education.—The inspector should have sufficient formal education to give him the capacity to understand the engineering principles involved in the construction of the work he is to inspect, an education equivalent to that of engineering technician.

Training.—Training in this context means learning, through experience, how to perform the duties of an inspector. The learning experience should be under the supervision of a construction engineer or experienced construction inspector. It also includes specific instruction relating to the particular work in which he will be engaged. The instruction should provide thorough indoctrination in technical matters specifically related to the particular work to be inspected and in matters pertaining to the inspector's behavior.

Personality.—To be successful in his work, the inspector must merit the respect and confidence of those he works for and of those whose work he inspects. He must be honest and fair, exercising his responsibilities with firmness and good nature. He should work cooperatively with the contractor but in such a way as not to prejudice his basic responsibility to the owner.

Compensation.—The inspector must be adequately compensated for the responsibility he is called on to assume and for the authority he is delegated to exercise. The inadequately compensated inspector is a prime target for pay off, will obviously be undermotivated, and most likely be unqualified. This can be related to the fees paid for inspection services, for the amount of the fee will generally establish the salary levels.

202

Responsibility

The inspector is responsible for seeing that the work he is inspecting is being constructed in accordance with the requirements of the plans and specifications. This, however, does not give him the right to unnecessarily or willfully disrupt the operations of the contractor. In the performance of his assigned duties, the inspector assumes the following responsibilities:

1. He must become thoroughly familiar with the plans and specifications as they apply to the work he is to inspect, and he should review them frequently. The inspector must be capable of recognizing immediately if the work he is inspecting conforms to the contract requirements.
2. If any material or any portion of the work does not conform to the requirements, the inspector should so notify the contractor, tell him why it does not conform, and record it in his daily report. Should the contractor ignore the notice and continue the operation, then the inspector should promptly advise his supervisor.
3. As a member of the construction team, the inspector must perform his duties in a manner that will promote the progress of the work. He should be familiar with the construction schedule and know how the work that he is inspecting fits into the overall schedule. Completion of the work within the contract time is of importance to the owner also.

4. The inspector must studiously avoid any inspection, testing, or other activity that could be construed as a responsibility of the contractor; otherwise he may prejudice the owner's position in the event of a dispute or claim. This applies particularly to the contractor's quality control program for testing and inspecting his materials and workmanship, as a part of his contractual responsibility.

5. When the inspector is assigned to an operation, he should cover it as long as the work is proceeding or see to it that another inspector takes over, should he have to leave. This applies particularly to work that will not be viewed again, such as driving piles, laying pipe in a trench, and placing concrete.

6. The inspector's daily report should include a recording of the day's happenings, the contractor's activity on the work he is inspecting, instructions given the contractor, and any agreements made. The inspector must remember that in the event of contract disputes, his daily reports assume legal importance.

7. In the matter of on-site testing, tests should be performed expeditiously and carefully; test samples carefully handled and protected; and test failures reported to the contractor without delay. It is a needless waste of time and money when a contractor is informed of an unsatisfactory result of a test that was performed 2 or 3 days previously.

8. Inspections and tests should be promptly made and timely:

a. Materials should be checked as soon after they are delivered as possible. An inspector who rejects material after it has been placed in its permanent position is not working in the best interest of the owner.

b. Preparatory work such as clean up inside the forms, fine grading of footing areas, winter protection for concrete, etc., should be promptly checked to minimize delay to subsequent operations. 203

c. Work should be inspected as it progresses. For example, postponing the inspection of the placing of reinforcing steel and other embedded items until they are 100% complete does nothing but delay progress.

d. An inspector has the responsibility to be available at all times to provide prompt inspection, and a decision on acceptance when required. A contractor should not be required to delay his work while the inspector is locating his supervisor to make this decision. Of course, by the same token, the contractor is expected to give adequate notice to the inspector when he (the contractor) will be ready for inspection on an operation.

9. If any specified tolerance governing the contractor's work is found to be unrealistic, it is the responsibility of the inspector to so report it to his supervisor.

10. Too literal an interpretation of the specifications can cause problems if it is not applicable to the particular situation. In such instances, the inspector must review the conditions and seek guidance from his supervisor, if necessary.

11. Whenever possible, problems should be anticipated in advance. The contractor's supervisor may seem to be unaware of a sleeve or other embedded item that must be set in the forms. It is incumbent upon the inspector to point this out to the supervisor. By this advance notice, the inspector contributes to maintaining progress of the work.

12. Unacceptable work should be recognized in its early stages and reported to the contractor before it develops into an expensive and time-consuming correction. The notification should be confirmed in writing where necessary. For example, if the contractor is using the wrong form lining, stockpiling

unacceptable select backfill material, or placing undersize riprap material, he should be informed of this at the first opportunity. An inspector who has thoroughly familiarized himself with the contract requirements can recognize these situations almost immediately.

13. Occasionally a problem may arise which the inspector is unable to handle by himself. He should report this to his supervisor for prompt action. Unresolved problems can sometimes develop into critical situations and claims.

14. Rather than make a hasty decision, the inspector should thoroughly investigate the situation and its possible consequences. Many embarassing situations develop from decisions made prematurely. For example, a request by the contractor to be permitted to begin placing concrete at one end of a long footing while his men are completing the reinforcing at the far end should be given consideration and not be automatically denied. If necessary, the inspector should seek advice from his supervisor.

15. When work is to be corrected by the contractor, the inspector should follow it up daily. Otherwise, the corrections may be forgotten or the work soon covered over.

16. The inspector should stand behind any decision he makes on the contractor's work. An untrue denial by the inspector may cause immeasurable damage to the relations between contractor and inspection personnel.

17. In the course of his work, the inspector must be capable of differentiating between those items that are essential and those that are not, as defined by his supervisor.

204 18. The inspector should be safety minded. If he observes a dangerous condition on the job, it is his responsibility to call it to the attention of the contractor and then note it in his daily report. The mere physical presence of the owner's representative on the site makes it his responsibility to report a recognizable unsafe condition.

19. The inspector has a responsibility to be alert and observant. He should report to his supervisor on any situation that he thinks may cause delay in the completion of the project.

Authority

The inspector must be delegated certain authority if he is to perform his duties properly. His close working relations with the contractor demand it. The inspector should use his given authority when the situation demands it. He should not, on the other hand, abuse it. Also, the contractor is entitled to know when his work is not proceeding in an acceptable manner:

1. The inspector should have the authority to approve materials and workmanship that meet the contract requirements and he should give this approval promptly, where necessary.

2. The inspector should not be given the authority to order the contractor to stop his operation. When a contractor is ordered to immediately halt an active operation it becomes a costly item to him, particularly if expensive equipment and material such as concrete, are involved. If the stop order is not justifiable by the terms of the contract, the contractor has just cause to demand reimbursement for the damage he has suffered. Because of the nature

of his duties, the inspector cannot become familiar with all details of the contract nor with all the other contractual relationships. Authority for the issuance of a stop order should be left to the judgment of the resident engineer.

3. The inspector should not have the authority to approve deviations from the contract requirements.

4. The inspector should not require the contractor to furnish more than that required by the plans and specifications.

5. The inspector should not under any circumstances attempt to direct the contractor's work; otherwise, the contractor may be relieved of his responsibility under the contract.

6. Instructions should be given to the contractor's supervisors, not to his workmen nor to his subcontractors.

Behavior

There are three relationships that are inevitable parts of an inspector's life and work: (1) His relationship with his fellow inspectors; (2) his relationship with his supervisors; and (3) his relationship with the contractor.

Fellow Inspectors.—The inspector must maintain a relationship of mutual respect, confidence, and trust with his fellow inspectors. This is accomplished by being diligent and thorough in keeping his associates informed of his activities and in relaying instructions and other information pertinent to the overall inspection activities.

Supervisors.—The inspector must similarly maintain a relationship with his supervisors which will insure mutual respect, confidence, and trust. He must be able to take and execute orders and accept decisions gracefully. He should be diligent in keeping his supervisors fully informed of the progress of the inspection and be particularly alert to observe and report to them matters that may be critical in the event of a dispute or claim. 205

In exercising his authority, the inspector should keep foremost in his thinking that his authority is a delegation from his supervisors and he should act accordingly in making decisions. He should recognize that there will be situations on which he should seek advice from his supervisors and should promptly seek such assistance before making the decision.

Contractors.—The inspector must assume and maintain an attitude that is impersonal, agreeable, and cooperative with the contractor and his work force. He should studiously avoid familiarity and accept no personal favors from the contractor. He should also use tact when pointing out deficiencies to the contractor and his staff. An inspector's behavior can materially help to improve or disrupt, the relationship between contractor, inspection personnel and owner:

1. Personality differences or preassumed evaluation of the contractor by an inspector should not be permitted to interfere with or affect the inspector's working relations with the contractor. An inspector should not prejudge the contractor. He must begin on the premise that the contractor is fair-minded and intends to do a good job.

2. Criticism on or off the job, of the contractor or any of his employees by the inspector, is unwarranted and dangerous, and should not be tolerated.

3. If the inspector has made a wrong decision, he should have the fortitude

to admit it. It is recognized that no one is perfect.

4. When dealing with the public the inspector should be courteous and respect their rights. The resulting good public relations will benefit all concerned.

5. The inspector should be alert not to allow himself to become involved in the contractor's labor relations. This is the contractor's responsibility.

6. The inspector should never discuss his personal problems with the contractor. This can sometimes lead to an unhealthy relationship.

7. The inspector should guard against developing an adversary attitude toward the contractor.

Conclusions

The Committee believes that these recommended standards for inspectors will, if adhered to, materially help to improve working relations and progress on the site and at the same time reduce the delays, extra costs, and inferior construction that plague so many projects.

The contractor and the owner assume certain obligations and responsibilities by virtue of their signed agreement. The contractor is required to furnish workmen skilled in the type of work they are to perform. By the same token, the owner is morally bound to furnish a qualified competent team to inspect the contractor's work. Advance knowledge of the inspection team by a bidder during the bidding period will often result in an adjustment to the bid figure.

The Committee wishes to thank the members of the construction industry for their assistance through participation in the questionnaire project, and also C. L. Gallimore, former committee member, for his assistance in reviewing this paper.

206

Respectfully submitted,

Joseph Artuso
Henry J. Cermak
Alfred W. Maner
Bernard F. Perry (deceased)
Orrin Riley
William R. Waugh
Bertold E. Weinberg
Michael C. Wilkinson
Joseph Goldbloom, Chairman

Appendix.—Reference

1. "Summary Report of Questionnaire on Construction Inspection," by the Task Committee on Inspection and Testing of the Committee on New Construction Techniques of the Construction Division, Joseph Goldbloom, Chmn., *Journal of the Construction Division*, ASCE, Vol. 98, No. CO2, Proc. Paper 9192, Sept., 1972, pp. 219-234.

The rural access roads programme

Appropriate technology in Kenya

Table of contents

		Page
	Preface	iii
**	Introduction	1
	1. Inception and objectives of the Rural Access Roads Programme (RARP)	7
	1.1 Inception and implementation	7
	1.2 Targets and objectives	9
	1.3 Results	10
**	2. Organizational structure	12
	3. The Technology Unit	15
	4. Selection criteria and design standards	21
**	5. Planning, reporting, control and procurement at RARP headquarters	26
	5.1 Centralised planning, reporting and control	26
	5.2 Expenditure control at headquarters	27
	5.3 Procurement of tools and equipment	28
**	6. Planning and survey at unit level	31
	6.1 Introduction	31
	6.2 Planning of construction projects - the initial survey	31
**	7. Recruitment and motivation	34
	7.1 Recruitment procedures for RARP personnel	34
	7.2 Motivation	37

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Page

** 8. Preparation and implementation of the works 42

8.1 Preparation for the works 42

8.2 Construction activities 43

8.3 Gravelling 44

** 9. Training of RARP personnel 49

9.1 Planning of training 49

9.2 Organisation and content of the training courses .. 49

9.3 Recruitment of suitable trainees 51

10. Maintenance of rural access roads 54

11. Conclusions 58

11.1. Relevance of the RARP to labour-based road construction projects elsewhere 58

11.2 Effects of the RARP on employment and agriculture in the rural areas where the programme is implemented 62

Appendices

1. Structure of the RARP headquarters and field organisation 71

2. Design standards of rural access roads 80

3. Expenditure control and reimbursement procedures 88

** 4. Procurement 93

** 5. Planning, programming and reporting at site and unit level 96

6. Construction activities: description and average task rates 104

7. Gravelling 126

8. RARP planning, programming and report forms 133

** 9. Payment systems for casual labour used in the RARP 157

10. Description of a time and location chart 162

11. Reports produced by the Technology Unit, SOE and ILO 163

INTRODUCTION

The RARP was initiated in 1974 to respond to concepts of employment creation and rural development embodied in the 1974/78 Development Plan for Kenya. The Development Plan stipulated that major emphasis should be placed upon the improvement of secondary and minor roads in the rural areas, especially in those areas with a high agricultural potential and an inadequate existing road network. The standards of the roads to be constructed were to be related directly to the anticipated traffic volumes.

This has meant that the design of the minor access roads under the RARP, which were expected to carry low traffic volumes,[1] could be adapted to the use of labour-intensive construction methods. It was decided to use these methods in the belief that they would be technically and economically justifiable. Consequently, the RARP has become the first road-construction programme in Africa where labour-intensive construction methods are implemented on a large scale. In the event this faith in labour-intensive construction methods has been justified. By constructing good-quality roads at low costs the RARP has proved that labour-intensive construction methods are economically and technically viable, provided that organisation and management techniques are adapted to their use. Furthermore, the Programme has shown that this type of construction technology is eminently suited to the socio-economic environment of many developing countries.

This statement merits some elaboration. In Kenya, as well as in most other developing countries, labour is relatively abundant and cheap, while capital is scarce. Nevertheless, capital-intensive

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[1] Less than 30 vehicles per day.

and labour-saving technologies from the developed world are usually transplanted to developing countries without having been adapted to the prevailing conditions in these countries.

The use of alternative technologies more adapted to these conditions was generally ignored, mainly because of the belief that more labour-based technologies are backward and inferior in terms of quality and productivity. In addition to this negative attitude a number of institutional constraints should be mentioned. First, there is usually a serious shortage of local technicians. Moreover, because the educational systems and syllabi have been taken over from the developed world, the few technicians that are available are only conversant with capital-intensive technology. Second, the administrative systems, e.g. personnel, procurement, in the construction industry are geared to the use of capital-intensive methods. Third, research on the improvement of traditional technologies has hardly been done, which is reflected in the fact that tools and equipment are not suited to heavy construction work, and organisation and management techniques have hardly been adapted to the use of labour-intensive methods. Finally, financial assistance to development programmes is often tied to the purchase of foreign technology.

The ILO was requested to provide advisory services on the design, planning, programming and organisational aspects of the RARP. The ILO was approached because its Technology and Employment Branch had for a number of years carried out research on the identification of alternative technologies which are technically and

economically viable, and a part of this research had concentrated upon road construction.[1]

The initiation of the Rural Access Roads Programme meant a major breakthrough, because it provided the opportunity to test the results of ILO and World Bank research on a large scale and to prove that labour-based technologies are not inferior.

In the RARP the development of local resources is emphasised. There is a high involvement of local personnel. The training of the supervisory personnel is specifically related to the management of large numbers of workers.

Furthermore, new planning, programming and organisational procedures have been developed. Research was carried out on tools and equipment to improve their quality.

212

Decentralisation of planning was realised by delegating the responsibilities of the initial screening and selection of the access roads in their respective areas to "District Development Committees".[2] Consequently, the rural communities at the grass-roots level have been involved in the identification of the roads to be constructed. The selection of these roads was done in accordance with guidelines established by the Roads Department of the Ministry of Works.

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[1] See, for instance, D. Lal, "Men or Machines": a study of labour capital substitution in road construction in the Philippines, ILO, Geneva, 1978. M. Allal and G.A. Edmonds, Manual on the Planning of Labour-Intensive Road Construction, ILO, Geneva, 1977. IBRD: Substitution of Labour and Equipment in Civil Construction, Phase I report, 1972, and Phase II report, 1974.

[2] A District Development Committee comprises representatives of the various ministries, the local administration and members of parliament of the district.

The Programme has a very low foreign exchange element. Because the roads have been constructed using mainly local resources, the foreign exchange component has been as low as 25 per cent, whereas the foreign exchange component in equipment-intensive projects of this kind commonly exceeds 50 per cent. Staff wages accounted for 12 per cent and casual wages for 47 per cent of the total expenditure.

The book is subdivided into two parts: text and appendices. The text discusses the most important aspects of the RARP in a general fashion and refers to the appendices for more detailed technical information. It should be kept in mind that the descriptions, data and figures used in the text and appendices are related to the existing environment in Kenya. Furthermore, it should be reiterated that the book describes the existing systems and procedures as developed during the course of implementation of the Programme. It is felt that a detailed analysis of these systems and procedures is outside the scope of this book.

Section 1 of the text describes the inception and implementation of the Programme and the scope of the technical and financial assistance given to the RARP.

The organisational structure of the Programme is discussed in section 2.

A description of the work of the Technology Unit[1] is given in section 3. Section 4 describes the selection and technical aspects of the access roads constructed under the RARP. The planning,

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[1] The Technology Unit, financed by the World Bank, was a multi-disciplinary group which advised the Ministry of Works on the implementation of the Programme from January 1976 to August 1978. Their work was a natural consequence of the work carried out under the MOW/ILO/WORAD study.

organisation and management of a large-scale labour-intensive project, both at headquarters and at site level, are crucial and are described and evaluated in sections 5 and 6.

Section 7 discusses recruitment procedures and motivation of the workers and refers to the payment systems used in the RARP. A description of the site arrangements and construction activities can be found in section 8. Section 9 shows how the training of personnel was planned, organised and executed. In this section the recruitment of supervisory personnel and the contents of the various courses are also briefly discussed. In section 10 a description is given of the organisation of road maintenance, which is carried out making use of some of the workers who had been employed to construct the road. Finally, in section 11, the relevance of the RARP to other developing countries is defined. This section also indicates in which areas future research would be useful.

The appendices with their detailed descriptions of the design standards, the construction activities, the average task rates, the expenditure control procedures and the administrative systems as applied in the RARP will be of particular interest to those officials who will be involved in the actual execution of similar labour-intensive construction works.

The text will provide useful information on an alternative way of road construction to planners and chief executives in developing countries, who are interested to apply employment-generating indigenous technologies, provided these can be implemented efficiently and effectively, i.e. without adversely affecting cost and quality of the product.

Further, it may be a useful source of information for officials of donor agencies who in principle might be interested in

the possibility of financing labour-intensive construction programmes, but would like to have more information on how a large-scale labour-intensive road-construction project can be implemented.

It is hoped that this document will contribute to a reorientation towards the use of appropriate technology, i.e. a fair judgement in each particular case - taking into account all the relevant parameters - of the optimum mix of labour and equipment, a mix that will be different for each country and possibly even for each region in a particular country.

2. ORGANISATIONAL STRUCTURE[1]

The RABP was a new type of programme for Kenya and for the Ministry of Works (MOW), the executing ministry, in particular. It was therefore recognised at an early stage that, for a large-scale programme such as this, a new branch within the MOW would be required to ensure a flexible approach inside the existing structure.

Consequently, the Special Projects Branch was established at the beginning of 1975. This branch was to be responsible for the planning, management and organisation of the RABP and the "Gravelling Programme", a major gravelling exercise, designed to improve the standard of the secondary road network.

The branch is headed by a Chief Superintending Engineer (CSE), who is responsible to the Chief Engineer (Roads). It has functional links with the Staff Training Department (section 10) and the Roads Department, Planning Section. Early 1979 the managerial staff of the RABP at headquarters, responsible for the execution of the works carried out under the Programme, consisted of a team of five civil engineers, one mechanical engineer and one construction superintendent. Most of these posts were filled by expatriate staff, provided under a GOK/UNDP/ILO technical assistance agreement. In this period, however, it was the intention to revise the organisational structure to a decentralised version. Both the centralised and decentralised structures are described in Appendix 1. This reorganisation was intended to provide a more effective supervision in the field. The reorganisation could be implemented

216

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[1] Appendix 1 shows how the RABP headquarters and field organisation are structured and describes in detail the responsibilities of the various categories of managerial and supervisory staff.

at this time because the administrative systems, developed and tested by the technical assistance specialists, were functioning adequately and were suited to the requirements of the RARP. Various manuals and guidelines were available for Unit Engineers and technical and administrative staff who implemented them satisfactorily. In other words, the design and experimental phases were over and the time had come to concentrate on the improvement of the efficiency. It was recognised that the measure of success of the use of labour-based methods primarily depends on the level of supervision and it was felt that a decentralised organisation would be more effective in this respect.

There was, however, another important reason to decentralise the Programme structure. It had always been the intention that the RARP would continue in another fashion once the construction period had finished. Since labour-based construction and maintenance methods had proved to be viable and effective, the MOW had decided that the RARP should be gradually transformed into betterment and maintenance programme. Moreover, the use of labour-based methods would be extended to include the maintenance of the classified minor road network. 217

The reorganisation of the Programme would provide a basis to implement this policy on a provincial level.

The existing administrative organisation at headquarters in respect of accounts, procurement and personnel matters would be maintained. In the field, 18 RAR Engineers/Field Supervisors under the over-all supervision of initially four and at a later stage six "Divisional" Engineers would be responsible for the running of 42 Units. It was expected that, as soon as the reorganisation had been carried through, the RAR engineer posts could be gradually taken

over by "field supervisors" with the responsibility for two units only. These field supervisors could be lower qualified, e.g. having a diploma from the Kenya Polytechnic.

The day-to-day running of the individual RAR Units is the responsibility of "Officers in Charge" (OIC), the most senior level of supervisory staff.

Depending on the circumstances, a centralised or decentralised system is used in the field. In a centralised system the units under the charge of an engineer/field supervisor share storage, office and culvert manufacturing facilities. In a decentralised system these responsibilities are delegated to the OIC.

Transport costs will be greatly reduced and it will take less time and effort to solve small administrative problems at unit level
218 if a decentralised system is used. Furthermore, there will be a clear dividing line between the units in terms of the responsibility for administration, planning and execution of the construction works and project management. Each officer in charge will have his own responsibilities without any possible confusion.

In a centralised system, however, the engineer/field supervisor in charge has a far greater opportunity to supervise, manage and control the ongoing activities. It would appear that the extent to which the system can be decentralised depends on the geographical situation of the Units, the abilities of the officers in charge and the availability of vital resources in a particular area. In the RARP it has become apparent that in most cases OICs need a certain period of experience in their jobs before responsibilities for store management and logistics can be handed over.

5. PLANNING, REPORTING, CONTROL AND PROCUREMENT AT RARP HEADQUARTERS

5.1 Centralised planning, reporting and control

The systems used in RARP for planning, reporting, expenditure control and procurement have been adapted to the existing structures within the Ministry of Works. Those systems would have to be adjusted for each different country to suit the structure of the Public Works Department there. The systems have changed during the course of the Programme in the light of the lessons learnt and the recommendations made by the HOW/ILO/NORAD study and the World Bank/ODM-sponsored Technology Unit.

As the Programme was financed by a variety of donors, it was necessary to set up an effective centralised system of physical and financial planning as soon as possible. A basic planning system was required in order to effectively control the large number of RAR units. This would ensure that each unit would receive its requisite supply of tools, equipment, materials, trained personnel and money. Furthermore, it would enable RARP HQ to control the technical and financial situation of each unit and to produce plans of critical steps, staffing and resource requirements.

For the smooth working of the planning system[1] it was necessary that targets in terms of required output of kilometres of road were established. This would ensure that the supply of resources could be calculated and organised well in advance. Another prerequisite was a good system for planning and reporting at site level so that a continuous flow of data from the units to

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[1] See section 6 and Appendix 5 for a detailed description.

headquarters could be established. This would enable headquarters to adjust quickly to different situations. For example, it might become necessary to provide more gravelling equipment to units operating in a certain area to keep up with the gravelling targets or to adjust output targets for units operating predominantly in a certain type of terrain.

There is no doubt that some of the problems encountered by the staff of the Rural Access Roads Programme were due to the fact that management and control systems had to be developed while the programme was being implemented. The lesson to be learnt here is that any programme of an innovative nature should establish management and control systems prior to programme implementation by executing a small-scale pilot project. The data and results of this pilot project should then be evaluated so that the full-scale
220 project can be more effectively implemented.

5.2 Expenditure control at headquarters

The RARP is financed by a number of donor agencies, who all require individual justifications and statements of account before they agree to reimburse expenditures. (Initially the funds are provided by the Government of Kenya.) Also each agency has its own set of rules regarding the reimbursement of expenditure. One agency will reimburse a fixed amount per kilometre of road produced; others will reimburse for the cost of a Unit; however, some will pay for one thing and not for another; for example, expenditures incurred for the provision of (semi) permanent base camps are usually not reimbursable. The RARP accounting system, therefore, had to be designed to suit the donor requirements. Appendix 3 describes the workings of this system in detail.

5.3 Procurement of tools and equipment

Procurement of hand tools for the RARP had been arranged through the existing procurement system of the Ministry of Works. Orders were made in advance to the Supplies Branch of the Ministry. If the tools were not available tenders were called and submitted to the Central Tender Board for contract awarding. Unfortunately, during the first phase of implementation, purchases for the RARP were normally made on the basis of price only, while other factors such as quality and design were hardly considered. Although this approach might be quite practical and justified under normal circumstances, it was not suited to the specific requirements of the RARP, since tools for labour-intensive road construction are used intensively and in difficult conditions. It was clear that the procurement system had to be adapted in order to ensure that tools would be bought on the basis of acceptable and approved specifications rather than on the basis of price only. It was felt that, even though the unit cost would be higher, the purchase of well-designed heavy-duty good-quality tools would reduce the overall cost to the RARP not only as a result of greater life expectancy but also as a result of improved productivity.

The Central Tender Board recognised that the Ministry of Works recommendations on this issue were sound: it has been possible to procure tools of the desired quality and design since the beginning of 1978, based on specifications prepared by the MOW.[1]

During the growth of the Programme a number of lessons have been learnt in respect of procurement. It is crucial not only that sufficient quantities of tools and equipment are available well in

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[1] These specifications covered wheelbarrows, shovels, hoes, forked hoes, bushknives, crowbars, axes, mattocks, and handles for shovels, hoes, and pickaxes.

advance but also that appropriate tools of good design and quality are provided.

To determine the types of tools to be ordered, it is a prerequisite to consider the function, use and user of the tools. What will be the function of the tool (digging, loading, spreading)? On which type of soil will the tool normally be used? What will be the physique of the average user? (This is of importance as it will determine characteristics such as length of handle and weight of blade.) A proper handle is of utmost importance as it influences the productivity of a tool. Not only because a tool with an "appropriate" well-designed handle is easier to use but also because its breakdown time will be reduced. "Appropriate" in this context means that the handle should be adapted to the function of the tool. The handle of a striking tool, such as an axe for example, will need
222 to be of a different shape and material than the handle of a digging tool such as a jembe or the handle of a loading tool such as a shovel.

In respect of manufacture and procurement, the following general issues need to be considered:

(i) The quantities of tools required.

(ii) The existing capacity for local manufacture of the recommended tools, in terms of technical and financial capabilities of local manufacturers to produce the required quantities of good-quality tools.

(iii) The scope of increasing the existing capacity for the local manufacture of tools.

(iv) How is the procurement of tools presently organised and will it be possible to use this existing procurement

system? If not, should it be adapted to suit the specific requirements of a large labour-based programme?

(v) Will it be feasible to adjust this system in such a manner that good-quality tools in sufficient quantities can be obtained from local sources?

Appendix 8 describes how the procurement of tools and light equipment for and within the RARP is organised and lists the tool requirements for a RAR Unit.

6. PLANNING AND SURVEY AT UNIT LEVEL

6.1 Introduction

The RAR engineer works within a framework of guidelines set by the RAR HQ. These guidelines cover such issues as personnel matters, accounts, procurement, equipment and accommodation. The RARP management has tried to standardise all the above aspects as much as possible, which is reflected in the standardisation of RARP accommodation, offices and stores.

In addition to the more specific issues mentioned above, general guidelines have been established in respect of compensation, public relations, communications, theft, and handover of responsibilities.

224

6.2 Planning of construction projects - the initial survey

The planning system of the RARP is based on the assumption that it should always be possible to specify the resources required for each unit six months in advance. This means that the construction projects scheduled to be carried out in the next six-month period by a particular unit are identified in terms of name, length, and the estimated required man-days and finance required. In order to achieve this, the RAR engineers are required to submit a priority list and a construction programme for a period of 12 months which should be updated regularly. The surveying and preparation of road construction projects are done six months in advance. Specific information on the roads proposed to be constructed in a particular district are available in the evaluation reports for rural access roads. As described in section 4, these

are prepared for each district by Ministry of Works Planning Engineers, based at HQ, in conjunction with the Rural Access Roads Engineer, the District Development Officer and the District Agricultural Officer. This report gives information on agricultural potential, population in the zone of influence and access. In addition to this, each road is briefly described, comments are made on soil types, river crossings and problems to be expected. Alignments are mapped on 1:50,000 scale maps. This road survey will normally have been done by the RAR engineer or his officer in charge.

As the area covered by an RAR unit is usually quite large, a zone of first priority for construction has to be selected by the District Development Committee. This is important because the construction sites should be kept as close as possible together in order to minimise transport and communication costs and to ensure that supervision can be carried out efficiently. Naturally, when it is evident that not enough labour is available to carry out several projects simultaneously in a certain area it is unavoidable to disperse the projects over a bigger area.

Further important issues to be dealt with before detailed project planning is started are the right of way and compensation. As explained earlier, only crop compensation for crops which have to be destroyed to allow the road through is paid in Kenya. This means that meetings with the local administration and the farmers concerned have to be organised where these issues are explained very clearly. When farmers insist upon land compensation and an alternative route is not practical, construction of that particular road will be postponed or even totally cancelled.

Appendix 5 shows the existing planning, programming and reporting arrangements within the RARP and describes how the overseer, after work targets have been established by the engineer, prepares his work programmes and organises his labour force. Finally, it discusses how the data on input and output are processed from the site through Unit headquarters to the RARP headquarters.

7. RECRUITMENT AND MOTIVATION

7.1 Recruitment procedures for RARP personnel

Within the establishment of the RARP there are three categories of labour: head office paid, works paid and casual employees.

(a) Head-office-paid MOW employees

These officials are paid from the MOW head office regular budget and are permanently employed. Usually they are qualified supervisory staff. They are not recruited by the RARP management but by the MOW head office. A number of this type of staff were temporarily posted to the RARP to assist with the implementation of the programme and to alleviate the urgent need for higher-qualified personnel, especially when the programme had just been initiated.

(b) Works-paid employees

These officials are paid monthly, but are not employed on a permanent basis. They can be dismissed at one month's notice, although this rarely happens in practice. Most MOW staff fall into this category; clerical personnel, supervisory personnel, drivers, plant operators, etc. They enjoy social benefits as stipulated in the "Code of Regulations" for Kenyan civil servants.

Works-paid staff have been transferred from the MOW establishment to the RARP in such the same manner as head-office-paid staff. However, the PAR engineer can also recruit his works-paid personnel from outside the MOW. The candidates can be employed if they are qualified to hold the position for which they apply.

Senior works-paid staff will normally be recruited by RAR HQ since they must be recruited through a body called the "Public Service Commission", who examine their experience and qualifications. A problem with the recruitment of senior works-paid staff has been that many candidates who had the necessary abilities, willingness and experience did not have the educational background and academic qualifications required by the civil service. They could therefore not be recruited. Although probably unavoidable this is unfortunate since the required attributes for personnel within the RARP are more related to man-management abilities, the ability to work without supervision and with common sense than to academic qualifications.

In the field it has fortunately been possible to fill most of the supervisor posts with young enthusiastic former headmen who could be employed at a salary scale below the senior works-paid salary scale.

228

All works-paid employees recruited from outside the Ministry of Works are recruited on probation for a period of three months. During this period their performance can be assessed and the employment can be terminated without the one month's notice applicable to regular works-paid employees.

(c) Casual employees

These are employees locally recruited for the execution of the construction works. Their wages are calculated on a daily basis, i.e. they will be paid only for the days on which they actually worked. They enjoy no social benefits and can be laid off when they are no longer required.

Casual labour is recruited on or very near the road which will be constructed. The conditions of employment are explained and the workers are required to sign a contract of employment when they are recruited. By signing the document the employee agrees that he has understood and accepted the conditions of work. When the persons applying for work outnumber the jobs available, workers are selected on a random basis to avoid charges of corruption and favouritism. Two systems have been used for selection:

(i) Each candidate is given a numbered ticket. If 400 candidates were present each candidate would have a number between 0 and 400. The duplicates of these tickets are placed in a container from which they are drawn one by one. The number of the duplicate is called out and the holder of the original will be recruited. The recruitment continues until all available vacancies have been filled. It is also possible to continue after the recruitment has been completed in order to list the remainder of the applicants on a reserve roll, so that they can be called by the local administration when required. However, it is often more practical to organise another recruitment day. 229

(ii) The number of applicants is counted and tickets are prepared with "yes" and "no" inscriptions. The total number of the "yes" and "no" tickets equals the number of applicants, while the number of "yes" tickets represents the available vacancies. Each applicant is then asked to pick one ticket out of the container in which the tickets are placed. Special care has to be taken that the details (name, age and name of chief) of the successful applicants are noted as soon as he receives his "yes" ticket and that the ticket is returned to the clerk immediately. This is necessary to prevent the

successful applicant from selling his ticket to somebody who had not been so lucky.

The second method is a lot quicker than the first and is therefore easier to use, especially when large numbers of people are involved. However, for the reasons described above, the recruitment has to be strictly controlled in order to avoid abuse.

Recruitment is done with the assistance of the local administration. The chiefs and subchiefs are usually enlisted to arrange the preparation for, and to assist with, the execution of the recruitment. Their assistance in the preparation consists of spreading the word that recruitment for a certain project will take place on a pre-arranged date. On the recruitment day they assist in the explanation of the conditions of work and help to ensure that the applicants come from within the vicinity of the road on which they will be working. This is especially important because the workers will be expected to walk to the site, no transportation being provided.

230

It is recommended that the worker be provided, after the project has been completed, with a statement of the number of days he worked, his earnings and a written explanation of deductions made. This avoids disputes at the end of the construction period. Moreover, each worker has a right to receive this type of information, which may serve as a reference for future jobs.

7.2 Motivation

Motivation of the labour is essential if a labour-based programme is to be successful. ILO studies have clearly indicated that workers paid on a piece- or taskrate system produce a much higher output than daily-paid workers. In the early stages of the

implementation of the RARP the labourers worked under a daily-paid system. After enough data had been assembled, taskwork was gradually introduced and has since then been implemented on most of the construction activities.

The daily payment system should only be used when no productivity data for the major operations in road construction are available. Daily workers are paid a fixed sum for a certain number of hours of work. But, whilst a reasonable output can be achieved, provided that supervision and work organisation are excellent, productivity will always be low because the workers have no incentive to increase production.

With the taskwork system a fixed daily wage is given in return for a fixed quantity of work. This means that workers are free to go home as soon as the given quantity of work has been done. The head man in charge of the worker ensures that the work has been completed satisfactorily, before the worker is allowed to leave the site. 231

Taskwork can be given to individuals (bush clearing, top-soil removal, ditching, etc.) or to groups (especially suitable for large quantities of excavation). If taskwork is given to a group of workers care should be taken that the workers are not in each other's way and have enough room to work. The workers should not be released before they have finished their task (even if this means that they have to continue after normal hours of work) unless unforeseen difficulties have arisen (like hard roots, rocks, bad weather, etc.).

Tasks will have to be adjusted when it is obvious that for some reason an average taskrate is not applicable any longer. It is easier to adjust taskrates by increasing or decreasing the number of

labourers doing a certain job rather than by increasing or decreasing quantities of work.

If a task is correctly set a good worker should be able to finish it in approximately 75 per cent of the nominal working time. Taskwork is most effective if the worker can go home every day to work for his own purposes or to spend leisure time at home. Imported labour may not be motivated by getting extra leisure time since it can be spent only in the labour camp or immediate surroundings.

Piecework is a system in which the worker is paid a fixed sum per unit of output, e.g. $1 per cubic metre of hard soil excavated. The worker himself decides how much he will produce and consequently earn. The payment per unit of output has to be determined very carefully and should be introduced only after enough reliable productivity data have been collected. To avoid exploitation of the workers, rates should be set in such a way that an average worker with a good motivation (with this system he is usually well motivated because production is related to financial reward) can earn a daily wage which is higher than the wage he would get for working the same number of hours (but less motivated) under the daily-paid system.

232

The advantages of this system are that the unit costs (payment per unit of output) are lower than the unit costs achieved with taskwork and that productivity is high.

It has not been possible to introduce the piecework system in the HARP because of administrative problems. A non-fixed monthly wage is usually not acceptable to a government agency. Furthermore, there is greater scope for corruption because the money is not provided by the persons who are measuring the output. These are

therefore not financially interested to ensure that measurements are made in a correct and fair manner.

Whatever system is used it is imperative that payment of wages is made on time and, if at all possible, not in arrears. Delayed payments reflect bad organisation and cause dissatisfaction among the workers. It may not always be easy to avoid delayed payment when workers are only paid for days worked. This is because payrolls have to be prepared in advance in order to allow the administration time to check them and to release the money. This problem may be overcome however by devising an efficient deduction system and by minimising the time between payroll preparation and payment as much as possible. (Two pay systems which have been used in the RMSP are described in Appendix 9.)

Finally, the importance of issues such as workers-management relations, occupational safety, general working conditions and welfare facilities should not be overlooked. It is essential that the site management does everything possible to establish good relations between workers and management and amongst workers themselves. It should always be possible for individuals or groups of workers to air their problems. The management should always explain decisions. They should also encourage group activities such as sports and recreation. Weekly site meetings by Engineer/OIC, overseer and headmen can contribute enormously to the establishment of good relations and will prevent the aggravation and in many cases the occurrence of problems on the site.

To ensure the occupational safety of the workers, it has been common practice to avoid the concentration of large numbers of workers in a small area by measuring out individual tasks in a specific area for each worker. First-aid kits containing the

necessary items to treat injuries are always available in the site camps. In case of the occurrence of more serious injuries, transport to health centres or hospitals is provided after the Office in Charge has been notified.

As regards general working conditions, the workers should be able to finish their tasks in a reasonable time. It has been a good custom in many HAR projects to allow the workers to start work very early in the mornings, so that tasks could be finished before noon and consequently working during the hottest hours of the day could be avoided. The workers can determine their own pace of work, providing they finish their daily tasks. Since the workers employed for a particular HAR project always come from villages in the immediate vicinity of the site, housing facilities do not have to be provided. The management ensures that a supply of drinking water is always available on the site and frequently local women can be seen at the place of work selling various types of food to the workers.

8. PREPARATION AND IMPLEMENTATION OF THE WORKS

8.1 Preparation for the works

A small camp will be required at each construction site consisting of accommodation, sanitary facilities and storage facilities. A typical site camp as used in the RARP consists of:

(a) a 20' x 10' prefabricated corrugated iron hut for the overseer in charge. In some cases different sizes have also been used, depending on the rank of the overseer and customary Ministry of Works provisions in a certain area;

(b) a 10' x 10' corrugated iron store for tools, light equipment and cement. In many cases the storekeeper will use this store as accommodation and then a dividing wall may be provided;

(c) a 8' x 8' corrugated iron latrine;) in some areas 2' x 6' 235
) structures were
(d) a 8' x 8' corrugated iron bathroom;) provided

(e) a tent where required, especially useful for the survey team.

All the corrugated iron structures are constructed in such a way that they can be transported easily from one site to another. They normally consist of a number of panels, bolted together so that assembling and dismantling is possible in a short period and can be done by unskilled labour.

After the camp has been set up the overseer in charge of the construction site is provided with facilities for the storage of drinking water, stationery, simple survey equipment and tools and wheelbarrows sufficient for the labour force to be employed. On some construction sites it has been found useful to provide the overseer with simple transport, e.g. a bicycle.

8.2 Construction activities

The actual road construction can be broken down into a series of activities, which may again be subdivided as required by the circumstances. In the RARP road construction is usually broken down into two categories of activities, one group which can be carried out by taskwork, the other which cannot. The first group comprises:

(a) bush-clearing;

(b) tree and stump removal;

(c) grubbing;

(d) boulder removal or rock excavation;

(e) excavation to fill and to spoil;

236 (f) loading;

(g) ditching;

(h) sloping;

(i) camber formation;

(j) culvert laying;

(k) construction of scour checks;

(l) compaction.

The second group are the non-taskwork activities:

(a) work at camp;

(b) carrying of water (potable water for the workers);

(c) setting out.

Additionally, there are the structural activities such as drift and bridge construction.

A short description of each activity is presented in Appendix 6. This appendix also describes which tools were found to be best suited for the work in the RARP and average taskrates found to be applicable in Kenya. It should be emphasised that these taskrates are only valid for specific conditions found in Kenya and should be adjusted when work is executed elsewhere in different circumstances.

A good assessment of productivity is possible only when enough data has been collected on the site, where construction takes place. Nevertheless, the data shows the output per man-day as achieved by average workers in average conditions in Kenya. They can therefore serve as a basis for assessment of productivity in reasonable circumstances.

8.3 Gravelling[1]

A basic target of the Programme is that, for each unit, 4 km of road should be surfaced every month. The surface layer consists of gravel 4 m wide and 10 cm thick when compacted. This requires 400 m³ compacted gravel (500 m³ loose) per km of road. Assuming 20 construction days per month, this means that a total of 34 trailer loads of gravel have to be dumped and spread per construction day if the target of 4 km is to be achieved. Up to the end of 1977 only 20 per cent of the newly constructed rural access roads had been

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[1] The actual execution of the gravelling is described in Appendix 7.

gravelled. There were a number of factors that contributed to this discouraging figure:[1]

(a) the delivery of tractors and trailers used for gravelling was severely delayed;

(b) the average hauling distance from gravel quarry to the site generally exceeded 8 km, the figure upon which the estimates were based;

(c) the equipment was underutilised, mainly due to unavailability of spares and welding equipment. Even when these items were available at provincial headquarters they had to be moved to the site or the tractor had to be moved to the workshop thus causing considerable delays;

238 (d) inexperience of the operators, especially with regard to the technique of reversing a tractor/trailer combination;

(e) insufficient quarry organisation.

To overcome the problems mentioned under (b) and (c) it has been decided to provide the RAR units with six (85 hp) tractors instead of four (75 hp) as originally supplied to the first units. This will ensure (a) that even with longer hauling distances the target number of loads can be achieved and (b) that a minimum of four tractors will always be operational.

It has been found that the original tractor-trailer combination (75 hp tractors pulling trailers of 5 tonnes payload) was not well matched. Trials under extreme conditions with 85 hp tractors indicated that these tractors are suitable for hauling 5

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[1] Appendix 8 contains examples of RARP report forms for gravelling.

tonne trailers under the average RAR hauling conditions. It was considered that trailers with a payload capacity of over 5 tonnes would not be suitable for handloading and manoeuvring on narrow roads.

Since tractors and trailers have to match not only in respect of engine power and payload but also in respect of optimum load transfer, hydraulic pressure and fluid capacity, eye, hook and couplings, all these aspects should be carefully considered before the purchase is made in order to ensure that the equipment is well matched. Another measure taken to reduce the breakdown time has been to provide the field engineers with a full range of essential spares. It is also intended that each unit will have its own mechanics to carry out minor repairs and maintenance.

Courses are organised (i) for tractor drivers, in order to ensure that they handle and maintain their equipment in a better way and (ii) for gravelling overseers, so that the quarry organisation will be improved. Naturally, on-the-job training of overseers by engineers or officers-in-charge remains vital if a well-organised gravel operation is to result.

The Transport and Road Research Laboratory have agreed to provide a materials engineer and to train a Kenyan materials engineer. The purpose is to identify sources of suitable surfacing material using aerial photographs and other terrain evaluation techniques. It is expected that it will be possible to locate suitable sources of material in this manner and to supplement the information on sources of gravel that can be acquired locally from MOW maintenance personnel, local administration and local people.

The present MOW policy is to gravel all roads. However, the costs of gravelling by tractor/trailer might become prohibitive and

out of relation to the construction costs of the earth road when the hauling distance becomes too great. In this case there is a choice between the following alternatives:

(a) use other hauling methods;

(b) use other sources of material (i.e. introduce (mobile) rock-crushing equipment to crush rock to aggregate). In this way a very good-quality gravel with a proper particle size distribution can be obtained.

(c) provide a gravel surface only where appropriate, depending on the suitability of the in situ material, the standard of the classified road linking to the rural access road, and the disruption to anticipated traffic if gravelling is not done;

240 (d) do not construct a particular road if it is obvious that gravelling will be too expensive although it is necessary for technical reasons.

Personnel

Since the gravelling operation is the most equipment-intensive and costly operation of the construction of the rural access road its organisation merits particular attention. The overseer in charge of gravelling is not only in charge of a gang of casual labourers but also of plant operators with their tractors and trailers. The administration and organisation of the gravelling demands much more of the person in charge in respect of initiative, flexibility, leadership and administrative and organisational abilities and this implies that this person should be selected with care.

Plant operators should be skilled and motivated to ensure optimal utilisation of equipment. If plant operators are engaged from outside the Ministry of Works establishment it is essential that they are thoroughly tested before they are employed. The Staff Training Department (see section 10) organises courses for tractor operators to familiarise them with the tractor and routine maintenance procedures to be followed.

The motivation of plant operators is more difficult to influence. It has been found that operators who have been engaged at lower levels and have consequently more chance to be promoted are considerably more motivated than their higher ranked colleagues. Of course it may not always be possible to find suitably qualified personnel at these lower levels and this incentive will only last until they have reached the upper levels. If it is possible to introduce bonus payments for good maintenance and general performance this should certainly be considered. 241

The gravelling operation is particularly suitable for group taskwork or piecework.[1] Although the workers can be motivated easily this way it is essential to motivate the operators as well before either of the systems can be implemented successfully.

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[1] See section 7.

9. TRAINING OF RARP PERSONNEL

9.1 Planning of training

The Ministry of Works has its own Staff Training Department which has been particularly concerned with the training of supervisory personnel, equipment operators and mechanical personnel for the execution of its road maintenance programme. In 1975, a study was carried out by the Ministry of Works to assess what training facilities were required by the Ministry of Works in the period 1975-80. This study assessed the additional demands placed upon the Staff Training Department by the Gravelling Programme and the Rural Access Roads Programme.

Inter alia, the study discussed the following aspects:

242 (i) the number, categories and levels of additional personnel to be trained during the period 1975-80;

(ii) adequate training courses and methods;

(iii) the number and qualification of required instructors;

(iv) the extension of the existing facilities of the Staff Training Department;

(v) sources of suitable trainees.

9.2 Organisation and content of the training courses

The schedule below gives an outline of the type, duration and content of the courses given by the Staff Training Department.

Category of staff	Duration of course	Number of staff/course
Officers in charge of construction units	6 weeks	8
Overseers in charge of construction	13 weeks	10
Overseers in charge of gravelling	3 weeks	8
Plant operators (tractor)	2 weeks	8
Landrover drivers[1]	1 week	-
Lorry drivers[1]	1 week	-

[1] At the time of writing these courses were proposed but had not yet started. The required annual output per year of trained overseers (gravelling), landrover drivers and truck drivers was intended to be 16-18.

The training schedule is established in relation to the demand for supervisory staff generated by the schedule of implementation of RAR units. Each unit has a supervisory staff establishment of one officer-in-charge, three construction overseers and one gravelling overseer. Additionally, there is a drivers' establishment of six plant operators, one landrover driver, one lorry driver and one spare driver.

In order to be able to provide practical training to overseers, the Staff Training Department is responsible for one RAR unit, under the nominal control of an RAR engineer. Each overseer trainee receives practical training of nine weeks in the field, supervising on-going construction projects.

The training unit is stationed in a district with a varied landscape (flat and hilly) and where sufficient gravel is available so that a gravelling team can operate continuously. Construction is carried out on a minimum of two road projects, each with a labour force of 100 workers.

An officer-in-charge is attached to the unit. He is responsible for the preparation new projects, unit administration, and the supply of materials to the sites. This enables the STD instructors to spend their time on training. The courses for officers-in-charge, plant operators, drivers and the theoretical part of the course for overseers are run within the existing facilities of the STD in Nairobi.

The technical content of the OIC courses is a repetition of the overseer course with additional information on surveying and structures.

The courses for gravelling overseers were set up in recognition of the importance of the gravelling operation.

The courses for drivers and operators cover maintenance aspects and driving techniques. Special attention is given to the difficult matter of reversing a tractor/trailer combination.

244

9.3 Recruitment of suitable trainees

One of the major differences between capital- and labour-intensive construction methods lies in the type and quantity of supervisory staff required. The handling and administration of large numbers of casual labourers requires a different approach to organisation and management. It also requires different attitudes from the supervisory staff - from engineer to overseer - who are responsible for the efficient use of a number of machines and the large labour force. Man-management and leadership abilities become very important, especially for officers-in-charge and overseers who have to work with the labour force in the field. Engineers need to be reoriented towards the specific problems of labour-intensive road

construction so as to become more aware of the possible alternatives in respect of planning, design and techniques to be used.

The Kenyan Government has recognised the importance of a proper training at every level. Several young graduate Kenyan engineers have been and are running rural access roads units.

For officers in charge of units there have been three different sources of recruitment. Many good candidates for officer in charge could be found from the ranks of overseers. The problem with a number of these persons has been that promotion to a rank, suited to an official carrying so much responsibility, has been difficult in many cases. Problems arise because the persons involved do not have the educational qualifications required by the Government for a particular rank.

It has been decided, therefore, to try and recruit suitable candidates who do have the required qualifications from the Kenya Polytechnic. These "inspector roads trainees" would be given a more thorough practical training in labour-intensive construction techniques, so that they can be prepared to take over as officers in charge of RAR units. Officers in charge with required qualifications have also been provided by various volunteer organisations. To obtain the necessary background knowledge and experience these volunteers have a familiarisation period in one of the on-going units where they study the available technical manuals and course manuals for officers in charge and overseers.

Overseer trainees have generally been recruited from the ranks of headmen within the ongoing units of the RARP, staff already employed by the Ministry of Works Maintenance Organisation and/or the "National Youth Service".

Before a headman can be selected to attend a RAR overseer course he has to have had a minimum practical experience of one year. Selection depends on the results of a technical and language test and the recommendations of the officer in charge and engineer. Candidates from the National Youth Service or the Ministry of Works Maintenance Organisation, who show the correct attitude towards the RAEP, have to have an experience of at least three months working in an on-going unit before they are considered for participation in a RAR supervisor course.

Plant operators and drivers, who should already possess a valid driving licence, are nominated by the rural access roads engineers to come for training at the Staff Training Department.

APPENDIX 4

PROCUREMENT

The procurement, storage and distribution systems for the RARP have been organised as follows: a store has been set up in Nairobi from where the supply services to the field are arranged. After tenders have been approved by the Central Tender Board, the items ordered will be supplied to this store either through the Supplies Branch of the Ministry of Works or direct from the suppliers. All items received are checked, recorded and stocked in this store until they are required in the field. A minimum stock level and a minimum re-order quantity have been established for each item. These minimum stock levels consist of the average monthly total issues multiplied by a lead time in months. The lead time for each item varies according to the time required to order and receive this particular item. Re-order quantities are at least one year's estimated requirement.

In order to avoid stocks running out it is extremely important that the above procedures are strictly applied so that tenders are advertised and orders are placed timely.

The following handtools are required to run a unit, employing approximately 300 casual labourers:

shovel	200
panga/bushknife	75
hoe	200
forked hoe	125
mattock	75
mason hammer	25

axe	25
pickaxe	75
rake/spreader	50
crowbar	25
sledgehammer	25
wheelbarrow	50
earthrammer	25

It should be noted that these figures are average requirements, based on Kenyan experience but that, depending on soil type and local customs, requirements may vary. Only the most important tools have been included above, but it will be necessary to procure small numbers of bowsaws, hacksaws, tape measures, spirit levels, buckets, uniforms, as well as a large amount of stationery.

248 As noted above, the central store at RARP headquarters should always contain sufficient quantities of tools to meet the requirements of the established units. During the first years of the implementation of the RARP, however, the procurement of the desired quantities and quality of tools was problematic. This has meant that in some cases the purchase of the handtools and light equipment such as wheelbarrows has been done locally by the RAR engineers when the required items could not be supplied in time. Local purchase of goods by government officials, however, is governed by very strict regulations. It is therefore not possible to purchase locally the number of tools and light equipment required to keep one or more units running throughout the year without referring to Central, Ministerial or District Tender Boards for approval. This is a lengthy process. It cannot be overemphasised, therefore, that it is essential to modify, where necessary, the existing procedures for they are often orientated towards equipment-intensive organisations or programmes. In the case of the RARP the

management has been allowed to tender for the Programme's own requirements, so that it is now responsible for its own procurement.

Stores[1] are delivered to the RAR engineers after a monthly stores demand has been submitted. This demand should reach headquarters not later than the tenth day of the month. Stores will then be issued by the RAR supply section to the units during the following 20 days either by car or by train, where this is possible. Local purchases may be made by the RAR engineer in respect of the following materials or services: ballast, sand, cement, timber, vehicle repair and other items or services after written authority from RAR HQ has been obtained. For most of the above materials and services, government contracts are awarded at the beginning of each financial year. If such a government contract is awarded to a particular supplier, the RAR engineer is obliged to obtain the materials concerned from that source. Petrol, oil and lubricants are usually obtained from existing HOW facilities. Where possible, engineers have installed bulk supplies for these items. 249

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[1] "Stores" comprise five categories: tools, survey equipment, building materials, stationery and general office items. A list of items available is in the possession of each RAR engineer.

APPENDIX 5

PLANNING, PROGRAMMING AND REPORTING AT SITE AND UNIT LEVEL

Planning

Before construction can be started, the quantities of work for each operation have to be known so that a project plan can be drawn up. In the RARP, two planning methods[1] have been used.

Method A. Some time before construction is to be started a small survey team, in some cases consisting of an overseer and a group of labourers, sets out the alignment of the proposed road. This survey entails initial bush clearing and a consideration of possible alternatives. After this prelisinary work has been carried out, the engineer or officer in charge inspects the proposed alignment and approves it when he is convinced that there are no better alternatives. After approval of the route, the overseer sets out the final alignment in detail. The next step is the preparation of a detailed bill of quantity (Appendix 8), in which the quantities of work for each operation per 20 metres of road length (clearing, excavation, etc.) are accurately described. Where necessary, remarks are made regarding the difficulty of the work (e.g. thickness of bush, soil type, throwing distances, length of haul when big fills are required, etc.).

After data collec[illegible], project plan is drawn up by the engineer in conjunct[illegible] the overseer/survey assistant who has prepared the bill of quantity and the overseer who will be in charge

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[1] Method A has been successfully tested in the initial period of the RARP in Kwale and Kitui districts. Method B has been introduced in a later stage of the Programme and has been established as the standard planning and programming method by the RARP management.

of the construction works (in some cases this is the same person). Productivity norms are established taking into account the parameters which are relevant for each section of road. These parameters are described in the remarks column of the bill of quantity.

Having established (a) the quantities of work, and (b) the productivity norms for each operation, the number of man-days required for each activity can be calculated by dividing (a) by (b).

The planned total number of man-days for the project can be computed after allowances for non-taskwork activities such as camp preparation and culvert laying have been made. The approximate duration of the project (number of construction days) is then reached by dividing the total number of man-days by the average size of the labour force. The average size of the labour force is determined by the availability of labour in the area, the available resources (the total number of casual labourers per unit should not exceed 300) and the size of the project.

Based on the above calculations and data, a "planning graph" can be drawn (see Appendix 8), where the planned progress of a control activity - usually camber formation - is plotted on a chart where the input in man-days is shown on the vertical (y-) axis and distances in kilometres on the horizontal (x-) axis.

This "graph" will be used for control during construction, when the actual progress and number of man-days spent can be plotted next to the planning line. The necessary data for this exercise are obtained from the monthly progress reports. The overseer in charge of the construction knows the targets to be accomplished and makes use of the bill of quantity to prepare his daily work programmes.

Method B. This method differs from the above-described system mainly because no detailed bills of quantity are prepared. The engineer estimates the required input in man-days for the construction of the road, basing this estimate on personal experience and general guidelines provided by RAR headquarters. Following previous data (project summaries and personal experience), the man-days required for each kilometre or identical part of the road are estimated for each activity (Appendix 8, RAR-1). A planning graph is then prepared in the same way as described under "Method A". Work targets are given to the overseer as: (i) the construction day when the control activity and, naturally, all preceding activities should be finished for each kilometre, (ii) the maximum of man-days to be used for this purpose (table 1).

Table 1

252

	km 1		km 2		km 3	
	Target	Actual	Target	Actual	Target	Actual
Construction day	18	19	28	34	38	52
Man-days	725	700	1 225	1 250	1 750	2 000

The overseer in charge of construction is expected to measure all quantities of work well ahead of construction in order to be able to prepare his daily work programme and to set his tasks in an efficient way.

The "planning graph" described above is a simple version of the "Time and Location Chart", which can be used effectively for production planning and control of more complex road construction projects. A description and example of such a "Time and Location Chart" is given as Appendix 10.

Programming

In order to allow the overseer to organise his labour force properly and to ensure that the workers will not be in each other's way, the latter do not all start on the same day. In accordance with the quantities of work as estimated in the bill of quantity, the size of the labour force will gradually be increased. The first group of workers hired will start work on the first activity. Two days later the next group starts with the next activity, and so on, until all labourers are at work. The size of each group will vary according to the number of man-days required for each activity. In this way, the rate of progress for each activity is approximately the same.

The overseer prepares a work programme[1] for all workers and instructs his headmen, one day in advance, of the intended work. On the work programme form he notes details for each planned activity, i.e. length of road to be completed, exact place of work, quantity of work, the taskrate and the number of men employed on this activity. In the space for remarks he notes deviations from the average taskrates (if any) and explains his reasons for adjustments. 253

The work should be programmed in such a way that no activity lags behind. In order to facilitate supervision the overseer should also take care that all construction activities are being carried out on a section of road that is short enough to enable him to visit all groups of workers at least three times daily. If the next morning a taskwork group is short of workers, labourers should be transferred from non-taskwork activities to the taskwork groups so that the taskwork activity can be carried out as planned. The headman should set out the tasks in the morning according to the

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[1] Appendix 8.

instructions received the previous evening. The overseer should then check as soon as possible whether his instructions have been carried out properly. In order to reduce supervision problems the number of activities planned is kept to a minimum by carrying out the construction in two phases. Phase I includes site clearance and excavation to level and phase II drainage and camber formation.

Administration

The overseer's administrative duties cover the monitoring of personnel, stores, input (man-days/activity) and output (production/activity). Although the overseer is responsible for all administration, his headmen may assist him with the administration of personnel, while the stores are being administered by the storekeeper. The overseer carries out random checks of certain items to check the work of his storekeeper. A 100 per cent check of site stores is carried out monthly, preferably immediately prior to pay day.

254

This system works very satisfactorily but requires storekeepers and headmen with some kind of educational background. There have always been plenty of candidates with a reasonable educational background for the white-collar job of storekeeper. However, the requirements for a headman post are different (man-management abilities and leadership are required rather than the ability to read and write), which implies that in many cases these posts are filled with workers without education. If the headmen are not capable of assisting with the administration of personnel this work will be done by the overseer, assisted by his storeman/timekeeper.

A muster-roll book is used for personnel administration. In this book the presence or absence of each worker is noted daily.

This information is kept in duplicate, as each month muster-rolls have to be collected and brought to the main office to provide the necessary information for the payrolls.

In a stores ledger-book all receipts, issues and balances of tools, materials and equipment are recorded. Daily issues are not recorded in this book, but names of workers and tools issued are noted by the storekeeper on a separate form at the beginning of the day when the tools are issued. In case of discrepancies the overseer is notified immediately and the worker will have to explain what has happened. When this explanation is not satisfactory the worker will have to pay for the tool and an appropriate amount of money will be deducted from his salary at the end of the month. Particular care should be taken by the storekeeper that the workers do not replace good-quality handtools by bad ones. This implies that the management should ensure that all tools are clearly marked. 255

Reporting

Reporting is done on a daily/weekly report form. The input (in man-days) to the various activities as well as the total number of workers on the muster-roll and their designation is reported on this form. At the end of each week the inputs for each activity are totalled and the stations between which work has been carried out are noted.

Based on the daily/weekly report forms, a monthly report form is filled in either by the overseer or the officer-in-charge. In any case, the officer in charge has to check the achievements of the month during a site visit in the beginning of the following month. After this inspection he then completes the monthly report by

calculating and recording the output, productivity, rates of pay and amounts.

The daily records, summarised in monthly reports, form the feedback to the engineer. The engineer then reports progress, total cost and resources used for his units to headquarters on a monthly basis. Quarterly the engineer submits a detailed breakdown of overheads to headquarters, where costs, etc. are analysed. When a project is completed, a summary is made and analysed in order to improve the planning and construction procedures.

The monthly accomplishment report (RAR-10)[1] and the monthly unit report (RAR-11)[1] give information on production and productivity, expenditure, personnel, equipment and gravelling. The quarterly engineer overheads report (RAR-12)[1] gives a detailed cost breakdown of overheads at engineer's level and contains information
256 on maintenance. On the reverse of the form the engineer's staff is listed. The quarterly unit overheads are calculated on form RAR-13.[1] The computing of the average unit overhead costs per man-day is necessary for the analysis of the cost per km of road constructed.

The project summary form (RAR-14) describes the inputs, outputs, parameters and costs of the project.

The monthly reports are forwarded to RAR HQ before the tenth of the succeeding month, together with a copy of the expenditure ledger and copies of payment vouchers and invoices, detailing and justifying expenditure incurred during the previous month. Orders for "stores" obtainable at RARP headquarters are made at the same time.

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[1] Appendix 8.

Since the level of supervision on individual construction sites is very variable, it is important that the problems of control and supervision are made as simple as possible. Planning and reporting procedures must be self-checking. For example, the number of man-days paid in a month as shown on the payroll must equal the number of man-days worked as shown on the monthly site record.

APPENDIX 9

PAYMENT SYSTEMS FOR CASUAL LABOUR USED IN THE RARP

Two payment systems have been used in the RARP although preference is given to the system as described under "A". The advantages and disadvantages of each system will be briefly discussed. The main problem with the payment of casual workers - who get paid only for the days they have worked - is that payrolls cannot be prepared in advance because salaries cannot be predicted unlike the case of permanent staff.

A. Payment is made on a monthly basis but two weeks in arrears. The normal payment period is from the 16th of the previous month up to the 16th of the current month. The duplicate masterrolls are collected every 16th of the month and the payrolls for the casual workers are prepared during the next three days. The masterrolls provide all necessary information in respect of daily rates of pay and number of days worked. The payrolls are submitted to the Provincial Engineer's (MOW Maintenance) Administration where they are checked for arithmetical errors. As per the directions of the RAR engineer one or several cheques per unit are then prepared for the signature of the provincial engineer and a second signatory (not the RAR engineer). Information on payment date and a breakdown of the cash for wages is forwarded to the bank at least two days in advance, so that the paying officer will be able to collect the money with minimum of delay on the date of payment. The paying officer proceeds to the sites where the workers have been assembled and pays every worker up to the 16th of the month.

258

The disadvantage of this payment system is that the workers are paid in arrears, the necessity of which many of them find

difficult to understand and accept, even after lengthy explanations. It also means that workers cannot be paid on the last day of work when the construction has been completed, but will have to come back for their final wages one or two weeks afterwards. To avoid these problems payments can also be made according to system B described below.

B. The collection of the muster-rolls, preparation of the payrolls and cheques and the giving of notice to the bank is done as described under A, the difference being that the wages for the period between the date of collection of the muster-roll and the date of payment are estimated and added on the payroll. It is assumed that every worker will be present every day during this period. To avoid overpayment the paying officer will have to deduct money according to a list prepared by the overseer, indicating the number of days workers have been absent during the above-mentioned period. A column for deductions is provided on the payroll and the worker signs for the actual amount received.

It is evident that this system increases the work of the paying officer substantially (deductions have to be made on the spot, total amount deducted has to be surrendered and accounted for). This may prove to be prohibitive especially if the paying officer does not come from within the RARP and is subsequently not responsible to the RAR engineer. The administrative work for the overseer, who has to prepare monthly deduction sheets, is also increased. An important disadvantage is that there is a scope for fraud by the paying officer and by the overseer.

Although the system can work and is better for the casual workers it depends too much on the personality and character of the paying officer because of the reasons described above. It is for

this reason that the NRRP management has preferred the system described under 2.

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CONTENTS

Transit Alternatives Analysis for Los Angeles
by Paul Taylor and Lenwood Howell
(Urban Transportation Division) 665

Ride Sharing: Psychological Factors
by Kenneth J. Dueker, Brent O. Bair, and Irwin P. Levin
(Urban Transportation Division) 685

Community Noise Study for Railroad Relocation
by Robert B. Jacko and Dana L. Hall
(Urban Transportation Division) 693

Interrelationship between Planning and Funding
by Mark G. Goode
(Urban Transportation Division) 703

Airport Choice in Low Demand Region
by Feng-Bor Lin
(Air Transport Division) 711

262 **Scheduling of Drawbridge Operations**
by Ira S. Kuperstein
(Urban Transportation Division) 729

Simultaneous Equation Model of Travel Demand
by Dale O. Stahl, II
(Urban Transportation Division) 741

→

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Formulation of Iowa State Airport System
by Robert L. Carstens and Joseph W. Murphy
(Air Transport Division) 751

Comparison of Cost Functions in Modal-Split Models
by John R. Underwood and Gerald R. Leake
(Urban Transportation Division) 763

** **Optimum Working Time**
by Marvin Gates and Amerigo Scarpa
(Highway Division) 773

Optimum Spacing of Supply Centers
by Marvin Gates and Amerigo Scarpa
(Highway Division) 783

Multipath Assignment Calibration for the Twin Cities
by Jerry L. Edwards and Ferrol O. Robinson
(Urban Transportation Division) 791

Estimating Transportation Mode Utilities
by Gary G. Makowski, M. M. Bakr, and Kumares C. Sinha
(Urban Transportation Division) 807

Trip Generation Analysis for Regional Studies
by Arun Chatterjee, Donald R. Martinson, and Kumares C. Sinha
(Urban Transportation Division) 825

263

TECHNICAL NOTES

Proc. Paper 13360

Use of the Dryer Drum
by Charles R. Foster
(Highway Division) 845

DISCUSSION

Proc. Paper 13310

State-of-the-Art of Ballastless Track at-Grade, by Walter L. Wheeler (Feb., 1976. Prior Discussion: Jan., 1977).
closure 851

The Resurgence of Light Rail Transit, by Martin Lenow (May, 1976. Prior Discussion: Mar., 1977).
closure 852

Traffic Generation from Land Development Proposals,* by Satish C. Sharma and Afifi H. Soliman (May, 1976).
by Suan-Sing Lau 853

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by Alfred E. Fazio and Charles Sarajian 854

Reviewers of the Air Transport and Urban Transportation Divisions 856

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TRANSPORTATION ENGINEERING JOURNAL

Optimum Working Time

By Marvin Gates[1] and Amerigo Scarpa,[2] Fellows, ASCE

(Reviewed by the Highway Division)

Introduction

More than a century ago, Lord William T. Kelvin formulated a simple solution for finding the optimum size of electric transmission cable. Electric line losses vary inversely while the capital cost of the cable varies directly with the cross-sectional area. The optimum size cable is the one that gives the least-cost for the cable itself and the offsetting loss of electricity. In mathematical terms, Kelvin's Law is the solution of the dependent variable in the first derivative of the sum of the equations of the two contending costs. In the intervening years, Kelvin's Law has been a model for many analogous solutions in every field of engineering. One of the classic cases in civil engineering is the optimum span of bridge structures. As the distance between bridge piers increases, their number and thus their total cost decreases. On the other hand, as the distance between bridge piers increases, so do the span lengths and thus the total cost of the superstructure. The least-cost or optimal distance between bridge piers that minimizes the combined cost of substructure and superstructure can be solved by Kelvin's solution or by trial and error. The former is a simple algebraic expression and is preferable to the latter that is frequently a time-consuming iterative process.

In construction planning and economics, similar problems are encountered that require minimizing costs by optimizing two contending factors. Those described in widely referred to texts are invariably solved by trial and error because the relationships have not been formulated. For example, one frequently mentioned problem is the optimum height of a cofferdam. Therein the tradeoff is between increased height and thus cost and reduced risk of loss on account of overtopping. Although this classic problem is both an important and an

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[1]Pres., Construction Estimating, Inc., West Hartford, Conn.; Lect., Worcester Polytechnic Inst., Worcester, Mass.

[2]Pres., Gates-Scarpa and Assocs., Inc., West Hartford, Conn.; Lect., Hartford State Technical Coll., Hartford, Conn.

instructive one, the solution in current texts is one of trial and error. Nevertheless, a simple solution based on Kelvin's approach was published in 1971 (2). Since that time the writers have applied this same optimizing procedure to construction management problems involving hauling units (3) and construction equipment (4). For each case the optimal solution is found directly and rapidly from a simple equation.

In this paper another familiar highway construction management problem is presented, analyzed, and solved. The problem is to determine the optimum working time and number of crews for an operation. The tradeoff is between overhead costs and equipment mobilization costs. An optimizing equation is derived and verified with a trial-and-error solution. This two-fold approach should appeal to the practicing field engineer or project manager as it enables him to get a better feel for the tradeoff. For this reason too, the problem and solution are stated in fundamental terms. Variations and secondary constraints, when considered, often complicate the solution and frequently obscure the pattern of the dynamics of the tradeoff. Moreover, the idealized optimizing equation is usually the practical limit to fine-tuning solutions of this type to construction management problems. Nonetheless, in every instance, particular job conditions must be considered as these solutions are implemented. For example, consider the bridge span optimization problem referred to before. This classic solution states that the least cost is achieved when the combined cost of the foundation and substructure of one pier is exactly equal to the variable cost of one span of the superstructure. Although this rule gives the bridge designer an important frame of reference, it does not inhibit him from deviating from this relationship.
266 Similarly, the optimizing equations and rules derived here give the construction manager an important frame of reference; for project planning in the first instance and claims evaluation in the last.

Statement of Problem

The construction time required to complete the work associated with a specific major activity is directly proportional to the quantity of work and inversely proportional to the number of crews employed. As construction time decreases, so do the costs of time-related overhead field functions such as supervision and administration. On the other hand, in this case, the number of crews required increases and this results in correspondingly increased costs for mobilization and logistical support, especially for equipment intensive operations. The optimum working time, T_{opt}, and thus the the optimum number of crews, N_{opt}, is when the combined total cost for time-related job overhead and crew mobilization is a minimum.

Three simplifying assumptions are justifiable and expedient. For example, it is assumed that the optimum number of crews necessary to complete the work in the optimum working time is readily available and can be conveniently accommodated within the working area. Furthermore, it is assumed that the total productivity per unit time varies directly with the number of crews employed. And finally, it is assumed that the costs for supervision and administration is practically independent of the number of crews employed. This last assumption is correct for any number of crews associated with any working time, T, that

even approximates T_{opt}. The terms, job overhead and supervision and administration, are used interchangeably herein.

Time-Cost Equations

The general time-cost relationships are shown in Fig. 1. The total cost for job overhead, as it is used herein, is the product of the variable part (time dependent) of this cost per unit time, C_{oh}, and T or

$$\text{Total Job Overhead Cost} = C_{oh}T \quad \ldots \quad (1)$$

The fixed part (nontime dependent) of job overhead, such as mobilization of overhead elements, need not be considered. These are one-time costs that are

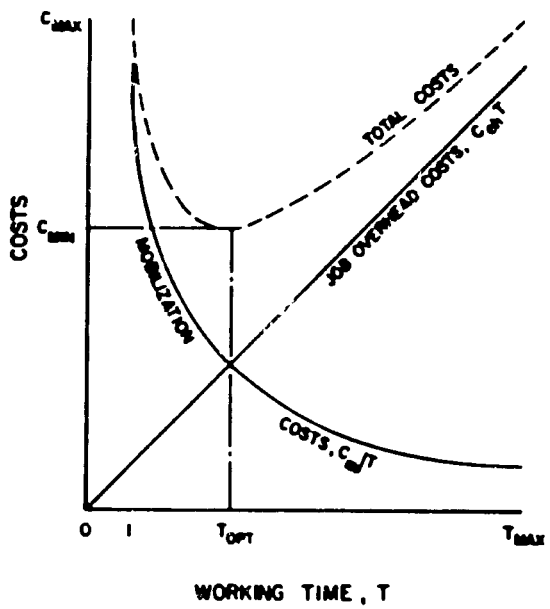

FIG. 1.—Relationships Between Construction Time and Costs for Mobilization and Job Overhead

independent of both the working time and the number of crews employed. Eq. 1 relates the costs of job overhead that vary directly with time.

If one crew can complete all of the work in T days, then two crews can complete all of the work in $T/2$ days. However, the cost of mobilizing two crews is twice the cost of mobilizing one. By analogy, the total cost to mobilize all of the crews necessary to complete all of the work in one unit of time, C_m, is

$$C_m = \frac{Q}{P} \times c_m \quad \ldots \quad (2)$$

in which Q = total quantity of work associated with the specific activity; P = productivity of one crew per unit of time; and c_m = cost to mobilize one

287

crew. So that the total cost to mobilize all of the crews required to complete all of the work in T units of time is

$$\text{Total Mobilization Cost} = \frac{C_m}{T} \quad (3)$$

The optimum working time, T_{opt}, is when the sum of the costs from Eqs. 1 and 3 is a minimum, or

$$C_{oh}T + \frac{C_m}{T} = \text{Minimum} \quad (4)$$

Differentiating the combined total cost with respect to time, in Eq. 4, yields

$$C_{oh} - \frac{C_m}{T^2} = 0 \quad (5)$$

Solving Eq. 5 for T yields

$$T_{opt} = \sqrt{\frac{C_m}{C_{oh}}} \quad (6)$$

Eq. 6 gives the optimum working time that minimizes the combined total cost of job overhead and crew mobilization.

The optimum number of crews required, N_{opt}, to complete all of the work within the optimum working time is

268

$$N_{opt} = \frac{Q}{PT_{opt}} = \frac{C_{oh}T_{opt}}{c_m} \quad (7)$$

Furthermore, the minimum combined cost of job overhead and crew mobilization C_{min}, is

$$C_{min} = C_{oh}T_{opt} + c_m N_{opt} \quad (8)$$

Moreover, from Eq. 7:

$$C_{oh}T_{opt} = c_m N_{opt} = \frac{C_{min}}{2} \quad (9)$$

In other words, the minimum combined cost is when the total cost for variable overheads equals the total cost to mobilize the crews, and occurs at T_{opt}.

Example

It is required to excavate and transport 1,500,000 cu yd (1,150,000 m³) of earth. The productivity of the crew described in Table 1 is 2,500 cu yd (1,920 m³)/day. The cost to mobilize and demobilize a crew is estimated as the cost of 2 crew days or $3,000. Regardless of the exact number of crews that will be employed, the variable (time-dependent) supervisory and administrative costs of job overhead are $300 a day and are described in Table 2. Table 2 does not include the cost to mobilize and demobilize the field office and storage areas because these elements are not time dependent. That is to say, these facilities incur one-time costs that are independent of both the working time

and the number of crews employed. However, rent, utilities and other time-dependent costs for these facilities are included in the daily charge of $60.

TABLE 1.—Composition and Cost of Earth Excavation Crew

Composition (1)	Cost, in dollars (2)
One foreman/pickup	120
One front end loader	240
One loader operator	100
Four trucks	640
Four truck drivers	320
One laborer	80
Daily cost of crew	1,500

TABLE 2.—Composition and Cost of Supervision and Administration

Composition (1)	Cost, in dollars (2)
One superintendent/auto	120
One timekeeper-clerk	60
One trafficman	60
Field office, complete, storage yard, and miscellaneous	60
Daily variable cost of job overhead	300

269

From Eq. 2 the cost to mobilize all of the crews, assuming that all of the work will be completed in 1 day, is

$$C_m = \frac{1{,}500{,}000}{2{,}500} \times \$3{,}000 = \$1{,}800{,}000 \quad (10)$$

Therefore, the optimum working time, from Eq. 6, is

$$T_{opt} = \sqrt{\frac{1{,}800{,}000}{300}} = 77.46 \text{ days} \quad (11)$$

Consequently, the number of crews required to complete all of the work within the optimum working time is, from Eq. 7:

$$N_{opt} = \frac{1{,}500{,}000}{2{,}500(77.46)} = 7.746 \quad (12)$$

also $$N_{opt} = \frac{\$300}{\$3{,}000} \times 77.46 = 7.746 \quad (13)$$

Furthermore, the minimum combined cost of job overhead and crew mobilization is, from Eq. 8:

$$C_{min} = \$300(77.46) + \$3{,}000(7.746) = \$46{,}476 \quad (14)$$

Table 3 and Fig. 2 comprise an alternate approach to the problem without

employing Eqs. 6-8. Because of the great range of values of costs and time, Fig. 2 is plotted logarithmically. Both job overhead costs and crew mobilization

TABLE 3.—Relationship Between Number of Crews, Working Time, Job Overhead Costs, and Mobilization Costs

Number of crews (1)	Mobilization costs, Col. 1 × $3,000 (2)	Working days, T, 1,500,000/(Col. 1 × 2,500) (3)	Overhead costs, Col. 3 × $300 (4)	Mobilization and overhead costs, Col. 2 + Col. 4 (5)
1	3,000	600	180,000	183,000
2	6,000	300	90,000	96,000
3	9,000	200	60,000	69,000
6	18,000	100	30,000	48,000
10	30,000	60	18,000	48,000
20	60,000	30	9,000	69,000
30	90,000	20	6,000	96,000
60	180,000	10	3,000	183,000
100	300,000	6	1,800	301,800
200	600,000	3	900	600,900
300	900,000	2	600	900,600
600	1,800,000	1	300	1,800,300

270

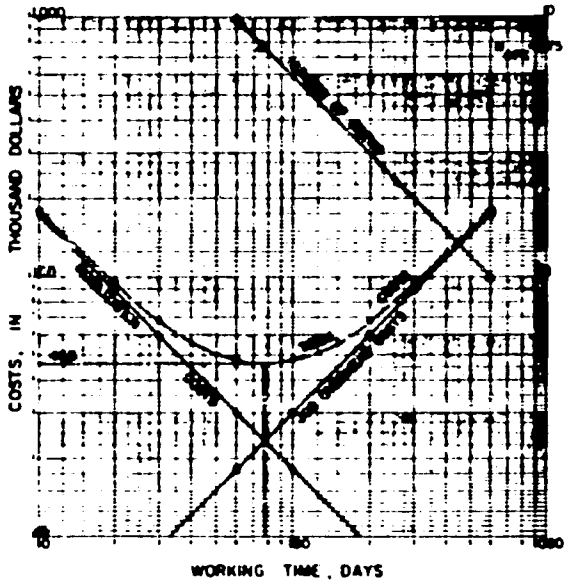

FIG. 2.—Number of Crews, Mobilization, Job Overhead, and Total Costs for Earthwork Example—Based On Data from Table 3

costs plot as straight lines; and the total cost plots as a symmetrical curve. Practically speaking, it is highly improbable that as many as 10 crews would

ever be employed; and 600 crews is absurd. The entire range of values of N is included in Table 3 for illustrative purposes only.

Additional Time-Cost Relationships

According to the time-cost equation, T and N are reciprocally related as

$$TN = \frac{Q}{P} \quad \text{(15)}$$

Therefore, when $N = 1$, T is maximized; and conversely when $T = 1$, N is maximized. Consequently, the maximum combined total cost of job overhead and crew mobilization occurs when: T is maximized and $C_{oh} > c_m$; or when N is maximized and $C_{oh} < c_m$.

Extension of Example—Overtime

From Eqs. 11 and 12 the optimum working time, T_{opt}, is 77.5 days and the optimum number of crews, N_{opt}, is 7.75. The question now is, can the combined cost for job overhead and crew mobilization from Eq. 14 be reduced further by making the crews work overtime. An increased workday means even less crews are required; therefore crew mobilization costs are reduced further. However, an increased workday means a penalty in the form of premium pay for the crew. This, then, is another tradeoff that some readers will claim should also be considered.

In the earthwork example, assume that all labor, except foremen and superintendents, are paid time-and-a-half for all time over 8 hr worked per day. Assume

271

TABLE 4.—Relationship Between Number of Crews, Overtime, Premium Pay, Job Overhead Costs, and Mobilization Costs

Number of crews (1)	Mobilization costs, Col 1 × $3,000 (2)	Working days, T_{opt} (3)	Overtime hours per day (4)	Overtime hours total, Col 3 × Col 4 (5)	Total premium pay, Col 5 × $40 (6)	Overhead costs, first 8 hr/day, Col 3 × $300 (7)	Overhead costs over 8-hr/day, Col 5 × ($300/8) (8)	Mobilization, premium pay, and overhead costs, Col 2 + Col 6 + Col 7 + Col 8 (9)
3.87	11,610	77.5	8	620	24,800	23,250	23,250	82,910
4	12,000	77.5	7.5	581	23,240	23,250	21,788	80,278
5	15,000	77.5	4.4	341	13,640	23,250	12,788	64,678
6	18,000	77.5	2.3	178	7,120	23,250	6,675	55,045
7	21,000	77.5	0.8	62	2,480	23,250	2,325	49,055
7.75	23,250	77.5	0	0	0	23,250	0	46,500
8	24,000	75	0	0	0	22,500	0	46,500

further that all other costs are pro-rata based on straight-time rates. Therefore, the hourly overtime cost of the crew in Table 1 is, in round numbers, $220. Similarly, the hourly overtime cost of supervision and administration in Table 2 is, in round numbers, $45. Then, the total premium (penalty) is ($220 + $45) − ($1,500 + $300)/8 = $40/hr for all overtime. This is the basis of Col. 6 in Table 4. Col. 8 in Table 4 is the cost of overtime at the straight-time rate.

If the longest workday is limited to 16 hr and T_{opt} = 77.5 as before, the number of crews required is 8/16 × 7.75 = 3.87. Table 4 is a comprehensive comparative cost study for 3.87 crews-8 crews. Therein T_{opt} = 77.5 is constant, but the number of crews varies inversely as the total number of hours worked per day. Rounding N_{opt} up to 8 and T_{opt} down to 75 does not sensibly alter C_{min} = $46,500.

Nevertheless, Table 4 indicates that the original solution is still the most economical. This is true even if Col. 6 is not included in the combined total cost that is Col. 9. This is a consequence of the fact that herein the costs for supervision and administration relate to the costs for crew mobilization exactly as they do in the original example: compare Col. 8 with Col. 7 and with Col. 2. In other words, the optimal solution is independent of overtime and premium pay as long as everyone is paid for all hours worked on at least a straight-time basis.

Summary and Conclusions

272

It is evident from Table 3 and Fig. 2 that substantial cost differences are associated with varying working times and numbers of crews. In the example, the difference in job overhead and crew mobilization costs, when employing three crews rather than one crew, represents a savings of more than $100,000. In practice, job conditions will probably mitigate against using many crews, such as the eight crews indicated in the example. However, a fair generalization, for earthwork at least, is to employ as many crews as job conditions permit.

An extension of the general case is the cost tradeoff between reducing the number of crews, and thus the mobilization costs, by working crews overtime, but paying even straight-time wages to labor and incurring continuing overhead costs on a pro-rata straight-time basis. It is evident from Table 4 that there is no advantage in working overtime if the purpose is to reduce the cost of crew mobilization.

This analysis leads to a valuable frame of reference that can be stated as:

> The optimum working time for a construction operation is when the total cost for variable overheads equals the total cost to mobilize and demobilize all of the crews.

The optimum duration-cost problem is a familiar one in network planning. However, according to Aras and Surkis (1), the calculations must be computerized because they are too lengthy and involved to be done manually. Nevertheless the proposed method is simple and can be effectively applied manually to all items on the critical path whenever network planning is employed.

The trial-and-error approach has one important redeeming feature. When the

results of a broad range of trials are plotted, the shape of the graphs, especially the total cost curve, indicates the sensitivity of the tradeoff. So that if a solution other than the optimal one is in contention, because of particular job conditions or other tradeoffs, the penalty for not selecting the optimum solution is immediately discernable for a wide range of alternatives.

Acknowledgment

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Appendix I.—References

1. Aras, R. M., and Surkis, J., "PERT and CPM in Project Management," *Journal of the Construction Division*, ASCE, Vol. 90, No. CO1, Proc. Paper 3823, Mar., 1964, pp. 1-25.
2. Gates, M., "Bidding Contingencies and Probabilities," *Journal of the Construction Division*, ASCE, Vol. 97, No. CO2, Proc. Paper 8524, Nov., 1971, pp. 277-303.
3. Gates, M., and Scarpa, A., "Optimum Size of Hauling Units," *Journal of the Construction Division*, ASCE, Vol. 101, No. CO4, Proc. Paper 11771, Dec., 1975, pp. 853-860.
4. Gates, M., and Scarpa, A., "Optimum Size of Equipment," *Journal of the Construction Division*, ASCE, Vol. 101, No. CO4, Proc. Paper 11772, Dec., 1975, pp. 861-867.

Appendix II.—Notation

The following symbols are used in this paper: 273

C_m = total cost to mobilize and demobilize all crews necessary to complete all work in one unit of time;
C_{min} = minimum combined cost of job overhead and crew mobilization;
C_{oh} = variable (time dependent) overhead costs per unit time;
c_m = cost to mobilize and demobilize one crew;
N = number of crews associated with T;
N_{opt} = number of crews associated with T_{opt};
P = productivity of one crew per unit time;
Q = quantity of work;
T = working time; and
T_{opt} = optimum working time.

Project Correspondent A. S. Jones-Dove, Chief Engineer (Highways), Ministry of Works, Sierra Leone.

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CONTENTS

Cost of Social and Environmental Regulations in Construction
by Enno Koehn, Ronald E. Benson, Jr., and David Shank 117

** **Optimum Number of Crews**
by Marvin Gates and Amerigo Scarpa 123

Alternate Bids for Bridge Deck Repair
by Robert J. Trapani 133

Use of Alternative Construction Methods
by David Scott and Naveed Athar Sheikh 141

Evaluation of Contractor Comments on the Quality of Specifications
by Maynard Charles Nugent 153

CPM—Interactive Training Tool
by Calin M. Popescu 157

Contractors and Production of Durable Air-Entrained Concrete
by Weston T. Hester 167

276 **Horizontal Slip-Form Construction—Low Slump Concrete**
by Frederick T. Hsia and Orlando B. Andersland 179

Equipment Costs by Current Methods
by James Douglas 191

Local Housing Demand
by Clayford T. Grimm 207

→

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Concreting and Formwork Logistics and Optimization
by Marvin Gates and Amerigo Scarpa 219

Safety: Function of Job Control
by Jimmie Hinze and John Pannullo 241

DISCUSSION

Proc. Paper 13783

Past and Future of Concrete Quality Evaluation, by Venkataswamy Ramakrishnan (June, 1976. Prior Discussions: Mar., June, Sept., 1977).
closure 253

State of Minority Contractor Participation,* by Shu-Tien Li (June, 1977. Prior Discussions: Dec., 1977).
by Narindar Bhandari 255

Pros and Cons of Construction Management,* by Alfred C. Maevis (June, 1977. Prior Discussion: Dec., 1977).
by James A. Ramsay 256

Road Construction—Simulation Game for Site Managers,* by Frank C. Harris and John B. Evans (Sept., 1977).
by Alan A. Lilley 257

Concrete Slab Performance on Expansive Soils,* by Richard L. Tucker and Arthur R. Poor (Sept., 1977).
by Robert E. Bigham 259

Gates' Bidding Model—A Monte Carlo Experiment?* by Michael Fuerst (Dec., 1977).
errata 260

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13807 JUNE 1978 CO2

JOURNAL OF THE
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Optimum Number of Crews

By Marvin Gates[1] and Amerigo Scarpa,[2] Fellows, ASCE

Introduction

This paper is a variation and continuation of another, by the same writers, published recently in the *Transportation Engineering Journal of ASCE* (3). In that paper, the optimum time of construction was formulated for equipment intensive construction operations. The trade-off there is between the cost to mobilize crews and the cost for job overhead. That solution gives the optimum number of crews as well as the optimum time of construction. Herein, the optimum number of crews is formulated for labor intensive construction operations. The trade-off here is between the cost of the crews as it is modified by the experience curve phenomenon and the cost for job overhead. The solution gives the optimum time of construction as well as the optimum number of crews. Fig. 1 depicts the general nature of the trade-off and the graphical least-cost solution.

278

The total time to construct all units of work associated with a specific contract item is directly proportional to the total quantity of work and inversely proportional to the number of crews employed. This implies that the number of crew-days is constant. However, this implication is correct only when the 100% Experience Curve applies. When any other experience curve applies, the required number of crew-days decreases as the number of crews decreases. In other words, because of the experience curve phenomenon, the total cost of the crews is exponentially and directly related to the number of crews employed. On the other hand, the total construction time tends to increase as the number of crews decreases. Therefore the total cost for job overhead such as supervision, administration, and support facilities is exponentially and inversely related to the number of crews employed. Both contending costs are optimized here to yield a least-total cost solution.

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[1]Pres., Construction Estimating, Inc., West Hartford, Conn.; and Lect., Worcester Polytechnic Inst., Worcester, Mass.

[2]Pres., Gates-Scarpa and Assoc., Inc., West Hartford, Conn.; and Lect., Hartford State Tech. Coll., Hartford, Conn.

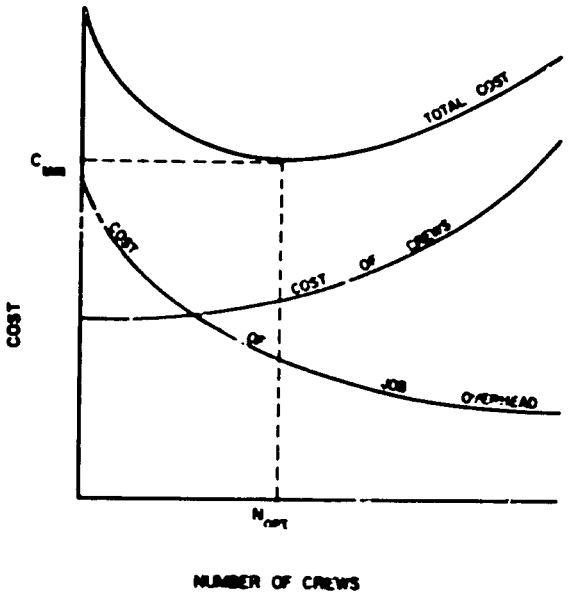

FIG. 1.—Minimum Total Cost and Optimum Number of Crews

279

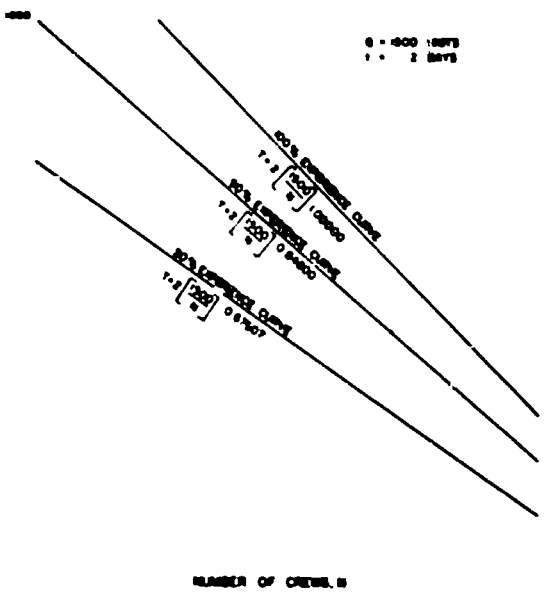

FIG. 2.—Total Construction Time

Fig. 2 shows the relationship between the total time, T, and the number of crews employed, N, for three experience curves. The 100% Experience Curve indicates simply that T and N are inversely related and that the experience curve phenomenon does not apply. However, the two other experience curves suggest a more complex relationship. Fig. 2 is based on a specific contract item of work that consists of 1,500 repetitive units, Q. It is estimated that it will take a typical crew 2 days to construct the first unit, t. Note how the total time, T, varies with both the experience curve and the number of crews, N, employed. This figure is related to the example at the end of this paper. Table 1 is based on Figure 2 and gives the equivalent number of crews, time and crew-day requirements for constant N and constant T to complete the identical task.

Experience Curve

The experience curve was formulated by Wright in 1936 (4), and in the literature is sometimes referred to as Wright's Law. This law states that the cumulative

TABLE 1.—Equivalent Relationships For Selected Experience Curves Based on Fig. 2

Experience curve, as a percentage (1)	Number of crews N (2)	Time, in days T (3)	Crew days Col 2 × Col 3 (4)
100	10	300	3,000
90	4	300	1,200
80	1	300	300
100	10	300	3,000
90	10	140	1,400
80	10	60	600

280

average time, CAT, to do complex repetitive work varies exponentially and inversely as the number of repetitions increases geometrically. Wright devised this relationship based on his work in the aircraft industry where he found that each time the number of airframes constructed doubled, the CAT of labor-hours declined by 20%. He called this relationship the 80% Experience Curve (100%-20%). The experience curve has been investigated in depth by the writers (1,2). Those papers review the limited experimental data and applications to construction management problems. In fine, construction operations are associated with particular experience curves as summarized in Table 2. By way of example, Table 3 gives the CAT and the total time, T, required to construct n units when the time to construct the first unit, t, is 1,000 man-hr and the 90% Experience Curve applies. Note that the first 100 items to be constructed will require, on average, 496 man-hr each. This is half the time required to construct the first item and is the result of increased efficiency resulting from increased number of repetitions. It is, of course, assumed that the same crew is employed to construct all 100 items.

The classical relationship between CAT and n is

TABLE 2.—Characteristics of Experience Curves (1)

Description (1)	Experience curve, as a percentage (2)
Entire structure of ordinary complexity such as high-rise office buildings and tract housing.	95
Individual construction elements requiring many operations to complete, such as carpentry, electrical work, plumbing, erection and fastening of structural units, and concreting.	90
Individual construction elements requiring few operations to complete, such as masonry, floor and ceiling tile, and painting.	85
Construction elements requiring few operations and on assembly-line basis, such as field fabrication of trusses, formwork panels, and bar bending.	80
Plant manufacture of building elements, such as doors, windows, kitchen cabinets, and prefabricated concrete panels	90–95

TABLE 3.—Man-Hour Requirements According to 80% Experience Curve

Number of items, n (1)	Cumulative average time (CAT), in man-hours (2)	Total time T, in man-hours (Col. 1 × Col. 2) (3)
1	1,000	1,000
2	900	1,800
4	810	3,240
8	729	5,832
10	705	7,050
20	635	12,700
100	496	49,600
200	446	89,200

281

TABLE 4.—Values and Functions of s

Experience curve, as a percentage (1)	Slope, s (2)	$1 + s$ (3)	$(1 + s)/s$ (Col. 3/Col. 2) (4)
100	0.00000	1.00000	∞
95	−0.07400	0.92600	−12.514
90	−0.15200	0.84800	−5.5789
85	−0.23447	0.76553	−3.2649
80	−0.32193	0.67807	−2.1063

$$CAT = n^s t \quad \text{(1)}$$

and between T and n is

$$T = n^s t n = n^{(1+s)} t \quad \text{(2)}$$

in which s = the slope and is a negative exponent less than one. Values and functions of s for selected experience curves are given in Table 4.

The experience curve phenomenon applies to individual workers working alone as well as to teams of workers working as integrated crews. The term crew, as used herein, may mean: (1) A single worker such as a painter; (2) a small group of workers such as two masons and one mason tender; and (3) a large group of workers with heavy equipment such as an erection crew. See Refs.

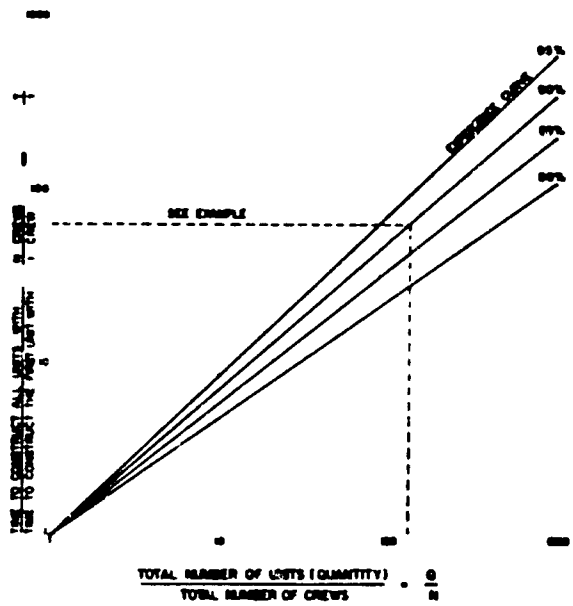

FIG. 3.—Relationship between Total Construction Time and Number of Units Constructed by Each Crew

1 and 2 for further detailed explanation of experience curve theory, its applications, and limitations.

Time-Cost Equations

Let Q equal the total quantity of work associated with a specific contract item, and N equal the number of crews employed. Then the number of units of work that must be constructed by each crew, n, is

$$n = \frac{Q}{N} \quad \text{(3)}$$

The total time, T, for a crew to construct all of the pro-rata units assigned to it, n, is Eq. 3 substituted in Eq. 2, or:

282

$$T = \left(\frac{Q}{N}\right)^{(1+s)} t \quad \ldots \quad (4)$$

Obviously, Eq. 4 is also the total time for all N crews to construct all Q units of work. Fig. 3 is based on Eq. 4 and conveniently relates the total construction time to the number of items assigned to each crew, for selected experience curves. The 100% Experience Curve (not shown) gives values on the ordinate equal to values on the abscissa.

Job overheads can be classified into two categories: (1) Time-dependent or recurring, sometimes call variable overheads; and (2) time-independent or nonrecurring, sometimes called fixed overheads. The first category includes such costs as salaries and rents. Clearly, they are a function of time. The second category includes costs for temporary support construction and installation. These are one-time costs and are assumed here to be independent of the total construction time and the number of crews employed. The latter category does not contribute to the solution and is not considered further. Contrawise, continued reference here to job overhead is limited to the overhead costs that are time-dependant and as classified in the former category. The total cost for job overhead associated with a specific contract item is

$$c_{oh} T = c_{oh} \left(\frac{Q}{N}\right)^{(1+s)} t \quad \ldots \quad (5)$$

in which c_{oh} = the cost for job overhead per unit time, and Eq. 4 is substituted for T. 283

Typically, a crew is composed of labor and equipment. The out-of-pocket cost for labor includes: (1) Base wages; (2) mandatory employer expenses for taxes; insurance, and contributions; and (3) voluntary employer contributions. The cost of equipment includes: (1) Rental; (2) fuel, fluids, and filters; and (3) field maintenance. Other elements that comprise the cost of the crew may include allowances for small tools and subsistence. The total of all such costs is the cost of the crew, which is also time-dependent. The total cost for crews associated with a specific item of work is

$$Nc_c T = Nc_c \left(\frac{Q}{N}\right)^{(1+s)} t \quad \ldots \quad (6)$$

in which c_c = the cost of a typical crew per unit time; Nc_c = the total cost of all typical crews per unit time; and Eq. 4 is substituted for T.

The optimum number of crews, N_{opt}, also optimizes the total time, T_{opt}, that results in the minimum total cost for job overhead and crews. Summing Eqs. 5 and 6 yields:

$$c_{oh} \left(\frac{Q}{N}\right)^{(1+s)} t + c_c N \left(\frac{Q}{N}\right)^{(1+s)} t = \text{Minimum} \quad \ldots \quad (7)$$

The optimum number of crews can be found by: (1) Differentiating the total cost in Eq. 7 with respect to N; (2) setting the result equal to zero; and (3) solving for N_{opt}; all of which gives:

$$N_{opt} = -\frac{c_{oh}(1+s)}{c_c\, s} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Eq. 8 gives the optimum number of crews that minimizes the total cost for job overhead and crews. The right-hand expression is negative but computes positively because s is negative. To reiterate, s is a function of the efficiency of productivity associated with the experience curve phenomenon. Fig. 4 is based on Eq. 8 and conveniently relates the optimum number of crews to the ratio of job overhead costs to crew costs for selected experience curves.

The optimum total construction time, T_{opt}, within which to construct all of

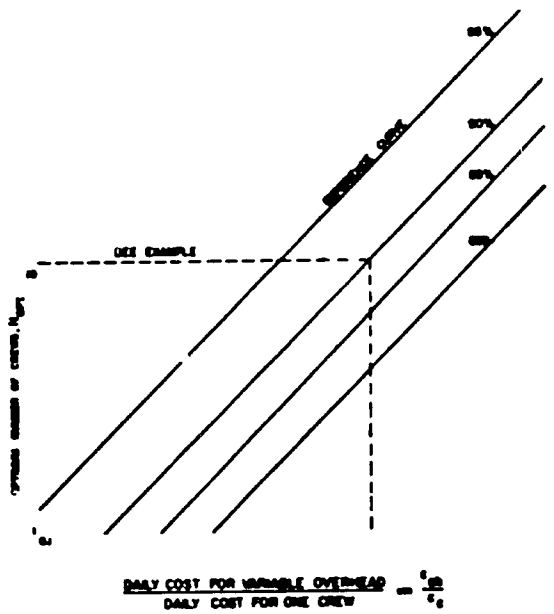

FIG. 4.—Optimum Number of Crews

the units with the optimum number of crews, is found by substituting N_{opt} in Eq. 4 which gives:

$$T_{opt} = \left(\frac{Q}{N_{opt}}\right)^{(1+s)} t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

The minimum total cost for job overhead and crews, C_{min}, is found by substituting Eq. 9 into Eq. 7 which gives:

$$C_{min} = T_{opt}\,(c_{oh} + c_c\, N_{opt}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Mobilization Costs

It is characteristic of labor intensive operations to find that costs for mobilization and demobilization of crews are negligible. This is contrary to capital intensive

operations, where such costs are incurred in connection with heavy construction equipment, and can be substantial. Nevertheless, let c_m equal the cost to mobilize and demobilize one crew. Then the cost to mobilize and demobilize all the crews is

$$c_m N \quad \ldots \quad (11)$$

Now the total cost to be minimized is the sum of Eqs. 7 and 11, or:

$$c_{oh}\left(\frac{Q}{N}\right)^{(1+s)} t + c_c N\left(\frac{Q}{N}\right)^{(1+s)} t + c_m N = \text{Minimum} \quad \ldots \quad (12)$$

As before, the optimum number of crews can be found by: (1) Differentiating the total cost in Eq. 12 with respect to N; and (2) setting the result equal to zero; all of which gives:

$$c_m N^{(1+s)} - s\, c_c\, Q^{(1+s)}\, t\, N - (1+s)\, c_{oh}\, Q^{(1+s)}\, t = 0 \quad \ldots \quad (13)$$

Further simplification is not possible; therefore, Eq. 13 must be solved for N_{opt} iteratively.

Example

A certain contract item consists of 1,500 repetitive units Q. A typical crew is comprised of two journeymen and one helper and small tools; and costs c_c = \$250/day all-in. It is estimated that it will take this crew t = 2 days to construct the first unit. Thereafter, productivity will follow the 90% Experience Curve (see Figure 2). 285

The related job overhead includes a superintendent, an engineer, and two clerks as well as rental of a field office, a storage yard, and sanitary facilities. Other allowances must be made for power, telephone, and subsistence. These time-dependent job overheads are estimated at c_{oh} = \$500/day, without regard to the precise number of crews employed.

From Fig. 4, based on Eq. 8, the optimum number of crews is N_{opt} = 11. Therefore, each crew will construct n = 1,500/11 = 136 units. From Fig. 3, based on Eq. 4, the total time to construct all 1,500 units is T_{opt} = 64 × 2 days = 128 days. This is equivalent to 11 × 128 = 1,408 crew-days, or an average of 0.94 crew-days/unit (Fig. 2).

The minimum total cost for job overhead and crews is, from Eq. 10:

$$C_{min} = 128\,[\$500 + \$250\,(11)] = \$416{,}000 \quad \ldots \quad (14)$$

A sensitivity analysis of this solution indicates that C_{min} does not vary by more than \$10,000 for the range N = 7–20. However, the cost for job overhead and crews varies by \$60,000 in this range when they are considered separately. The sensitivity of this form of analysis increases significantly as the ratio c_{oh}/c_c decreases. If c_{oh} = \$125/day, this ratio decreases from 2 to 0.5. From Fig. 4, N_{opt} = 3 and the total cost, C_{min} = \$333,000. A variation of \$10,000 from this amount includes only the range N = 2–5. Furthermore, T_{opt} = 388 days or three times the optimum time found earlier.

Summary and Conclusions

Two principal notions are developed separately and then combined to yield a simple solution to the question of the optimum number of crews and the optimum construction time for labor-intensive construction operations. In the first instance, it is shown that the total output of one crew working 100 days is not the same as the total output of 100 crews working 1 day or any other analogously paired data. In fact, the total output of one crew working 100 days exceeds the total output of any other combination. This phenomenon is explained by experience curve theory that is reviewed here. In the second instance, it is shown that certain costs of construction vary directly with time while other costs vary inversly. The sum of these two contending costs also varies with respect to time and frequently has a minimum value. The minimum cost is associated with the optimum value of the independent variable, which, in this study, is the number of crews.

Expressions are developed for finding the optimum values for the number of crews and the total construction time. These expressions are the basis of two graphs that facilitate the solution. These data are developed for labor-intensive operations in which the cost to mobilize and demobilize crews is negligible. Nevertheless, an expression is also developed wherein the mobilization cost of crews is considered. It requires an iterative solution.

An example illustrates the nature of the problem and the simple and rapid solution. Moreover, an extension of the example illustrates the sensitivity of the analysis. As the ratio of the daily cost of job overhead to the daily cost of one crew decreases, the solution becomes increasingly sensitive. Generally speaking, when the ratio is less than unity, a departure from the theoretical solution of the optimum number of crews will result in a significant increase in the total cost of construction. When the ratio exceeds unity, the penalty for not employing the theoretical optimum number of crews is not significant for a broad range. This ratio can have far-reaching effects in (network) planning, assessing the labor market, establishing contract time requirements, and evaluating claims, especially those related to acceleration.

286

Acknowledgment

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Appendix I.—References

1. Gates, M., and Scarpa, A., "Learning and Experience Curves," *Journal of the Construction Division*, ASCE, Vol. 98, No. CO2, Proc. Paper 8778, Mar., 1972, pp. 79-101.
2. Gates, M., and Scarpa, A., errata to "Learning And Experience Curves," *Journal of the Construction Division*, ASCE, Vol. 102, No. CO4, Dec., 1976, p. 689.
3. Gates, M., and Scarpa, A., "Optimum Working Time," *Transportation Engineering Journal of ASCE*, Vol. 103, No. TE6, Proc. Paper 13355, Nov., 1977, pp. 773-781.
4. Wright, T. P., "Factors Affecting the Cost of Airplanes," *Journal of Aeronautical Science*, Feb., 1936.

Appendix II.—Notation

The following symbols are used in this paper:

CAT = cumulative average time per unit constructed according to experience curve, in days;
C_{min} = minimum total cost of job overhead and crews for T_{opt} days, in dollars;
c_c = cost of one crew, in dollars per day;
c_m = cost to mobilize and demobilize one crew, in dollars;
c_{ob} = cost of time-dependant job overhead, in dollars per day;
N = total number of crews;
N_{opt} = optimum value of N associated with C_{min};
n = number of units constructed by one crew;
Q = total quantity, in units of work, constructed by N crews;
s = negative exponent, less than one, that is slope of experience curve;
T = total time to construct Q units, in days;
T_{opt} = optimum value of T associated with C_{min}; and
t = time for one crew to construct first unit, in days.

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ASCE – July, 1980 Volume 50, Number 7

ASCE News
8 ASCE Briefs
86 Sims is President-Elect nominee
88 Implementing highway safety improvements
88 Col Carey, former ASCE executive secretary, dies
89 ASCE Foundation status clarified
90 International conference set for New York City
90 R C Reese dies
92 Members

Professionally Speaking
84 Salary survey highlights latest professional journal
84 Ethics and engineering
85 Weld protests proposed FTC rule

Engineering News
6 Engineering Briefs
10 Court Decisions
12 Earth-sheltered housing conference held
14 Unusual cofferdam protects against catastrophic failure
25 Beauty and function combine in water storage tank in resort area
128 Washington by Virginia Fairweather

Calendar
91 ASCE Meetings
91 Other Meetings
104 Continuing Education

Publications
36 New Books and Reports
123 Proceedings
122 Abstracts

New Products
98 Engineers Information Service Coupon
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IN THIS ISSUE: Birth of synfuel industry. Program ASCE Annual Convention. Energy-saving sewage plants. Critical path scheduling.

41 **Portland Eighty.** Photo essay of ASCE's recent convention in the City of Roses

49 **Birth of synfuels industry,** by Gene Dalaire. By 2000 liquid fuels made from coal and oil shale could provide over 20% of domestic oil production

57 **Municipal wastewater treatment plant pioneers in conservation approach,** by R. F. Bonner, Jr. Plant recovers energy from effluent, air, exhaust and skimmings

60 **Basics in failure analyses of large structures, Part 2,** by Richard Roberts and Alan W. Pense. Analysis includes scanning and electron microscopes, hypothesis testing and fracture examples

63 **Venezuelan dock features unconventional design, quick set up.** Racing against return of highwaters, dock was designed and built simultaneously

** 66 **Critical path scheduling: an overview and a practical alternative,** by Steve S. Pinnell. Long-developed methods for scheduling big projects aren't being used as much as they should be

71 **Portland Convention Story.** Highlights include
Structural failures, triumphs (71)
Management, ASCE news, financing public works (76)
Environmental engineering and pipe (77)
Energy, transportation, geotechnical, surveying, metrication (80)

86 **ASCE Annual Convention and Exposition Program.** Preview of the Hollywood meeting, October 27-31.

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On the cover: Emerging U.S. synthetic fuels industry may transform the U.S.'s abundant supplies of coal and oil shale into liquid and gaseous fuels.

Critical path scheduling: an overview and a practical alternative

Although critical path scheduling (CPM/PERT) was developed in the late 1950s and has been taught in seminars and university courses since then, it is used by few and understood by even fewer. Yet it is an extremely powerful and adaptable—but simple—tool.

STEVEN B. PINNELL, M. ASCE
Principal
Pinnell Engineering
Portland, Oregon

THE REASONS FOR CPM/PERT'S LIMITED USE seem to be a failure to appreciate its simplicity and a misconception that computers and scheduling specialists are necessary for its use. Project managers have either attempted to plan and control their jobs with bar charts or have surrendered their basic role of planning, scheduling and controlling progress to a machine and a technician. Subsequent failure of computerized schedules to reflect the thinking of those doing the work often results in schedules that are not—or cannot—be followed. In addition, many managers are unable to cope with the reams of data that the computer spews forth. The end result is that most projects are still being planned with bar charts—if at all.

290

Alternative

There is a method of CPM/PERT scheduling that is simpler, easier and just as powerful as computerization. It is the time-scale arrow diagram—a method used successfully by this firm for years on all types of projects. It's been taught to hundreds of people who have found it vastly superior to computer printout on most jobs. The following discussion presents a brief overview of CPM/PERT, then explains how and when to use the time-scale arrow diagram method of CPM scheduling.

CPM/PERT

CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique) were both developed in the late 1950s on very large computers for massive projects. PERT, developed for research and development projects, focused on major events (called milestones)—and used probabilities to calculate the most likely time between milestones. CPM, oriented toward construction, focused on those activities required to accomplish a project by using one estimate of activity duration instead of the three used in PERT.

Although there has been a mind-boggling proliferation of CPM and PERT variations, the two techniques have become quite similar. CPM users have adapted the use of the milestone to highlight the beginning or end of a major phase of work. And now PERT users seldom use three estimates of activity duration because one is plenty of work and not many have the time or patience to estimate two more durations when the results are scarcely better.

Today, few civil engineers or contractors use PERT—and those who do should recognize that the techniques are essentially the same. Therefore, the following discussion focuses on CPM.

Basic steps

There are three basic steps in preparing a CPM schedule: 1) planning (or diagramming), 2) estimating of activity durations, and 3) scheduling (or computing).

First, one must plan the job—usually by laying out the activities in sequence on a piece of paper. This is the network diagram; it defines the activities and their relationship. The two types of network diagrams are the arrow diagram and the precedence diagram. Either of these, or some variation, must be prepared even if the schedule is eventually computerized.

Second, one must assign time durations to each activity. This step is almost as difficult as the first step and also must be done manually.

Third, only when the diagram is prepared and durations assigned, can one compute the critical path, early start (ES), late start (LS), early finish (EF), late finish (LF), float, and total project duration. This is the easiest step as it requires only simple mathematics—addition and subtraction. It can be done by computer.

There are four methods of computing the critical path. Two are computerized (i-j node and precedence) and two are non-computerized (manual computation directly on the network and time-scale computation with the network diagram).

i-j node computing

CPM was originally developed using the i-j node method. In this method, each activity is identified to the computer by its beginning (i) node number and its ending (j) node number. These two numbers (i-j) uniquely define each activity and the relationship between them. For example, if activity B follows activity A *(as in Fig. 2)* then the j (ending) node number of activity A is the i (beginning) node number of activity B *(as in Fig. 1)*.

It is nearly impossible to determine accurately the complex relationships between activities of a major project from just a table of activity descriptions and their i-j nodes *(such as Fig. 1)*. Consequently, activities first are laid out on a network diagram that graphically shows the relationship between them. This is called arrow diagramming, as an arrow represents the activity (with no time-scale) and a circle (or node) at each end contains the i node number and j node number. A relationship between two activities that cannot be shown by directly connecting the arrows is indicated by a

i-j numbers	Activity description
1-3	A
3-4	B
4-7	C
3-8	D
8-4	dummy
8-7	E
7-10	F

Fig. 1. i-j node table

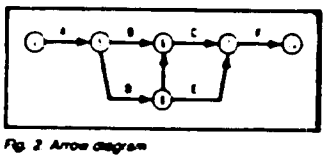

Fig. 2. Arrow diagram

dotted-line arrow, called a dummy arrow (*Fig 2*).

Precedence computing

The precedence method is a new approach to CPM scheduling. It assigns one number to the activity itself and simply lists all preceding activities, making it much easier to update and revise than the i-j node method (*see Figs 3 and 4*)

Precedence diagramming uses a box instead of an arrow to represent an activity. A solid line goes from the back of the preceding activity to the front of the following one to show relationships, making the precedence diagram much easier to draw and revise than the arrow diagram (*see Fig 4*)

Although the precedence diagram appears to be quite different than the arrow diagram, they are really quite similar (*as shown in Figs 5-8*)

Manual computation

One of the first non-computer scheduling methods was developed by Prof John Fondahl of Stanford University in 1963. Non-computer methods are easy to use, requiring only a network diagram and basic skills in addition and subtraction to compute the ES, LS, EF, LF, float, and total project duration

It has been found to often be cheaper and faster to manually calculate the critical path than to input data into a computer, make the run, debug it, and rerun

Incidentally, if one doesn't computerize, there is no need for the nodes (circles) and i-j numbers except to highlight a milestone. This will significantly speed drafting (*the typical activity arrow and notation is shown in Fig 9*)

The ease of manual CPM schedule computation can be illustrated with the example network (*seen in Fig 10*)

Forward pass

The first step is to start activity A at the beginning of work day 1 (*Fig 11*), which is the ES for activity A. If activity A starts the beginning of work day 1 and takes 5 working days, its EF will be 1 + 5 = 6 (the beginning of work day 6, which is the same as the end of work day 5, *see Fig 12*) If the earliest that activity A can finish is (the beginning of) work day 6, then the earliest that activities B and D can start is (the beginning of) day 6 ($ES_B = ES_D = EF_A = 6$), *see Fig 13*

Since activity B can start the 6th day and takes 6 days, the earliest it can finish is the 12th day ($EF_B = ES_B$ + duration = 6 + 6 = 12) Also, activity D can start the 6th day and takes 8 days so it can't finish before the 14th day ($EF_D = ES_D$ + duration = 6 + 8 = 14), *see Fig 14*

To compute the Early Start for activity C, one must consider what activities have to finish before C can begin and what is the earliest that they will finish From Fig 15, it is apparent that activities B and D both must be finished before C can start—and that the earliest that they will be finished is day 14 (ES_C = latest EF of B or D = 14) Therefore the ES for C (and also E) is 14

The computations continue 1) $EF_C = ES_C$ + duration = 14 + 5 = 19, 2) $EF_E = ES_E$ + duration = 14 + 2 = 16, 3) ES_F = latest of EF_C or EF_E = 19, 4) EF_F

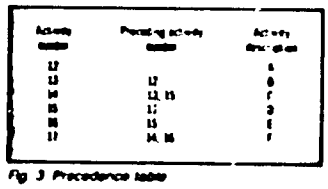

Fig 3 Precedence table

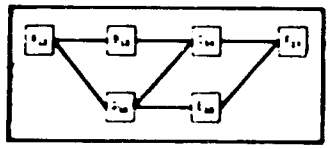

Fig 4 Precedence diagram

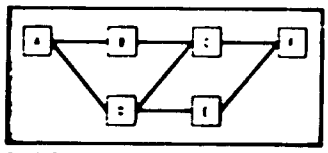

Fig 5 Typical precedence diagram

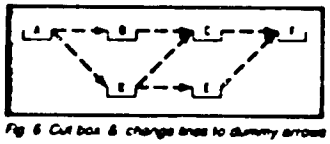

Fig 6 Cut box & change lines to dummy arrows

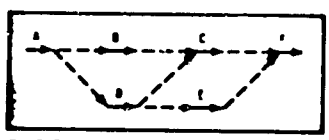

Fig 7 Change bottom of box to arrow

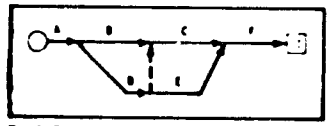

Fig 8 Eliminate dummy arrows where possible

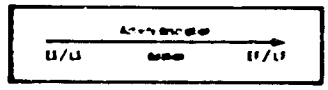

Fig 9 Typical activity arrow & notation

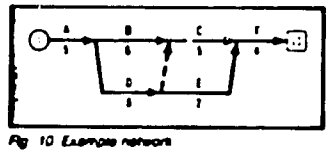

Fig 10 Example network

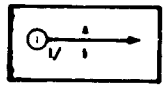

Fig 11

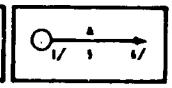

Fig 12

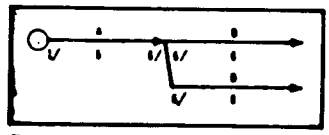

Fig 13

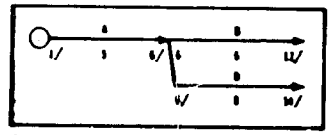

Fig 14

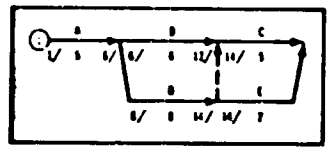

Fig 15

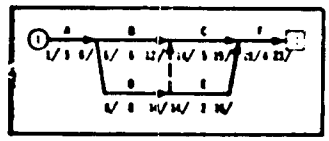

Fig 16

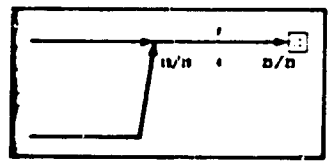

Fig 17

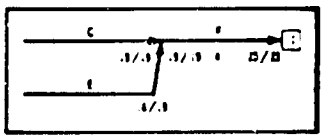

Fig 18

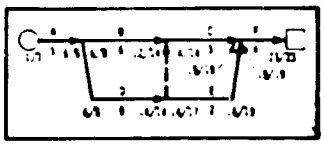

Fig 19

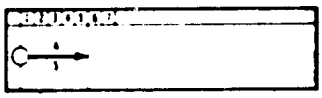

Fig 20

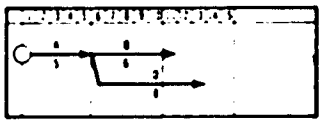

Fig 21

= ES_F + duration = 19 + 4 = 23 (*see Fig 16*)

Backward pass

This completes the "forward pass," which gives the early start, early finish, and total project duration. The next step is the "backward pass," which gives the late start, late finish and float. To begin the backward pass, set the late finish of the last activity equal to the early finish ($LF_F = EF_F = 23$). The earliest the project can finish is (the beginning of) the 23rd day. The latest the project can end is also (the beginning of) the 23rd day. If activity F takes 4 days, then the latest it can start and not delay the project is the 19th day ($LS_F = LF_F$ − duration = 23 − 4 = 19) (*see Fig 17*)

If day 19 is the latest activity F can start and not delay the project, then day 19 is also the latest that activities C and E can finish and not delay activity F (and thus the project). Therefore, the late finish of both activities C and E is day 19 (*see Fig 18*)

From here, it is simple subtraction to determine that: 1) $LS_C = LF_C$ − duration = 19 − 5 = 14, 2) $LS_E = LF_E$ − duration = 19 − 2 = 17, 3) $LF_B = LS_C$ = 14, 4) $LS_B = LF_B$ − duration = 14 − 6 = 8, 5) LF_D = earliest of LS_C & $LS_E = LS_C$ = 14, 6) $LS_D = LF_D$ − duration = 14 − 8 = 6, 7) LF_A = earliest of LS_B & $LS_D = LS_D$ + 6, 8) $LS_A = LF_A$ − duration = 6 − 5 = 1. This completes the "backward pass" and gives the late finish and late start of each activity (*see Fig 19*)

Computation of float

Float is the number of days between either the early start and late start or the early finish and late finish (float = LS − ES = LF − EF). Activities with an early start equal to the late start have *zero* float and are therefore critical. Note that activity A is critical ($LS_A - ES_A$ = 1 − 1 = 0 = $LF_A - EF_A$), as is activity D ($LS_D - ES_D$ = 6 − 6 = 0), activity C ($LS_C - ES_C$ = 14 − 14 = 0), and activity F ($LF_F - EF_F$ = 23 − 23 = 0). However, activity B has 2 days float ($LS_B - ES_B$ = 8 − 6 = 2 = $LF_B - EF_B$ = 14 − 12 = 2), and activity E has 3 days float ($LS_E - ES_E$ = 17 − 14 = 3)

Conversion to calendar date

The final step is to convert the computed work days for ES, LS, EF, & LF to calendar dates. This can be accomplished by providing a simple conversion table on the network diagram or even developing a table with the calendar dates. Conversion to calendar date is tedious, but for only one project it is probably cheaper and faster than to: 1) learn how to use a particular computer program, 2) key punch the date, 3) make the computer run, and 4) debug the data so that it runs correctly.

Time-scale arrow diagrams

Fortunately, there is another non-computer alternative to the time-scale arrow diagram. The initial step is to draw the first activity – to scale. As seen from Fig 20, activity A begins on work day 1 and ends (the beginning of) work day 6.

Next step is to draw the activities directly following activity A (*see Fig 21*). The natural tendency is to draw activity C starting day 12, directly after the finish of activity B. However, activity C is also dependent upon activity D and therefore can't start before day 14. Therefore, activity C has a two-day float arrow from activity B and a vertical relationship (dummy) arrow from activity D (*see Fig 22*)

Activity E starts immediately after activity D is completed, then continues as a float arrow until the end of C. Activity F follows C & E and takes 4 days.

A quick review of this network diagram will reveal that Activity B has 2 days float, activity E has 3 days float, and activity path A, D, C, F have zero float and is therefore critical. In addition, one can quickly determine early start and early finish days (ES_F = 19, EF_E = 16, ES_E = 6, etc.)

Comparison with bar chart

It's interesting to compare the time-scale arrow diagram with the bar chart (*Fig 24*). Both are easy to read and understand. The time-scale arrow diagram takes less space, shows the relationship between activities, and shows float.

It has been found that the time-scale arrow diagram is but slightly more difficult to prepare than the bar chart and can be just as simple. Yet it has many advantages over the bar chart.

But the bar chart is still a good technique for projects without a critical path. For example, a process machine shutdown is often more dependent upon resources than upon a certain sequence of activities. In such cases, either a bar chart or a modified time-scale arrow diagram may be used.

Criticisms

Alleged criticisms of the time-scale arrow diagram are: 1) Too hard to draw, 2) too difficult to update, 3) too long a drawing, and 4) too little information. None of these criticisms have been found to be true.

First of all, one should remember that the vast majority of work in CPM scheduling is in gathering and evaluating information – not drafting the network. Secondly, a network diagram always has to be drawn in order to schedule a project; it also frequently is erased and redrawn before it is satisfactory. Although time-scale diagrams are more work to draft and change than non time-scale diagrams, the extra effort is negligible. Besides, drafting techniques developed by Pinnell Engineering more than compensate for the additional work. In fact, they make time-scaling easier than normal methods of non time-scale networking.

One time-saving technique is to eliminate the i-j nodes (they aren't needed unless the schedule is computerized with the i-j method). The amount of work required to draw the circles is much greater than normally realized. Also, the

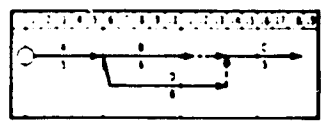

Fig 22

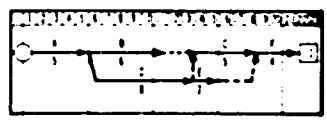

Fig 23

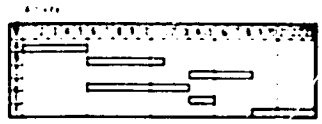

Fig 24

circles clutter up the diagram, making it difficult to read. Instead of circles to mark the beginning and end of activities one need only use arrowheads to give a sense of flow.

Another time-saving technique is to draft the network on fade-out grid paper (a translucent grid paper with light blue lines at 1-in or 25-mm intervals). A blue-line preprint drops out the grid lines, leaving only items drafted onto the network. The grid lines greatly facilitate drafting the network because: 1) horizontal lines are easily drawn; 2) activities are easily and evenly spaced 1-in apart, with subnetworks separated by 2 in (50 mm) for clarity, and overlapped activities inserted at ½-in spacing; 3) lettering is fast because the small grid lines provide an adequate guide; 4) time scaling is simplified: if a scale of 1-in per week is used, then 1 working day = two ½-in grid lines on a 10 x 10 grid, or if a scale of 1-in per month is used, then 1 week equals approximately two ½-in grid lines; and 5) drawing of consistently sloped angle portions of activity arrows is facilitated as one can easily lay out a 1:10 or 1:8 slope.

Difficult to update

One of the most frequent criticisms of the time-scale arrow diagram is that it is too time consuming to update when work falls behind or gets ahead of schedule.

First, there is no more need to redraw a time-scale arrow diagram than there is a non time-scale arrow diagram. An out-of-date time-scale arrow diagram is at least as valid as the non time-scale arrow diagram. Second, the preferred method of showing deviation from plans is not to redraft the network (obscuring the original plan and deviations) but, rather, to show a vertical status line. This starts at the revision date, drops vertically to the first activity, jogs horizontally to the percent complete of that activity arrow, and continues to the bottom of the page (*see Fig. 25 for example of an update line*).

As can be seen in Fig. 25, "Pour concrete" is 4 days behind, "Excavate footings" is on schedule, and "Mechanical & electrical work" is one week ahead. This provides an excellent guide for the project manager as to what needs expediting. Naturally, if the project gets too far ahead or behind schedule—or if there are major logic changes—redrafting is necessary in order to maintain the usefulness of time-scale.

A classic example is the computer-generated, time-scale arrow diagram that starts over the project engineer's desk, runs across the wall, around the corner into the next office, and clear down to the other end of the job trailer.

One need not do this. The smallest necessary scale is usually 1-in per week. This allows one working day to equal ½-in

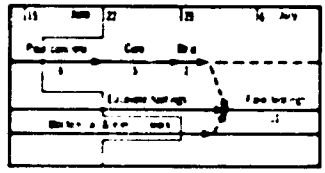

Fig. 25

(10 x 10 grid paper) and is enough to draw a very short arrow with an arrowhead for those infrequent activities that require only one day. If some activities take less than a day, they can be combined with others. If there isn't room to put the description directly over the activity, then it can be put up out of the way with a leader (*see Fig. 26*). Sometimes, of course, 1 in per week doesn't give enough room (as in a paper machine shutdown). In these cases, overall project duration is usually quite small and the scale can be expanded.

At one inch per week, a one-year project becomes rather unwieldly (52-in plus 2-in margins or 1320-mm plus 50-mm), and a two-year project becomes impossible. One solution is to stack one half of the schedule over the other on the same sheet of paper. Using a 30-in (762-mm) wide sheet with ½-in margins top and bottom—plus 2 in between the halves—14- x 14- (355-mm) widths are available for each half. Since some activities will be separated by ½-in and a few by 2-in, there is room for about 20 concurrent activities at the same time (which is adequate for most projects). If a schedule is stacked, plenty of room must be left between halves so that the two are clearly delineated.

Another solution [illegible] match lines and two or more sheets. Although this may be required in some cases, it is obviously not as desirable as viewing the entire schedule in one piece.

Yet another solution is to break the scale, drafting the first part at 1 in per week and the rest either at another scale or not-to-scale. This often works well, as it is best to avoid too much detail too far into the future because: 1) one seldom has sufficient time, and 2) plans will probably change by the time one gets closer to doing the work.

The final solution is to use a different scale. One inch per two weeks works very well and even 1 in per month does well for many projects. This is about as far as one need go, as a 4-ft (1.2-m) drawing can then cover about four years.

Too little information

The time-scale arrow diagram does have some limitations, however. Assume an average vertical spacing of 1 in, an average activity length of 1½ weeks at one in/week, and 25% of the space unused due to the organization of the network. A large drawing (36 in x 60 in or 1524 mm x 914 mm) can have up to 1000 activities and a medium-sized drawing (30 in x 36 in or 762 mm x 914 mm) can have up to 500 activities.

For projects up to $30 million, Pinnell Engineering has seldom exceeded 300 activities on any one network. It is best to have additional detail in subnetwork schedules tied to the master schedule—but prepared and maintained by the organization responsible for that portion of the project. Not only does this reduce the information required, it places the scheduling responsibility where it belongs.

This firm does not, in fact, recommend having over 500 activities on a network (at any one time) as managers cannot—and should not—grapple with such detail. However, as the project progresses, completed activities are dropped off and new activities added so that the total number of activities may be several thousand over the life of the project.

Advantages of time-scale arrow diagram

Rather than being inferior to computer scheduling, time-scale arrow diagramming actually has several distinct advantages, these are: 1) greater flexibility, 2) quicker and clearer communication and visualization, 3) faster and cheaper preparation, and 4) more power.

Good graphics (time-scale arrow diagram) implies relationships between two concurrent activities or shows an approximate relationship between activities that computer printout could never do. Many work activities (e.g., Mechanical embedded in concrete), take only a short time to accomplish, must occur sometime concurrent with another activity (e.g., form for concrete), yet cannot (and need not) be precisely defined as to exactly when they will occur (*see Fig. 27*).

Other activities must be completed at some uncertain time prior to completion of another activity (e.g., rebar footings

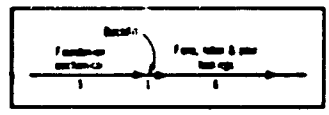

Fig. 26

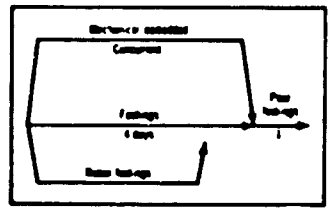

Fig. 27

Applications of CPM-PERT

Contrary to popular belief, CPM is more important before construction than during. True, a good CPM construction schedule can save several weeks construction time and avoid some of the delays that vex a typical project. But the greatest (and least expensive) time savings can be realized only by careful planning and tight control of owner decisions, design, and regulatory reviews. Unfortunately, even those owners who require extensive and often onerous CPM scheduling of their contractors either fail to use it themselves or require their engineers to use it.

The typical designer's bar chart usually shows no more than a gross simplification and often is made to fit the predetermined project time. Result is that it nearly always takes longer than expected to get a project under construction. The bar chart never even attempts to show resource demands, cash-flow requirements, or the true critical path through the complex maze of planning, funding, designing, and obtaining permits.

Example

A good example of preconstruction CPM scheduling is the master schedule for the Rock Creek Advanced Wastewater Treatment Plant in Hillsboro, Ore. (for the Unified Sewerage Agency of Washington County, Ore.)—the first EPA-funded CM project. This schedule compared the traditional method of design and construction with the Construction Management (CM) method. The analysis indicated that—with tight control—construction could be initiated in September of that same year and the project completed nine months early. That, in fact, did happen but required very tight schedule control, especially of funding and the regulatory review process.

A short-interval schedule, updated weekly, was used to control permits, grants, and government approvals (as this was the most critical phase of the project). It is possible to schedule, and to some extent even control, regulatory reviews and agencies. The requirements of such effort are: 1) good personal relations with the people involved, 2) a means of recording and graphically describing the sequence and duration of the review process (no one person ever knows all the steps or why it takes so long), and 3) an effort to get regulatory personnel involved in scheduling the project and committed to meeting the schedule.

Example two: Multnomah County, Ore.

A second example of the application of time-scale arrow diagrams by owners is the new Project Management System for Multnomah County, Ore. For control of over 40 capital improvement projects, Pinnell Engineering: 1) conducted a one-day CPM seminar, 2) assisted the project engineers in preparing simple time-scale arrow diagrams for planning, permits, design and construction of each project, and 3) established a system to monitor and report progress. The system has operated successfully for over a year and is now being extended to cover the cost accounting system and manpower management.

before completing form footings in Fig 27). The computer requires precise relationships and cannot show generalities.

In addition, the time-scale arrow diagram can show assumptions, questions about durations, relationships or activity descriptions, and alternatives that are impossible to show with computer printout. All that is needed is a brief note on the diagram informing readers as to what assumptions have been made, questioning what the relationship should be, or a different type of line (say a dot-dash) to show an alternative path from a decision point or a differing outcome event.

The human eye and brain can grasp the fundamental organization, repetitive patterns, critical path, float, and a sense of the overall criticality and complexity of the entire project and subnetworks from a brief review of a well-prepared time scale arrow diagram. A similar understanding gleaned from computer printout would take hours of dedicated concentration and elude all but the most determined.

Time-scaling takes longer to draft initially, but once the network is drafted, there is no delay or cost to keypunch data, make the computer run, or wait for printout and debug the data. It also costs much less to update. If a status line is used to show current status instead of redrafting, the cost of monthly or weekly revisions can be negligible compared to computer runs.

More powerful

Finally, the time-scale arrow diagram can permit concurrent consideration of resource availability, space limitations, weather effects, and related activities. If the scheduler rough-drafts the schedule in time-scale instead of converting later, all these factors can be considered initially instead of first going through the laborious, expensive and inaccurate process of computer rescheduling, resource leveling, and least-cost expediting. In fact, no existing or contemplated computer system can begin to compete with the sophistication, power, and accuracy of an experienced manager with such a practical tool to aid him in visualizing and analyzing a project.

Summary

In summary, CPM and PERT are seldom used or understood in spite of over 20 years availability. In fact, many are strongly opposed to it, having had reams of computer printout and unreasonably detailed, poorly planned CPM schedules forced upon them.

Computer printout alone is not adequate for scheduling. Computer scheduling without an understanding of the basics is largely responsible for CPM's limited use; it is similar to finding one's way from a list of streets and intersections instead of from a map.

Computer-generated, time-scale network diagrams, at least the ones seen by this firm, are not yet satisfactory due to the poor quality of graphics. They do, however, hold promise for the future.

Precedence scheduling, although recently quite popular, also is not the answer. If a computer is used, precedence computing is far superior to i-j node computing. In addition, precedence diagramming does have some advantages over arrow diagramming, especially when "roughing out" a very complex network (because it is easy to modify relationships). It doesn't, however, lend itself to time-scaling, and always must be eventually converted to time-scale arrow diagram.

The most important step to increase the use of CPM scheduling is for everyone to understand it, and to use more judgment when applying it. Whether one uses i-j node or precedence computer computing; non time-scale or time-scale arrow diagramming, precedence diagramming or other methods isn't as important as properly understanding and using the method selected. The profession must first learn and apply the basics before attempting sophisticated computer technology. O

Steven Pinnell has used CPM-PERT scheduling since 1964 and is currently involved in preparation and implementation of a number of project-management systems based partly on CPM scheduling. He recently developed a scheduling and project management program on microcomputers.

Bibliography

The following bibliography contains two sets of references. The first set consists of a reference for each selected text that appeared in the preceding part of this compendium. The second set consists of references to additional publications that either were cited in the selected texts or are closely associated with material that was presented in the overview and selected texts. Each reference has five parts that are explained and illustrated below.

(a) Reference number. This number gives the position of the reference within this particular bibliography. It is used in the compendium index but should ***not*** be used when ordering publications.

(b) Title: This is either the title of the complete publication or the title of an article or section within a journal, report, or book.

(c) Bibliographic data: This paragraph gives names of personal or organizational authors (if any), the publisher's name and location, the date of publication, and the number of pages represented by the title as given above. In some references, the paragraph ends with an order number for the publication in parentheses.

Bibliografía

La siguiente bibliografía contiene dos series de referencias. La primera serie consiste en una referencia para cada texto seleccionado que apareció en la parte anterior de este compendio. La segunda serie consiste en referencias a publicaciones adicionales que fueron mencionadas en los textos seleccionados o que se asocian íntimamente con el material que se presentó en la vista general y los textos seleccionados. Cada referencia tiene cinco partes que se explican y se ilustran abajo.

(a) Número de referencia: este número indica la posición de la referencia dentro de esta bibliografía en particular. Se utiliza en el índice del compendio pero ***no*** deberá utilizarse al pedir publicaciones.

(b) Título: el título de la publicación completa o el título de un artículo o sección dentro de una revista, informe, o libro.

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(d) Availability information: This paragraph tells how the referenced publication is available to the reader. If the publication is out-of-print but may be consulted at a particular library, the name of the library is given. If the publication can be ordered, the name and address of the organization from which it is available are given. ***The order should include all information given in parts (b) and (c) above.***

(e) Abstract: This paragraph contains an abstract of the publication whose title was given in part (b).

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(a) Numéro de la référence

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(b) Título
(b) Titre

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(c) Datos bibliográficos
(c) Données bibliographiques

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(d) Disponibilidad de la información
(d) Disponibilité des documents

(e) Abstract
(e) Resumen
(e) Analyse

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El pedido deberá incluir toda la información dada en las partes (b) y (c).
L'ordre de commande doit inclure toutes les informations données dans les parties (b) et (c).

Reference 5
A REVIEW OF HIGHWAY DESIGN PRACTICES IN DEVELOPING COUNTRIES

Cron, Frederick W. Washington, DC: International Bank for Reconstruction and Development; 1975 May. 57 p.

Order from: International Bank for Reconstruction and Development, 1818 H Street, N.W., Washington, DC 20433.

The design standards of some 150 highway projects financed by the International Bank for Reconstruction and Development between 1960 and 1970 are reviewed, and areas of agreement between the standards of the 63 countries studied are identified; practical highway standards based on these areas of agreement are sketched for the guidance of planners in developing countries. The roads discussed here, fall into three functional categories: a small group of expressways, freeways and toll roads carrying large volumes of traffic; a very large group of 2-lane highways carrying a wide range of traffic volumes serving both local and long distance traffic; and a smaller group of low-traffic tertiary or special purpose roads existing primarily for land service. Comments are made on the problem of classifying highway standards, and on the comparison of standards. Conclusions regarding standards for the capacity- related elements of design and standards for the velocity-related elements of design (radius of curvature, stopping sight distance, passing sight distance) are discussed, as well as the horizontal and vertical clearances for bridges. The standard live loadings for bridges, the structural capacity of pavements and legal load limits are covered, and conclusions relating to pavement design, design standards for 2-lane highways, incremental development of highways, and levels of service are presented.

SELECTED TEXT REFERENCES

Reference 1
CONSTRUCTION BY CONTRACT AND BY DAY LABOR

Conner, Carlton N. Highway Research Board, Proceedings of the Twenty-Third Annual Meeting Held at Edgewater Beach Hotel, Chicago, Illinois; November 27–30, 1943. Washington, DC: Highway Research Board; 1943; pp. 3–10.

Order from: University Microfilms International, 300 North Zeeb Road, Ann Arbor, Michigan 48106.

The relative advantages and disadvantages of public works construction by means of day labor or contract are discussed and data from two surveys are presented. Under the day labor method a public agency performs the work with employees hired for the purpose. There are five forms of the contract method: cost plus percentage, cost plus fixed fee, negotiated lump sum, competitive lump sum, and competitive unit price. Most public road and street construction is done by the unit price contract method. Prequalification of contractors and the facilities of the Bureau of Contract Information are discussed as factors in successful public work contracting. Under authorization by the U.S. Congress and with the cooperation of the Bureau of Public Roads (now Federal Highway Administration), 46 states and one territory built 53 highway projects by day labor after first taking competitive bids in order to get a basis for comparison of the two methods. The total cost of the 53 projects by day labor was 18 percent in excess of the bid prices. On 40 of the jobs the day labor cost exceeded the bid prices by 31 percent, and on 13 the cost was less than the bid prices by 10 percent. In a questionnaire survey of county practices conducted in 1941, 62 percent of 595 counties replying reported in favor of day labor and 38 percent in favor of the contract method. Generally, contract work was favored for heavy excavation, large bridges, and high type paving, types of work that are relatively infrequent in county operations. Advantages of day labor appeared to be most apparent on small operations. It is concluded that, except under the most favorable conditions, contract work is superior in economy and efficiency to day labor.

Reference 2
A COST COMPARISON STUDY OF FORCE ACCOUNT AND CONTRACT CONSTRUCTION ON FIVE SECONDARY PROJECTS IN NORTH CAROLINA

Farrel, F.B.; Kilpatrick, M.J. Highway Research Board, Proceedings of the Thirty-Fifth Annual Meeting, Washington, DC, January 17–20, 1956. Washington, DC: Highway Research Board; 1956; pp. 102–109.

Order from: University Microfilms International, 300 North Zeeb Road, Ann Arbor, Michigan 48106.

This report presents the results of comprehensive job cost studies made on three contract and two force account secondary road projects in North Carolina during 1952 and 1953. A complete study of the relative merits of contract and force account methods would require a much wider coverage of the kinds and conditions of highway work. Also, it would be necessary to analyze social and economic benefits of the two methods, to weigh carefully the inherent managerial and operational advantages of each method, and to review policy considerations. These broader phases of the problem are not part of this report. It is essential that this fact be recognized in appraising the findings presented herein.

Reference 3
MANUAL ON ROUTE LOCATION, DESIGN, CONSTRUCTION AND MAINTENANCE OF RURAL ROADS (OTHER DISTRICT ROADS AND VILLAGES)

Indian Roads Congress. New Delhi, India: June 1979; 112 p. (Indian Roads Congress Special Publications 20).

Order from: Indian Roads Congress, Jamnagar House, Shahjahan Road, New Delhi 110011.

These guidelines on rural road development and maintenance cover route location, soil and material surveys, geometric design, road drainage, structures, project preparation, properties and specifications of construction materials, plant and equipment, construction procedures, quality control, and maintenance. Route selection should take into consideration the population to be served, existing roads, topography, subgrade conditions, environmental factors, and the availability of materials. Effort should be made, at the preinvestigation stage of road projects, to identify soil types and assess their strength. Geometric design standards relating to roadway width, cross-drainage structures, carriageway width, camber, side slopes, cross sections, horizontal and vertical alignment, sight distance, vertical curves and hair pin bends are discussed. Materials and techniques used for rural road construction are discussed. Recommendations are made about the design of flexible pavements particularly with regard to pavement thickness and composition. Side drains, catchwater drains, cross-drainage structures, retaining walls and breast walls are covered. Project data collected during the investigations should be presented in three parts: report, estimate, and drawings. Tools, plant, and equipment required for construction will depend on the type of specifications and degree of mechanization. Construction procedures, quality control, and maintenance are discussed with regard to embankments, granular sub-base, mechanical stabilization, lime-soil stabilization, soil-cement stabilization, soil-bitumen stabilization, brick soling, water bound macadam, and bituminous work. Appendixes present additional information on route selection and location, laboratory investigations for stabilized soil specifications, and a soil map of India.

Reference 4
STANDARD SPECIFICATIONS FOR CONSTRUCTION OF ROADS AND BRIDGES ON FEDERAL HIGHWAY PROJECTS

United States Department of Transportation, Federal Highway Administration, Bureau of Public Roads. Washington, DC: 1969; 451 p. (FP–69).

Not available.

This book, which is patterned after the AASHO (American Association of State Highway Officials) Guide Specifications for Highway Construction, contains specifications for materials and construction methods used in road and bridge construction on

federal highway projects. The first section of the book considers general provisions and covers bidding requirements and conditions, award and execution of contract, scope and control of work, control of material, legal aspects and responsibility to public, prosecution and progress, measurement, and payment. Construction details are covered in six sections: earthwork, bases, bituminous pavements, rigid pavements, incidental construction, and materials. See Reference 16 (FP-79) for the updated edition of these specifications.

Reference 5
COMPETITIVE BIDDING AND AWARD OF HIGHWAY CONSTRUCTION CONTRACTS

Netherton, Ross D. Selected Studies in Highway Law Volume 3 (Editor John C. Vance), Washington, DC: Transportation Research Board, National Cooperative Highway Research Program; 1978; pp. 1125–1214.

Order from: Transportation Research Board, Publications Office, 2101 Constitution Avenue, N.W., Washington, DC 20418.

The basis, purpose, and essential principles of competitive bidding are reviewed, and competitive bidding requirements for federal and federally aided highway construction contracts are examined. The scope of state competitive bidding laws, the advertisement for bids and the preparation of bids, as well as the submission of bids and award of contract, and the effect of bid mistakes in contract awards are also covered. It is noted that there are difficulties in giving full effect to the principle that public construction contracts must be awarded to the lowest responsible bidder as determined by open competition. The body of statutory and administrative law that prescribes the competitive bidding procedures has become extensive and complex because of provisions that reflect the responsibilities of state and federal highway agencies and their funding commitments. Yet the record of the past 20 years documents the success of its implementation by the government and the construction industry. The question is considered whether the existing system has served the public regarding the long-range interest in developing a broad, vigorous and financially sound construction industry. It is noted that there has been little study of the economic impact of the competitive bidding system on the construction industry or the public investment in highways. Some analysts believe that many of the traditional assumptions about highway construction contracts are not warranted if the contracting process is examined closely.

Reference 6
STANDARD SPECIFICATION FOR ROAD AND BRIDGE WORKS (METRIC EDITION)

Malawi Government, Ministry of Works and Supplies, Design Department. Lilongwe, Malawi: April 1978; 89 p.

Order from: The Government Printer, Printing and Stationary Department, Box 37, Zomba, Malawi.

This specification, which was written for the specific conditions found in Malawi consists of 16 parts. The section on general provisions covers factors (35 in all) such as land availability, housing and workshop areas, accommodation and transport of engineer, traffic safety and control, water supply, quarries and borrow pits, weather conditions, amenity and access, units of measurement, and clearing of site on completion. The section on site clearance covers 32 areas such as topsoil, excavations, blastings, backfilling, benching, slips, compaction, testing, soiling and grassing. Drains, pipelines, culverts, cleaning and maintaining drains, and lined drainage channels are among 21 items covered in the section on drainage. Subgrades, sub-bases and bases are considered in detail (prevention of damage to partially completed structures, tolerances, selection of materials, laying and compaction, stabilizing, etc.). Materials for surface dressing, bitumen heaters and distributors, and application of dressing are among the topics considered in the section on surfacing. Various clauses are considered in detail in sections on piling for structures, formwork and surface finish for structures, steel reinforcement for structures, concrete for structures, prestressing for structures, structural steelwork, protection of steelwork against atmospheric corrosion, miscellaneous structures for roadworks, materials, and testing of materials and workmanship. Information on British Standards and other references are included in appendixes.

Reference 7
FIELD SUPERVISOR'S DUTIES AND RESPONSIBILITIES; VOLUME I; CONTRACT ROADWORKS

National Association of Australian State Road Authorities. Sydney, Australia: 1975; 24 p. (Volume I Contract Roadworks)

Order from: National Association of Australian State Road Authorities, Secretariat, P.O. Box 3141, Brickfield Hill, New South Wales, 2000, Australia.

This guide for supervisors responsible for the supervision of roadworks carried out by contract, considers such aspects as authority, hours of duty, relations with the contractor, public relations, documents and records, preliminary works, order of work, materials emergencies, contract payments, and cleaning up. Sampling and testing aspects are covered and include soils and pavement materials, tars and bituminous materials, precast concrete drainage structures, concrete constituents, concrete mix, reinforcing steel, paint, and despatch of samples. Aggregate tests and concrete tests are also considered. Aspects of road construction that should be inspected by supervisors are noted. Additional information on equipment and safety measures is presented in appendixes. See Reference 18 for Volume II of this series of guides.

Reference 8
RECOMMENDED STANDARDS FOR THE RESPONSIBILITY, AUTHORITY, AND BEHAVIOR OF THE INSPECTOR

American Society of Civil Engineers, Committee on Inspection of the Construction Division. Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Volume 101, No. CO2, June 1975; pp. 359–364. (Golden Jubilee Issue No. II, Proceedings Paper 11384)

Order from: American Society of Civil Engineers, Publications Office, 345 East 47th Street, New York, New York 10017.

The paper presents standards that are applicable to

construction projects in which the owner is represented on the site by an inspection team headed by a resident engineer and including a supervisory chief inspector. Many of the standards can also be applied to projects having only one or two inspectors. The inspection team should be staffed with knowledgeable, qualified people with appropriate education, training, and personality. The inspector should assume responsibility for familiarity with plans, specifications, and construction schedule; should notify contractor of work that does not conform to requirements; should avoid activity that is the responsibility of the contractor; and should record daily activity relating to contractor's work and instructions to contractor. On-site testing should be performed expeditiously and carefully. The inspector should have the authority when the situation demands it. Recommendations are made regarding the inspector's behavior and working relations. These recommendations relate to his relations with other inspectors, with supervisors, and with the contractors.

Reference 9
THE RURAL ACCESS ROADS PROGRAMME; APPROPRIATE TECHNOLOGY IN KENYA

de Veen, J.J. Geneva, Switzerland: International Labour Office; 1980; 167 p. (A WEP Study).

Order from: International Labour Office, Publications (Sales) Service, CH-1211 Geneva 22, Switzerland.

The text provides information on an alternative way of road construction to planners and chief executives in developing countries who are interested in applying employment-generating indigeneous technologies, provided these can be implemented efficiently and effectively without adverse effect on the cost and quality of the product. The Rural Access Road Programme (RARP) was initiated in Kenya to provide all-year farm-to-market access throughout the country. The text consists of 11 parts. Section 1 describes the inception and implementation of the program and the scope of the technical and financial assistance given to RARP. Section 2 describes the organizational structure and section 3, the work of the technology unit. Section 4 describes the selection and technical aspects of the construction of the access roads. The planning, organization and management of a large-scale labor-intensive project, both at headquarters and at site level are described and evaluated in sections 5 and 6. Recruitment procedures and motivation of the workers including the payment systems are discussed in section 7. Section 8 describes site arrangements and construction activities. Section 9 describes the training of personnel, the recruitment of supervisory personnel, and the curriculum contents. Section 10 describes the organization of road maintenance. Section 11 discusses the relevance of the RARP to other developing countries. Appendixes provide further information on the structure of the RARP, design standards, average task rates, expenditure control procedures, procurement, planning, programming and reporting at site and unit level, gravelling, and time and location chart.

Reference 10
OPTIMUM WORKING TIME

Gates, Marvin; Scarpa, Amerigo. Transportation Engineering Journal of ASCE; Proceedings of the American Society of Civil Engineers; Volume 103, No. TE6, November 1977; pp. 773–781. (Proceedings Paper 13355)

Order from: American Society of Civil Engineers, Publications Office, 345 East 47th Street, New York, New York 10017.

The familiar problem relating to the trade-off between direct and indirect cost relative to project duration is solved in closed form. Elementary cost-minimizing methods give simple algebraic expressions that optimize constraints. The following rule evolves: The optimum working time for a particular operation is when the total cost for variable overheads (time dependent) equals the total cost to mobilize and demobilize all of the crews. This least-cost solution is not altered by working overtime as a means of reducing equipment requirements. The theoretical solution is illustrated with a solved problem by employing the derived formulas as well as by iteration for comparison and sensitivity. The solution to the problem of optimum working time also gives the solution to the problem of the optimum number of crews that should be employed. See Reference 11 for a discussion of the problem of optimum number of crews by the same authors.

Reference 11
OPTIMUM NUMBER OF CREWS

Gates, Marvin; Scarpa, Amerigo: Journal of the Construction Division, Proceedings of the American Society of Civil Engineers; Volume 104, No. CO2, June 1978; pp. 123–132.

Order from: American Society of Civil Engineers, Publications Office, 345 East 47th Street, New York, N.Y. 10017.

Experience curve theory is used to determine the time and manpower requirements to construct labor intensive projects. In essence, according to this theory, one man working 100 hours is more productive than 100 men working 1 hour or any other analogously paired data. This leads to the conclusion that an extended construction timetable may be economical. However, as the duration of a project increases, so does the cost of job overheads that are time-dependent. This leads to the conclusion that a contracted timetable is preferred. These two contending circumstances are formulated, related mathematically, and then solved to find the optimum manpower and the optimum construction time that minimizes costs. Several graphs are included that mechanize the solution. An illustrative example ties theory to practice. This paper is a continuation of another by the same authors. (See Reference 10.)

Reference 12
CRITICAL PATH SCHEDULING: AN OVERVIEW AND A PRACTICAL ALTERNATIVE

Pinnel, Steven S. Civil Engineering, Volume 50, Number 7. New York, American Society of Civil Engineers, July 1980; pp. 66–70.

Order from: American Society of Civil Engineers, Publications Office, 345 East 47th Street, New York, N.Y. 10017.

A simple procedure for scheduling construction projects by using the time-scale arrow diagram of Critical Path Method (CPM) scheduling is described. The three basic steps in preparing the CPM schedule (planning or diagramming, estimation of activity

durations, and scheduling or computing) are explained. Four methods of computing the critical path are described. Two are computerized (i–j node and precedence) and two are non-computerized (manual computation directly on the network and time-scale computation with the network diagram). A method for updating the time-scale arrow diagrams is also described. Time-scale arrow diagramming has several advantages over computer scheduling. These are greater flexibility, quicker and cheaper communication and visualization, faster and cheaper preparation, and more power. It can show assumptions (e.g., about durations and relationships) and permits concurrent considerations of resource availability, space limitations, and so forth.

ADDITIONAL REFERENCES

Reference 13
PROCEEDINGS—SIXTH CONFERENCE; PART 6; LOCAL GOVERNMENT SYMPOSIA

Australia Road Research Board. Canberra, Australia: 1972; 141 p.

Order from: Australian Road Research Board, 500 Burwood Road, Vermont South, Victoria 3133, Australia.

This volume includes the papers presented at four sessions. The paper—An Assessment of Works for Local Authorities by Contract and Day Labor—discusses plans, specifications, design and supervision, volume of work, tenders, type of contract, and day labor. The paper concludes that maintaining a day labor organization to carry out the ordinary continuous construction work of a local authority is justified. Contracts should be made for extra work and varying work in excess of the day labor organization, for work that can be defined in detailed plans and specifications, and for work (e.g., buildings) where the day labor is not skilled and/or where the work is not regular. Other papers presented at this session discussed areas for consideration when contemplating contract works, specific types of contract and relative advantages, an assessment of contract versus day labor with reference to the city of Perth, Australia, and the merits of contracts and day labor. The session's last paper presented a contractor's viewpoint. The session on urban road design included a paper on residential street design with special emphasis on the reduction of accidents, and the session on subdivisional planning and design included a paper on subdivisional layout and planning procedures.

Reference 14
COST RECORDS AND BUDGETING

National Association of Counties, Research Foundation, Washington, DC: July 1972; 70 p. (National Association of Counties Action Guide Series, Volume II; A Revision).

Order from: National Association of Counties, 1735 New York Avenue, N.W., Washington, DC 20006.

Accepted procedures are presented that can aid a county engineer in updating cost records and budgeting procedures. Three systems (manual, machine, and electronic data processing) of accounting procedure are discussed, and details are given of cash and accrual accounting. The criteria for selecting the system are also discussed. Steps that should be considered in establishing cost records for the road department are summarized. The use of numerical codes, functional or activity accounts, object accounts, equipment, labor, material, field, departmental and historical records are considered, and the use of cost data (basic and comprehensive reports and report review) is discussed. The various aspects of the budget covered here include cost records, the functions of the auditor or accountant, budget funds, types of county budgets, budget committee, budget estimate, preparation of the budget, public hearings, and budget control. Notes on definitions and expenditure classifications (functional and object accounts) are appended.

Reference 15
HIGHWAY ACCOUNTING MANUAL

Jorgensen (Roy) Associates, Incorporated. Gaithersburg, Maryland: November 1975; 162 p. (Prepared for United States Agency for International Development; Project Number-Accounting Manual AID/OTr C-1420). (Available on Microfiche.)

Order from: United States Agency for International Development, AID Resources Center, Office of Development Information Utilization, Bureau for Development Support, Washington, DC 20523.

This manual, which is intended for highway agency personnel responsible for the development and implementation of accounting systems, outlines a general framework for accounting systems, indicates the purpose and interrelationship of the numerous accounting processes, and provides examples of record formats, input data and reports. General ledger and program account structures are considered in the chapter on account structure, which also examines object-of-expenditure coding, full program coding, organizational coding, general and program ledger subsidiary accounts. The chapter on budget process covers the general budget process, preliminary forecasts, program guidelines, detailed estimates, specialized budgeting documents and performance budgeting. The other chapters cover subsystems relating to appropriation, allotment and apportionment, encumbrance processes, receipts and disbursements, transaction recording processes, branch accounting, fiduciary statements, management statements, year-end closing processes, internal audit, and computerization.

Reference 16
STANDARD SPECIFICATIONS FOR CONSTRUCTION OF ROADS AND BRIDGES ON FEDERAL HIGHWAY PROJECTS (FP-79)

United States Department of Transportation, Federal Highway Administration. Washington, DC: 1979; 355 p. (Stock No. 050-001-00145-4).

Order from: United States Government Printing Office, Superintendent of Documents, Washington, DC 20402.

This book is patterned after the AASHTO Guide Specifications for Highway Construction and contains specifications for items of work, materials, and construction methods. The contents are presented in eight sections. The first section covers bidding requirements, contract award and execution, scope and control or work and material, legal aspects, measurement, and payment. Construction details are covered in the remaining seven sections. These

sections cover earthwork, base courses, bituminous pavements, rigid pavements, bridge construction, incidental construction, and materials. (See Reference 4).

Reference 17
HIGHWAY AND BRIDGE CONSTRUCTION MANUAL

Jorgensen (Roy) Associates, Incorporated. Gaithersburg, Maryland: No date; 191 p. (Prepared for United States Agency for International Development; Project Number—Highway Manual AID/OTr C-1420). (Available on microfiche).

Order from: United States Agency for International Development, AID Resources Center, Office of Development Information Utilization, Bureau for Development Support, Washington, DC 20523.

This manual for highway agency personnel responsible for supervision and inspection of contract projects for highway and bridge construction, provides basic orientation and understanding of contract construction practices and responsibilities, documents policies and procedures regarding standardized inspection procedures and reports, defines criteria to guide judgements and decisions by construction personnel, describes the most effective techniques and procedures, and presents reporting systems, tables, and other information valuable to the construction project engineer and inspector. The manual has five chapters. The first chapter—Organization and Responsibilities—defines and discusses three levels of responsibilities: headquarters construction division, district engineers, and field organization. Five categories of public relations are also discussed. The second chapter—General Provisions—provides basic orientation related to specifications, highway plans, bridge plans, construction staking, and highway terms and definitions. The third chapter—Roadway Construction—describes procedures for construction of major roadway items and identifies responsibilities for supervision and inspection. The roadway items covered are earthwork, roadway excavation, embankments, balancing earthwork quantities, culverts, and pavements. The fourth chapter—Bridge Construction—covers functional responsibilities of the resident engineer and inspectors related to bridge construction items and includes reinforcing steel, welding, pile driving, and concrete. The fifth chapter describes the reporting system used to document work performed and to provide specific information to assist inspection personnel in completing necessary reports and maintaining required records. The Manual also includes tables and conversion charts.

Reference 18
DUTIES AND RESPONSIBILITIES OF SUPERINTENDING OFFICERS

National Association of State Road Authorities. Sydney, Australia: 1969; 83 p. (Volume II Contract Bridgeworks).

Order from: National Association of Australian State Road Authorities, Secretariat, P.O. Box 3141, Brickfield Hill, New South Wales, 2000, Australia.

This publication is designed to assist officers responsible for the supervision of bridgeworks carried out by contract. The book has six sections. The first section covers such general aspects as authority, hours of duty, relations with contractor, right of entry and resumption, progress reports, materials, sampling and testing, etc. The second section covers foundations including spread footings, bored piles or cylinders, driven piles, and the placing of concrete in foundations. The third section—on concrete—covers falsework and formwork, steel reinforcement, concrete manufacture, placing, finishing and curing concrete, concrete batch records, and handling of precast members. The fourth section—prestressed concrete—covers a number of aspects such as tensioning, tendon failure, forms, prestressing, reinforcing, and bearing. Section five covers various aspects of structure steelwork, and section 6 covers bearings. A metric addendum is included. See Reference 7 for Volume I of this series of guides.

Reference 19
CONSTRUCTION CONTRACT STAFFING

Transportation Research Board. Washington, DC: 1978; 62 p. (NCHRP Synthesis of Highway Practice 51)

Order from: Transportation Research Board, Publications Office, 2101 Constitution Avenue, N.W., Washington, DC 20418.

Transportation agencies need to know whether their construction engineering and contract administration are being performed in the most effective and efficient manner. This report compiles and evaluates current methods for determining staffing levels, resource allocations, and skill requirements for construction engineering and contract administration. Current practices with regard to manpower management systems are discussed in detail. Also discussed are state practices on personnel classification, training, temporary employees, and other management considerations.

Index

The following index is an alphabetical list of subject terms, names of people, and names of organizations that appear in one or another of the previous parts of this compendium, i.e., in the overview, selected texts, or bibliography. The subject terms listed are those that are most basic to the understanding of the topic of the compendium.

Subject terms that are not proper nouns are shown in lower case. Personal names that are listed generally represent the authors of selected texts and other references given in the bibliography, but they also represent people who are otherwise identified with the compendium subjects. Personal names are listed as surname followed by initials. Organizations listed are those that have produced information on the topic of the compendium and that continue to be a source of information on the topic. For this reason, postal addresses are given for each organization listed.

Numbers that follow a subject term, personal name, or organization name are the page numbers of this compendium on which the term

Indice

El siguiente índice es una lista alfabética del vocablo del tema, nombres de personas, y nombres de organizaciones que aparecen en una u otra de las partes previas de este compendio, es decir, en la vista general, textos seleccionados, o bibliografía. Los vocablos del tema que aparecen en el índice son aquellos que son necesarios para el entendimiento de la materia del compendio.

Los vocablos del tema que no son nombres propios aparecen en letras minúsculas. Los nombres personales que aparecen representan los autores de los textos seleccionados y otras referencias dadas en la bibliografía, pero también pueden representar a personas que de otra manera están conectadas a los temas del compendio. Los nombres personales aparecen con el apellido seguido por las iniciales. Las organizaciones nombradas son las que han producido información sobre la materia del compendio y que siguen siendo fuentes de información sobre la materia. Por esta razón se dan las direcciones postales de cada organización que aparece en el índice.

Los números que siguen a un vocablo del tema, nombre personal, o nombre de organización son los números de página del compendio donde el vocablo o nombre aparecen. Los números romanos se refieren a las páginas en la vista general, los números arábigos se refieren a páginas en los textos seleccionados, y los números de referencia (por ejemplo, Ref. 5) indican referencias en la bibliografía.

Algunos vocablos del tema y nombres de organizaciones están seguidos por la palabra ***see***. En tales casos los números de página del com-

Index

Cet index se compose d'une liste alphabétique de mots-clés, noms d'auteurs, et noms d'organisations qui paraissent dans une section ou une autre de ce recueil, c'est à dire dans l'exposé, les textes choisis, ou la bibliographie. Les mots-clés sont ceux qui sont le plus élémentaires à la compréhension de ce recueil.

Les mots-clés qui ne sont pas des noms propres sont imprimés en minuscules. Les noms propres cités sont les noms des auteurs des textes choisis ou de textes de référence cités dans la bibliographie, ou alors les noms d'experts en la matière de ce recueil. Le nom de famille est suivi des initiales des prénoms. Les organisations citées sont celles qui ont fait des recherches sur le sujet de ce recueil et qui continueront à être une source de documentation. Les adresses de toutes ces organisations sont incluses.

Le numéro qui suit chaque mot-clé, nom d'auteur, ou nom d'organisation est le numéro de la page où ce nom ou mot-clé parait. Les numéros

or name appears. Roman numerals refer to pages in the overview, Arabic numerals refer to pages in the selected texts, and reference numbers (e.g., Ref. 5) refer to references in the bibliography.

Some subject terms and organization names are followed by the word ***see***. In such cases, the compendium page numbers should be sought under the alternative term or name that follows the word ***see***. Some subject terms and organization names are followed by the words ***see also***. In such cases, relevant references should be sought among the page numbers listed under the terms that follow the words ***see also***.

The foregoing explanation is illustrated below.

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pendio se encontrarán bajo el término o nombre alternativo que sigue a la palabra ***see***. Algunos vocablos del tema y nombres de organizaciones están seguidos por las palabras ***see also***. En tales casos las referencias pertinentes se encontrarán entre los números de página indicados bajo los términos que siguen a las palabras ***see also***.

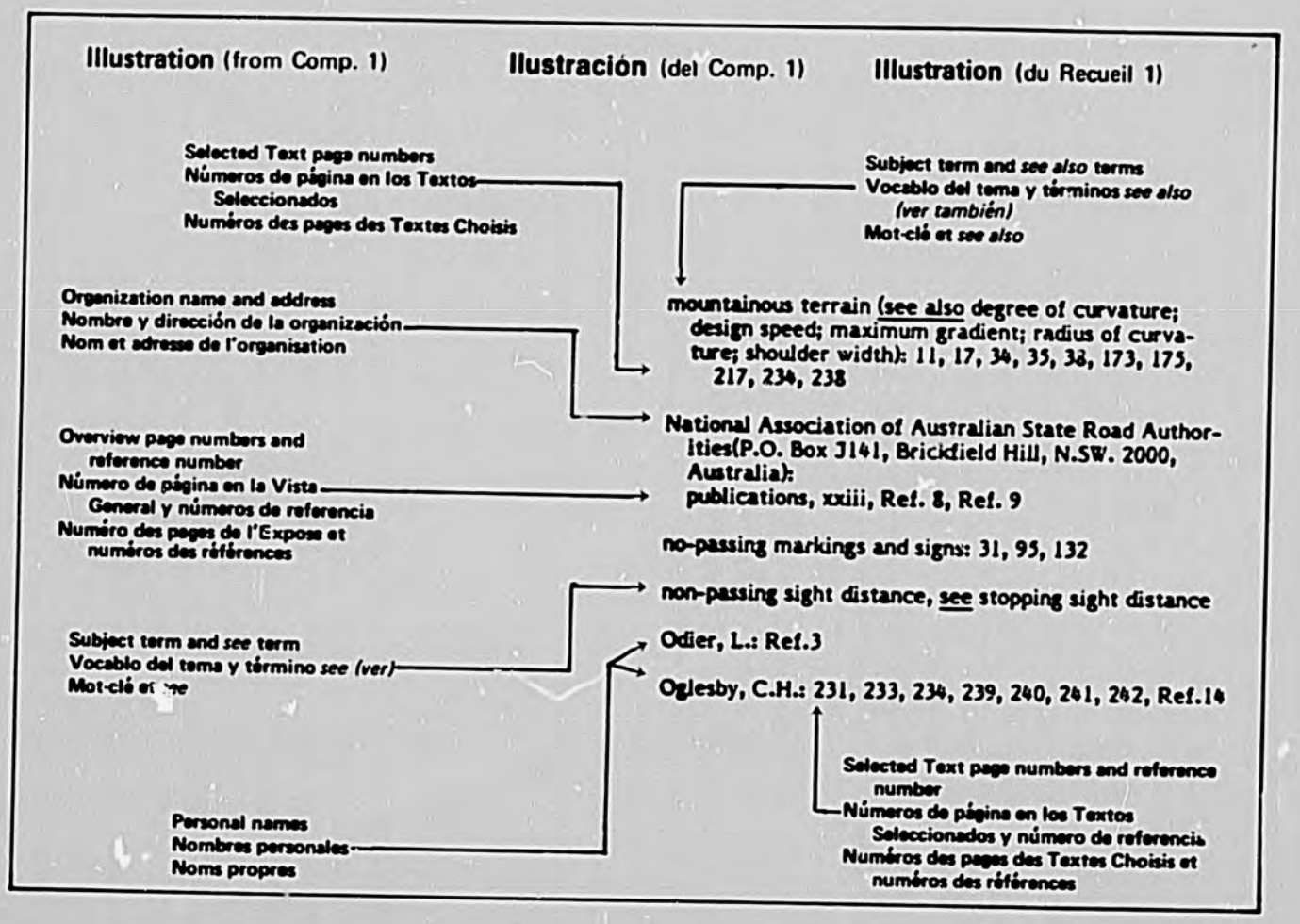
La explicación anterior está subsiguientemente ilustrada.

écrits en chiffres romains se rapportent aux pages de l'exposé et les numéros écrits en chiffres arabes se rapportent aux pages des textes choisis. Les numéros de référence (par exemple, Ref. 5) indiquent les numéros des références de la bibliographie.

Certains mots-clés et noms d'organisations sont suivis du terme ***see***. Dans ces cas, le numéro des pages du recueil se trouvera après le mot-clé ou le nom d'organisation qui suit le terme ***see***. D'autres mots-clés ou noms d'organisations sont suivis des mots ***see also***. Dans ce cas, leurs références se trouveront citées après les mots-clés qui suivent la notation ***see also***.

Ces explications sont illustrées ci-dessous.

Illustration (from Comp. 1) **Ilustración** (del Comp. 1) **Illustration** (du Recueil 1)



access roads, see rural access roads programme

accounting: Ref. 15

advertisement of bids: xxvi, 89, 93, 102, 103–117, 121, 130, 143, Ref. 5

American Society of Civil Engineers (345 East 47th Street, New York, New York 10017): xxviii, xxx, xxxi, Ref. 8, Ref. 10, Ref. 11, Ref. 12

anthills: 174

Australian Road Research Board (500 Burwood Road, Vermont South, Victoria 3133, Australia: Ref. 13

backfilling: 169, 204

base course construction: 20, 21, 22, 23, 24, Ref. 16
  materials, 25

bids (see also advertisement of bids; competitive bidding): xxv, 8, 9, 11, 12, 20–21, 41, 42, 43–47, 88–89, Ref. 4, Ref. 16

bituminous materials: 56, 57–59, 186, Ref. 7
  pavements, Ref. 16

borrow pits: 164, 173, Ref. 6

breast walls: 32, Ref. 3

bridge construction: xxvi–xxvii, 6, 12, 40–76, 61, 114, 131, 138, 169–174, 179, Ref. 1, Ref. 4, Ref. 6, Ref. 16, Ref. 18
  design, 265

British Standards: 160

claims (see also damages): 72–73
  disputes, 54–55

clearing: xxvi, 7, 12, 20–21, 22, 23, 24, 167, 174, 180, 231, 236, 250
  of site on completion, 166, Ref. 6

collusion (see also collusive contracts): 144–145

collusive contracts (see also collusion): 84–89, 125

combined bidding, see joint bidding

compaction: 172–173, 186, 193, Ref. 6

competitive bidding (see also bids): xvii, xxiv–xxvi, 8, 11, 83–152, Ref. 1, Ref. 5

competitive lump sum (see also lump sum): xi, xvii, 6, 7–8, Ref. 1

composite costs: 21–26

concretes and concrete structures: 187–189, 190–191
  tests, 191

Conner, Carlton N.: Ref. 1

construction activities (see also schedules; specifications; standard specifications): xv–xvi, xxvi–xxvii, xxxi–xxxii, 214, 265, Ref. 3, Ref. 4, Ref. 9, Ref. 16, Ref. 17
  documentation, 29–36
  time, 266, 267–268, 270, 278, 279–284, 286, 290, Ref. 9, Ref. 11

construction materials, see materials, construction

contract award: xxiv–xxvi, 47, 83–152, Ref. 5, Ref. 16
  criteria, 96, 97

contract system (see also competitive bidding; competitive lump sum; contract award; cost plus fixed-fee; cost plus percentage; joint ventures; negotiated lump sum; unit price contract): xi–xx, xxiii, xxvii, 6–13, 19–26, 40–76, 177–196, Ref. 1, Ref. 2, Ref. 5, Ref. 7, Ref. 13, Ref. 17, Ref. 18, Ref. 19

contractors (see also bids; competitive bidding; contract award; contract system): xi, 6, 7, 44, 49, 50, 51–52, 54, 56, 60, 62–63, 64–65, 66, 67, 73–75, 125, 177–178, 205, Ref. 7, Ref. 8, Ref. 13, Ref. 18
  prequalification, 8–9, 12, 118, 119, 125, Ref. 1

control of work: 50–55

Cooperation Act of 1968: 91

cost plus fixed-fee: xi, 6, 7, 8, Ref. 1

cost plus percentage: xi, 6, 7, Ref. 1

costing: Ref. 14

costs of construction: xv, xxxii, 7, 10, 11, 13, 30, 219–220, 240, 265–273, 278–287, Ref. 9, Ref. 10, Ref. 11, Ref. 14, Ref. 15
  comparative study, H, 19–26, Ref. 2
  estimates, 12, 29, 30, 141, 146
  job overhead, xxii, 267, 270, 271, 272

courts, see legal aspects

CPM, see critical path scheduling

crews: 268–272
  optimum, xxxi–xxxii, 266, 278–287, Ref. 10

critical path scheduling: xix, xxxi, xxxiii, 290–294, Ref. 12

damages: xi, 63, 64

Davis-Bacon Act: 74–75

day labor: xi, xii, xiv, xv, xvii, xviii–xix, xxxii, 6–13, Ref. 1, Ref. 13

diagrams (see also drawings; time-scale arrow diagram method): xxxii, 180

disputes, claims: 54–55

documentation: xvii, xxi–xxii, 178–182, Ref. 7
  of costs, Ref. 14, Ref. 15
  preparation and presentation, 29–36

drainage:
  design, Ref. 3
  inspection, 193

drawings (see also diagrams): xxi, 29, 30–36, 43, 50–51, 165, 178, 179, 195, 290

earthworks: xxvi, 193, Ref. 4, Ref. 16, Ref. 17

embankments: 171, 173, Ref. 3, Ref. 17

emergencies: 100–102, 184

employment conditions (see also safety; work hours; working time; workmen's compensation): 229, 233–234

engineers (see also superintending officers; supervisors; supervisory engineers): 50, 52, 162, 181, 285, Ref. 6, Ref. 8, Ref. 17

equipment: xi, xviii, 7, 12, 21, 25, 26, 42, 65, 114, 162, 173, 178, 195–196, 212, 238, 239, 255, 266, Ref. 3, Ref. 7, Ref. 14
maintenance, xii, 239
operators, 7, 239, 240–241, 242, 243, 244, 246
procurement, xxviii, xxix, 221–223, 247–249
rental, 93

excavation: 21, 22, 23, 120, 167, 168, 169, 170, 268–269, Ref. 17
heavy, 6, 12, Ref. 1

experience curve: xxxi, 278, 280–282, 283, Ref. 11

explosives: 61, 169

farm-to-market roads (see also rural access roads programme): xxviii, Ref. 9

Farrel, F.B.: Ref. 2

Federal Highway Administration, see United States Department of Transportation, Federal Highway Administration

federal-aid highway construction: 8, 12, 85, 89–92, 109, 111, 114, 117, 123, 127, Ref. 4, Ref. 5, Ref. 16

fills and filling (see also backfilling): 170–171, 172, 173

fire protection: 62–63

force account work: xi, xii, xx, xxiv, 10, 11, 12, 70, 90
cost comparison, 19–26, Ref. 2

foremen: 269

forests: 62, 161

Gates, Marvin: Ref. 10, Ref. 11

general provisions: xv, xvi, xxiii, xxvi, Ref. 4, Ref. 6, Ref. 17

gravellings: 237–240, 241, 243

hand tools: 247–248, 255

hauling: 168–169, 266
distance, 24, 26, 238, 240

headmen: 245, 246, 253, 254

highway design: xiii
documentation, 29–36, Ref. 3

Highway Research Board (now Transportation Research Board) (see also Transportation Research Board): xix, xx, Ref. 1, Ref. 2

Indian Roads Congress (Jamnagar House, Shajahan Road, New Delhi 110011, India): xxi, Ref. 3

inspection (see also inspectors): 52–53, 58, 192–194, Ref. 8, Ref. 17

inspectors (see also inspection): xvii, xxvii, xxviii, 52–53, 177, 201–206, 245, Ref. 17

International Bank for Reconstruction and Development (IBRD) (1818 H Street, N.W., Washington, DC 20433): 212, 219

International Labour Office (CH-1211 Geneva 22, Switzerland): xxviii, 211, 212, 216, Ref. 9

job overhead costs: xxxii, 267, 270, 271, 272, 283, 284, 285, 286, Ref. 11

joint bidding: 88–89

joint ventures: 121–123

Jorgensen (Roy) Associates (P.O. Box 3310, Gaithersburg, Maryland 20760): Ref. 15, Ref. 17

Kenya: xxviii, 210–260, Ref. 9

Kilpatrick, M.J.: Ref. 2

labor (see also crews; day labor; labor-intensive construction; personnel; productivity, labor): xi, 7, Ref. 14
disputes, 129
regulations, 10, 152

labor-intensive construction: xxviii, xxxi, 210–260, 278–287, Ref. 9, Ref. 11

land acquisition (see also right-of-way): 32, 103
compensation, 225

landscape protection and restoration: 61–62

laws, see legal aspects; regulations

legal aspects (see also regulations): xi, xvi, xxv, 7, 59–64, 83–152, Ref. 4, Ref. 16

losses (see also claims; damages): xi, 7

lump sum (see also competitive lump sum; negotiated lump sum): 12, 21, 120

maintenance: xii, 12, 19, 256, Ref. 3
programs, 217

Malawi: xxvi, Ref. 6
Standard, 160

Malawi Government Ministry of Works and Supplies (Private Bag 316, Capital City, Lilongwe 3, Malawi): Ref. 6

manuals: xxi, Ref. 3, Ref. 14, Ref. 17

maps: 31, 33

materials, construction (see also sampling and testing of materials; testing of materials): xi, xvi, xviii, 7, 8, 42, 46–47, 182–184, 193, Ref. 3, Ref. 4, Ref. 7, Ref. 14, Ref. 16, Ref. 18
aggregates, 20, 187, 190–191, Ref. 7
control, 55–56

measurement: xvi, 68–71, 166, Ref. 4, Ref. 16
recording, xxvii, 181–182

metric publications: Ref. 6, Ref. 18

mobilization costs: 266, 267, 268, 270, 271, 272, 284–285, 286

motivation, personnel: xviii, xxix, 214, 230–234

National Association of Australian State Road Authorities (P.O. Box 3141, Brickfield Hill, New South Wales 2000, Australia): xxvii, Ref. 7, Ref. 17

National Association of Counties (1735 New York Avenue, N.W., Washington, DC 20006): Ref. 14

negligence: 149

negotiated lump sum (see also lump sum): xi, 6, 7, 8, 9

Netherton, Ross D.: Ref. 5

optimization: xxx-xxxi
  equations, xxx, 266

optimum number of crews: xxx-xxxi, 266, 278-287, Ref. 10

optimum working time: xxx, 265-273, Ref. 10

overseers: 243, 244, 245, 252, 254, 255

overtime: 271-272

paints: 189

paving: 130
  high type, 6, 12, 126, Ref. 1

payments: xvi, xxiv, 22-23, 41, 68-76, 184, 233, 253-260, 271, Ref. 4, Ref. 16

personnel (see also crews: foremen; headmen; inspectors; labor; overseers; superintending officers; supervisors; supervisory engineers): xviii, xxix, 41-42, 98-100, 211, 240-241, Ref. 19
  casual, 228-230, 247-248, 258-260
  motivation, xviii, xxix, 214, 230-234
  recruitment, xxix, 214, 227-230, Ref. 9

piecework: 232, 241

Pinnel, Steven S.: Ref. 12

plans and planning construction: xvi, xxviii-xxix, xxxii, 9, 12, 42, 44, 51, 93, 111-114, 125, 137, 138, 141, 178, 195, 202, 212, 213-214, 216, 219-226, 250-252, 257, 290-294, Ref. 8, Ref. 9, Ref. 13, Ref. 17

pollutants: 61-62

preinvestigations: 29, Ref. 3

prequalification of contractors: 8-9, 12, 118, 119, 125, Ref. 1

procurement of equipment: xxviii, xxix, 221-223, 247-249

productivity, labor (see also task rates): 22, 237, 251, 254, 285

public utility services: 103, 162, 163-164, 193

quarries: 164, 238, Ref. 6

RARP, see rural access roads programme

recruitment, personnel: xxix, 214, 227-230, Ref. 9

references: xxxiii, 13, 273, 286

regulations (see also legal aspects): xxii, 10, 42, 76, 90, 108, 112, 117, 122, 123, 135

reports, progress (see also documentation): xxvii, xxviii, 29-30, 179, 203, 219-223, 255-257, Ref. 17, Ref. 18
  costs and accounts, Ref. 14, Ref. 15

resource allocation: xviii, Ref. 19

retaining walls: 32, Ref. 3

right-of-way (see also land acquisition): 42
  acquisition, 64, 132

rural access roads programme (RARP): xxviii-xxx, 210-260, Ref. 9
  organizational structure, 216-218, Ref. 9

rural roads (see also rural access roads programme): project reports, 29-36, Ref. 3

safety (see also fire protection): 64, 100, 162, 177, 192, 193, 196, 204, 233-234, Ref. 7
  Standards Act, 122

sampling and testing of materials (see also testing of materials): xxvii, 56-59, 183, 185-189, Ref. 18

Scarpa, Amerigo: Ref. 10, Ref. 11

schedules (see also critical path scheduling): xviii, xxxii, 30, 202, 290-294, Ref. 8, Ref. 11

shoulder, roadway: 42

site conditions: 48-49

site plans: 31, 33

slump test, concrete: 191

specifications (see also general provisions; standard specifications; supplemental specifications): xv, xvi, xviii, 9, 12, 43, 44, 51, 56, 93, 111-114, 119, 121, 125, 137, 138-139, 141, 178, 193, 195, 202, Ref. 3, Ref. 8, Ref. 13, Ref. 17

standard specifications: xv, xvi, xxii, xxiii, xxvi, 40-76, 85-86, 111, 112, 121, 131, 135, 143, 160-174, Ref. 4, Ref. 6, Ref. 16
  safety, 122

steel, reinforcing: 188-189

subgrades: 120-121, 185, Ref. 3

subsurface investigations: 44

superintending officers (see also inspectors; supervisors): xxvii, 43, 177, 216, 269, 285, Ref. 18

supervisors (see also headmen; overseers; personnel, superintending officers): xvi, xvii, xxvii, xxix, 7, 205, 212, 216, 227, 228, 239, 243, 244, 245, 252, 253, Ref. 9, Ref. 13, Ref. 17
  costs, 266, 269, 272, 278
  field, 177-196, 218, Ref. 7

supervisory engineers (see also superintending officers; supervisors): xvi, 216

supplemental specifications: xvi, 43

suspension of work: 50, 67-68

task rates: 214, 237, 253, Ref. 9

taskwork: 231–232, 241

testing of materials (see also sampling and testing of materials): xvi, xxvii, 56–59, 172, 179, 191
apparatus, 196
on site, 190–194, 203, Ref. 8

time-scale arrow diagram method: xxxii, 290, 292, 293, 294, Ref. 11

top soil: 167, 168

traffic control devices: 109, 163, 192

traffic maintenance: 25, 49, 63, 163, 192, Ref. 6

Transportation Research Board (2101 Constitution Avenue, N.W., Washington, DC 20418) (see also Highway Research Board): xxiv, Ref. 5, Ref. 19

Uniform Relocation Assistance Act: 109

unit costs: 21, 22

unit price bids: 120–121

unit price contract: xi, xiv, xvii, xix, 6, 7, 8, 9, 12, Ref. 1

unit prices: 95, 146

United States Agency for International Development, AID Resources Center, Office of Development Information Utilization, Bureau for Development Support (Washington, DC 20523): Ref. 15, Ref. 17

United States Department of Transportation, Federal Highway Administration (400 Seventh Street, S.W., Washington, DC 20590): xxii, 90, 92, 107, 108, 110, 111, 122, Ref. 4, Ref. 16

utility services, see public utility services

de Veen, J.J.: Ref. 9

wage differential: 22, 24, 26

warning signs: 61

work accounts: 20, 21, 22, 24

work hours: 75, 122
supervisors, 177, Ref. 7, Ref. 18

working time:
optimum, xxx, 265–273, Ref. 10

workmanship: xviii, 46–47

workmen (see also crews; labor; personnel): 65, 177

workmen's compensation: 60

World Bank, see International Bank for Reconstruction and Development

Wright's Law, see experience curve

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Las publicaciones citadas abajo fueron publicadas en el proyecto Apoyo de Tecnología de Transporte para Paises en Desarrollo y pueden ser pedidas franco de porte al TRB a los precios indicados para cada publicación.

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Transportation Research Board, National Research Council, 2101 Constitution Avenue, N.W., Washington, DC 20418 USA

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