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UNIDAD DE INFRAESTRUCTORA

ACHIEVEMENT OF OPPORTUNITIES TO REDUCE CONSTRUCTION COSTS IN PUBLIC WORKS

Report of the Ad-Hoc Group

(Version in English)

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DEPARTAMENTO
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PLANEACION

UNIDAD DE INFRAESTRUCTURA

ACHIEVEMENT OF OPPORTUNITIES TO REDUCE CONSTRUCTION COSTS IN PUBLIC WORKS

Report of the Ad-Hoc Group

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I. SUMMARY

A. PURPOSE AND SCOPE

Construction is a significant activity in Colombia by virtue of the funds spent on it annually, and by virtue of the current emphasis on the National Plan of Development on this activity as one of the strategic sectors for development, since it offers good prospects to generate more and better paying jobs. At the same time, there is recognition that costs of construction in Colombia may be distorted and thereby could impede the progress desired. The reasons are the use of technologies possibly inappropriate to Colombian conditions, and the recognition of institutional practices in the construction sector that can lead to inefficiencies in the implementation of public construction projects.

Accordingly in January 1972, Planeacion Nacional formed an Ad-Hoc Group of Planeacion personnel, assisted by the services of a consultant (Arthur D. Little, Inc.) provided by the Agency for International Development of the United States, to undertake a project of investigations aimed at identifying appropriate cost reduction opportunities. The modus operandi of the Group was then set forth in a published Project Statement (Document DNP 846-UINF, 22 February 1972).

To enable the vast and diverse field of activities comprising the construction sector to be managed in the available time, the Ad-Hoc Group focused its attention on two sectors of construction, roads and highway and urban multifamily dwellings, which are important currently and will be so in the future; and on the materials-of-construction sector, cement and burned-clay products specifically. Also, the Group followed a set of specific policies in order to guide its investigations toward producing results that could be implemented immediately and that would be responsive to the goals for economic progress that have been identified in the National Plan of Development.

The policies were:

- Undertake the work program for the project as the initial effort of a longer-term effort that ultimately could provide detailed analyses of all activities within the construction sector, i.e. from the planning, the programming, and the design stages through to the actual construction efforts, the project completion, and the maintenance of the facility constructed.

- Adopt as the immediate aim of the work emphasis on those activities that could produce cost-reduction results of immediate usefulness.

- Identify the immediately-useful cost-reduction opportunities sharply, so that the actions to achieve them are clear and enable decisions to implement to be taken readily.

- Recognize that costs of construction involve not only the financial costs of the projects but also the implications that reductions in these costs can have on the use of labor-intensive technologies, on the demand for foreign exchange, and on the relations between initial value of a construction and the ultimate value.

B. FINDINGS AND CONCLUSIONS

1. Specific actions to achieve reductions of cost in each of the three sectors investigated have been identified, and for each sector they have been organized as an action plan. The specific actions may be classified into three categories as follows:

- actions for which implementation steps have already been taken;

- actions for which decisions are required in order to enable implementation steps to be taken;

- actions for which decisions to implement should be deferred until the time is appropriate.

2. Implementation steps have already been taken for four opportunities to achieve cost reductions.

a. By Improved Usage of Heavy Construction Equipment

The preliminary planning and the estimation of the cost of the work to complete a national inventory of heavy construction equipment in the country has been completed by the Unit of Infrastructure (UINF) with the cooperation of the Colombian Association of Engineering Contractors (ACIC). On completion, the results will enable Government and private organizations engaged in heavy construction to improve the utilization of the equipment already in the country, restore equipment that may have been retired prematurely, and reduce the unjustifiable import of new construction equipment.

Funding the program of work and selecting the method of supervision are still required.

The Ministry of Public Works will fund a study by a local consultant firm to explore the establishment of a "Bolsa de Equipo," in which the members would interchange the use of construction equipment they own individually as the needs are identified. The objective will be to reduce idle time of equipment available for use while demand exists. UINF has suggested specific measures to the Ministry of Public Works in this respect and in relation to the broader inventory of equipment on a national scale.

b. By a More Appropriate Masonry Cement

The Industrial and Agrarian Study Unit (UEIA) of Planeacion Nacional has arranged to receive a proposal from Instituto de la Construccion de la Universidad del Valle (ICUV), expected in September 1972, concerned with the development of a non-portland cement binder material, which will define the problems, scope of work, the technical aspects, and the raw materials. Planeacion should arrange to fund this proposal if it is found responsive and administratively acceptable. The results of the work will be useful in introducing a new product which can reduce the cost of constructing masonry walls in building and in other construction, and also which can help to reduce the cost of brick walls with respect to walls of cement-block formulations. The formulation of the product could involve the use of blast-furnace slag produced by the country's only integrated iron and steel complex at Belencito (Boyaca). This material is now being wasted in a dump.

c. By More Appropriate Construction-Labor Intensiveness

UINF has established the terms of reference whereby the Capital-Labor Model (CLM) developed by the World Bank will be applied in a limited way to the evaluation of the effectiveness of the labor-intensive "Pick-and-Shovel" secondary-road construction program in Colombia, which is sponsored by the Fondo Nacional de Caminos Vecinales. UINF intends to acquire the details of the CLM from the World Bank and to obtain its guidance to accomplish the data collection effort for Colombian conditions, the first step in the application of the CLM on a broader scale.

d. By Accurate Quantity Surveys

UINF is arranging to acquire the Highway Cost Model (HCM), completed by the Massachusetts Institute of Technology for the Department of Transportation of the United States. UINF expects to apply this model to a sample of recently completed Colombian road

and highway construction projects. The short-term objectives are to check the accuracy of the quantity surveys used as a basis for award of construction contracts, and also to check the appropriateness of the road alignments actually selected in terms of alternatives that could have reduced the quantity survey.

3. The following actions require decision in order to enable implementation steps to be taken to achieve additional cost-reduction opportunities.

a. By More Intensive Use of Transport of Cement by Rail

Unit-train transport of bulk cement or cement clinker from factory to market could in the long term temper pressures to raise cement prices by eliminating the regional character of the cement demand/supply pattern in Colombia through reduction in the cost of transport between factory and market; and in the short term for a similar reason stabilize cement prices in Bogota. The technology to achieve this type of transport for cement in bulk can be transferred, but a successful demonstration in the country is first needed. The specific technology has been successfully applied in England, and an attractive candidate for piloting this technology transfer in Colombia is available. It is based on the transport of cement in bulk from Cementos Boyaca at Nobsa to its marketing depot in Bogota using the existing rail line. A pilot technology-transfer project in this respect is technically feasible. The primary objective will be the development of complete knowledge of changes needed in details of technique, the actual cost experience that will result, and the reliability of the transport method. Another attractive candidate, but based on cement clinker, is the transport by unit train from Nare to Bogota.

b. By Anticipation of Future Cement Demand

It is difficult as the National Development Plan is implemented, to forecast cement demand rise in the country with an accuracy

that justifies construction of new cement manufacturing capacity. The reason is the new constant-value savings and loan policy of the Government to finance housing construction. Conceivably, progress in implementing the Plan through this policy could be rapid enough so that the country will face chronic and extensive shortages of cement to the extent that construction activities could be cut back. Such shortages could occur before new cement manufacturing capacity can be built. Some mechanism is needed to monitor demand and supply of cement on a current basis so that quick knowledge of imminent shortages will be detected, as well as indications of how much and when new cement manufacturing capacity should be made available.

c. By Increasing Efficiency in Burned-Clay Products Manufacture

The investigations of the technical performance of the burned-clay-products industry, which has now been completed by the Instituto de Investigaciones Tecnologicas (IIT) with assistance from the UNIDO, has produced a clear and unified set of technological recommendations whereby the efficiencies of the medium and small Colombian producers of burned-clay products can be increased. The result can be a more profitable or stronger competitive position for the industry with respect to alternative wall and partition materials, a more effective utilization of skilled labor, and an increase in productive capacity with a relatively small demand for new investment capital. However, there has been little, if any, evaluation of the findings by those engaged in the day-to-day activities of burned-clay product manufacture, who would be directly affected by the implementation of the IIT recommendations. Such an evaluation could be useful in identifying a method of implementation that assures a successful result particularly with respect to the cooperation the industry could offer.

d. By Creating the Institutional Structure to Focus on Specific Areas of Housing Construction

A number of opportunities to improve operations in the building construction sector and thereby reduce costs seem to be possible by further investigation of specific areas such as the following:

- Communication channels among the organizations involved in the sector, which facilitate the planning and acquisition of the labor and managerial resources to accommodate an expanded construction volume, and the procedures involved in accomplishing such construction.

- The adequacy and stability of the skilled labor supply in the sector.

- Control of material quality and conformance to standards.

- The pattern of utilization of equipment.

- The appropriateness of technological methods.

No institution exists in the country legally competent to investigate these areas and enforce the results.

4. Decisions to take steps to implement the following actions should be deferred until the time is more appropriate because:

a. Stepwise Progress is Needed

This reason applies particularly to the introduction of the computer-based modeling techniques, already noted above, as analytical tools. In the longer term these will provide the quantitative data necessary to support recommendations for significant changes in institutional practices which can result in attractive cost reductions. Step-wise progress permits a gradual build-up of confidence by those

organizations involved in the construction sector and affected by its performance. Such confidence is a prerequisite, if implementation of change is to be practical and the expected results achieved. Therefore, the consideration of such changes as

- a revision of construction standards and specification to reflect a labor/capital balance more appropriate to the conditions in Colombia and its national goals;

- the adoption of maintenance policies for the country's road and highway grid reflecting a balance between first costs and deferred costs more appropriate to the nation's financial position; and

- new procedures for award of contracts reflecting a more accurate quantitative definition of work scope and the avoidance of delays in making progress payments;

should await the results of the analytic work involving computer-oriented models already described above.

b. Actions Depend on Results of Prior Actions

Examples of actions which fall into this category are the following:

- Consideration of an import of cement through international tender, until it becomes clear that serious shortages in cement supply for the country are imminent, and new construction of manufacturing capacity cannot be completed in time.

- The construction of new cement-manufacturing facilities based on the Rio Nare limestone reserves. The construction should be carried out in a manner that will stabilize cement prices and assure adequate future supply. The construction should begin as soon as both the demand for cement clearly justifies this and unit-train bulk-cement trans-

port is successfully demonstrated and prospective costs are known. With these preconditions, the limestone reserves along the Rio Nare provide the best assurance that new production capacity can employ modern technology, offer low production costs, and provide unlimited quantities to match growing national demand.

- Consideration of a Technological Service Center for the Building Construction Sector that can from the point of view of data and evaluation of systems of construction and alternative materials of construction help solve some of the problem areas in this sector.

5. The concept of a single conference/seminar described in the project statement (paragraph 4.5.3), in which all the results of the investigations by the Ad-Hoc Group would be considered, should be modified, as should also be the intention to incorporate the results of such a conference in the final report of the Ad-Hoc Construction Cost Reduction Project. The modification should recognize that the nature of the technical findings from the work specifically indicate that conference topics should be narrowly defined rather than all inclusive, and that each topic can warrant a separate conference more or less unrelated to that for any other topic.

C. RECOMMENDATIONS

We recommend as follows:

1. That the preliminary efforts by UINF to transfer the two model-oriented approaches to provide analytical tools for the road and highway construction sector be supported in the following specific manner.

a. Form a working group comprising personnel representing experience in the different disciplines required for the technology transfer.

b. Assist this group with personnel from the different government organizations involved in road and highway construction.

c. Arrange for the services where indicated of a consultant firm of appropriate qualifications, and seek funds to cover the cost.

d. Designate UINF of Planeacion Nacional as the organization responsible for the success of the effort.

2. That the specific efforts, already begun to bring the HCM computer program to Colombia for adaptation to the DANE computing center, be continued. These are

a. to request from MIT, the card deck, the user's manual, and their final report to the U. S. Department of Transportation. Also, to request a set of sample input cards,

b. on receipt, to adapt this program, written in FORTRAN IV for an IBM 360-50, for use with the DANE computer. The program requires a 230,000 bit core, which can be reduced by the use of disks as supplementary memory; or by taking advantage of the overlay structure,

c. to designate a staff member from the Ministry of Public Works and from Planeacion to be responsible to manage the computer program in the way that will be responsive to the limited application foreseen in the early stages of the work.

3. That the two implementation efforts already begun, namely the equipment inventory and low-cost masonry binder cement, be continued. For the inventory of heavy construction equipment, proceed with the recommendations already submitted to the Ministry of Public Works regarding responsibility and finance for both the national inventory and the study of the "Bolsa de Equipo" concept. For the investigation of a substitute for portland cement as a masonry binder, arrange for Planeacion

Nacional to evaluate the proposal from ICUV, to provide the supervision of the work, and to secure the funds to cover the cost.

4. That Planeacion Nacional management exert a concentrated and intense effort to bring the managements of Cementos Boyaca and the National Railways together at a conference, whose objective will be reaching formal agreement in principle to share the responsibilities and the costs of a pilot program of unit-train transport of bulk cement from Nobsa to Bogota. The topics to be covered at the conference should be the following:

a. The formula by which the actual cost experience generated by the pilot program will be translated to the rate to be charged later for the transport service.

b. The formula for the maximum cost of transport Cementos Boyaca will ultimately accept based on their present total cost of transport by road.

c. The formula by which the total capital cost of the pilot program will be shared.

d. The method by which the optimum single train capacity will be established such that the capital cost of the pilot program will be minimum while the train capacity will still be large enough for the experience to be meaningful.

e. The schedule under which the planning, the construction work, and the pilot operations will be conducted.

f. The cost accounting procedure for the pilot program.

5. That Planeacion Nacional undertake a similar effort oriented toward transport of cement clinker from Nare to Bogota.

6. That Planeacion Nacional sponsor a technical conference for participants who would be concerned with the design, implementation, and operations of a cement demand monitoring group. The function of this group will be to operate a fact-gathering system that will be capable of monitoring cement demand at frequent intervals (perhaps monthly or quarterly) and to compare this demand with the actual current industry supply position. The objective of the conference should be to determine the manner for creating this function. Organize the conference in the following manner:

a. Invite participants from the manufacturing industry, the major consumers, trade or industry associations, DANE, cement distributors and dealers, architect associations, among others.

b. Prepare papers in advance for discussion covering techniques that could be employed to process facts, such as development on an empirical simulation model, method for updating the model constants, the kind of data that should be collected.

c. Secure from the discussions suggestions for the methods of collecting data, the cooperation that may be expected, and who would take the responsibility for the efforts.

Use the results to design the method of operation, and consider whether it would be useful to monitor construction-steel demand; and if warranted, add this to the functions of the monitoring group.

7. That Planeacion Nacional sponsor a technical conference for participants involved in the burned-clay products industry. The objective of the conference should be to determine the manner by which the recommendations of the IIT/UNIDO study should be implemented. Organize the conference in the following manner:

a. Invite participants from brick and tile manufacturing enterprises, government organizations involved in setting standards and having interest in quality control, major building contractors experienced in brick utilization, wholesalers and distributors, among others.

b. Distribute the findings of the IIT/UNIDO study as the basis for discussion.

c. Provide a forum that encourages free exchange of ideas and the formulation of a set of recommendations by the conference participants.

After the conference, Planeacion Nacional should consider the conference results, particularly the receptivity of the audience to technological improvement, and then formulate an action plan for implementation.

8. That Planeacion Nacional sponsor a conference for the building construction sector designed to offer a forum for the free exchange of ideas on two specific aspects in the areas identified for investigation:

- the identification of the nature and extent of the problems that exist in this area, and

- the solicitation of suggestions on the nature and possible powers of an institution which could find solutions to the problems identified, and then enforce them.

9. That the work continue on an Ad-Hoc basis until such time as it becomes evident that a more formal organization is convenient.

IX. INTRODUCTION - THE NEED FOR ACHIEVEMENT

The original title of the project to which this report is responsive was the identification of opportunities to reduce costs in public construction. The project team has seen fit to amend the title to read the achievement of such opportunities rather than only the identification. Nevertheless, identification remains a necessary and all-important component of the work efforts; but now this aspect is supplemented by the additional aspect of physically obtaining benefits from the results.

A. BACKGROUND

Construction activities are recognized in the national Plan of Development for Colombia as one of the strategic sectors for development, offering the potential for generating more and better paying jobs. Although the emphasis in the Plan is in the construction of urban multifamily housing, a major emphasis nevertheless remains in the construction of roads and highways. A large share of the national budget is devoted to road construction for specific reasons. Either legal requirements generate funds devoted to this purpose of prevailing agreements to obtain loans from external sources for road construction require that counterpart funds be provided. Supporting all construction is, of course, an adequate supply at reasonable prices of suitable materials of construction.

The project arose because of the interest of the Government, through the Departamento Nacional de Planeación and other official organizations, to undertake a study of identify the ways and means to reduce costs in the construction of public works. Such costs may have become distorted for various reasons. Construction technologies may be in use that are not appropriate to Colombian conditions, or institutional practices may exist that lead to inefficiencies in the implementation of public construction projects.

The result was the formation of an Ad-Hoc Group to take the responsibility for the study within a designated time period. The Group formulated a program of work and the methodology for its accomplishment, and issued the Project Statement in February 1972. This Statement appears in this report as Appendix A.

B. THE CONCEPT OF COST

For a potential reduction in public construction costs to be meaningful, it should be considered from two points of view. From one point of view, a reduction in the actual number of pesos expended in the public construction sector is important, but the real benefits may be realizable only from a second point of view; namely, the consideration of the implications of such a cost reduction on the economy of the nation itself. The following implications are significant.

- the effect on imports. If imports increase as the result of a cost reduction, then the effect may be to produce negative benefits, or impedances, to economic progress. The importance of this effect depends on the national foreign exchange position at the time. A conclusion regarding a particular cost-reduction opportunity which is based on the foreign-exchange effect should be reviewed periodically, particularly if public construction practices have actually changed because of that conclusion.

- the effect on the generation of employment opportunities. One of the goals of the present Development Plan is to increase employment opportunities through the construction activity. More labor-intensive construction activity would, of course, help achieve such a goal. But, if a more labor-intensive approach in public construction increases the completion time for a new highway project, for example, then the loss in the expected benefits from the increased construction schedule may be large, and the net effects could be negative development.

- the effect on the balance between the long-term and short-term costs of a construction project. Value can be removed from a construction when its initial cost is reduced, and this removal can increase the long-term cost of the construction, such as increases in maintenance over the life of the construction. Whether or not such a reduction in the global value of a construction project can be justified by the initial reduction in its cost, depends on the local conditions that determine the present value of money to be spent sometime in the future, and on what the schedule might actually be for such future expenditures.

Thus, one can expect that opportunities in public construction in which actual monetary expenditures increase rather than decrease might actually represent "cost-reduction" opportunities in the sense discussed above. In any event, a broad-minded approach to identification of cost-reduction opportunities is appropriate.

C. THE PROMISE OF BENEFITS

Ultimately in the steps of implementing the Development Plan, the construction cost will be estimated for each public works project specified, in terms of its local cost in pesos and its foreign exchange cost in dollars. The costs then serve as a basis for foreseeing and planning how the full implementation of the Plan will be financed. As it is generally the case, the intent of the Plan is then satisfied once the means for financing are clear. Work then proceeds on the basis of the balance between finance and cost thus established, with the reasonable expectation that ultimately most of the benefits from the Plan will be realized.

It is obvious that an additional set of benefits can be realized, if the estimate of construction cost could be reduced without changing the scope of the construction projects contemplated. Thus, achievement of cost reduction opportunities in public construction will result in the

generation of additional benefits from the Development Plan that may be a significant proportion of the results of the Plan itself.

D. THE FOCUS FOR ATTENTION

The focus for attention originally was the five topics specified in the Project Statement (Appendix A). As the work proceeded and the results were evaluated, the five areas consolidated to three as follows.

- Road and Highway Construction
- Multifamily Urban Housing
- Materials of Construction

For each of these topics the time limitation given the project required the investigations to be undertaken on an Ad-Hoc basis. Three distinct topics for investigation were involved in the project areas.

1. Materials

   - the predominant materials and the current pattern for their usage. The usual materials of construction are cement, aggregates, reinforcing steel, asphalt, wood and burned-clay products. Attention in the project focussed only on cement and burned-clay products.

   - the current state of research in government, academic, and private organizations into the aspects of improvement of properties and adaptation to new uses through analysis, testing and innovation.

   - the current emphasis on value engineering (i.e. seeking the proper balance between long-term and short-term costs) in the specific usages of alternative materials.

   - the potential to use indigenous sources of construction materials that may not yet be developed.

   - the state of standardization of formal materials specifications, and the appropriateness of the standards employed.

- the extent that foreign exchange is represented in current usage pattern of construction materials.

2. Construction Technology

- the appropriateness of the construction technology employed, as this may be defined by the balance between capital and labor intensiveness that is represented in the technology.
- the appropriateness of the construction technology employed, as this may be defined by the balance between first cost and maintenance cost (or the balance between the short-term and long-term costs) that is represented in the technology.

3. Public Construction Institutions

The institutions are important not only because both government and private organizations are involved in the utilization of materials and the application of construction technology, but also because they would be the key factors in achieving the cost-reduction opportunities that may result from the investigations. Some of the topics in this category were:

- A clear description of the individual activities in the procedures followed by government organizations and private construction contractors between the time a construction project is conceived and the time that it is completed and handed over for use.
- The use of analytical methods capable of expressing inefficiencies in public construction that arise from institutional practices, and using the results to generate the incentive to make the changes necessary for greater efficiency.
- A description of the physical facilities available that could be useful when change involves technological research and

development, and an assessment of the problems involved in introducing technological change into the institutional procedures.

4. Action Plan

Finally, effort is required in a way that will organize the findings as a plan of action each step of which bears a logical relationship to the others, is consistent with the capability to implement, and is timely. An action plan for each of the three consolidated topics resulted from the project efforts.

III. ROAD AND HIGHWAY CONSTRUCTION

A. SUMMARY

This section presents an action plan which ultimately should enable the country in its road and highway construction activities to realize a combination of the following factors which is most responsive to economic goals:

(1) total financial cost incurred in the construction of roads and highways;

(2) the generation of new employment opportunities in the construction activities; and

(3) the avoidance of unjustifiable expenditures of foreign exchange during construction.

At the same time the plan does not prevent, in the short-term, taking action on opportunities already identified to reduce costs, or that will be identified during the course of the implementation of the action plan itself.

The action plan is based on the results of investigation into current Colombian road and highway design practices, into the construction technology employed into the practices for implementing road and highway construction projects, and into the institutional practices involved. Also, the action plan is based on current activities outside of Colombia concerned with the development of analytical models. These models can evaluate quantitatively local policies regarding labor and capital employment in road construction and the corresponding appropriateness of final designs, standards and specifications. They can also produce sets of alternative quantity surveys and cost data for evaluation within a specific construction project.

The results of the investigations indicate that:

- the total set of activities involved, between the concept of a road or highway project and its ultimate operation, can in fact be treated as a process in which the parameters are susceptible to mathematical modeling and high-speed data processing techniques;
- the application of such techniques can lead to construction of the specific road or highway installation in which combination of labor/capital employment, the foreign exchange demands, and the total financial costs is responsive to the national goals; and,
- achieving such road or highway installations requires the transfer of the techniques to Colombia in carefully designed stages.

Accordingly, the action plan to identify cost-reduction opportunities on such a basis is divided into three stages of activities, namely:

- Those immediate actions based on the results of the Ad-Hoc approach that can produce cost-reduction results in the medium term; and
- those later actions dependent on the earlier ones but involving an integrated approach that can produce cost-reduction results in the long term.

For results in the short term, the national inventory of heavy construction equipment already organized will be completed. On completion, it should become practical to identify quickly further actions which the Government can take to encourage a more effective utilization of the construction equipment already in the country, and to encourage that new construction equipment is not imported unnecessarily.

A potential immediate action for results in the short and medium term concerns the usage of materials. The relative global merits of cement paved versus asphalt-paved highways could be compared on a technical

and cost basis to determine whether a Government policy of encouraging the use of cement is feasible as a means of supporting expansion of the Colombian cement industry. Also, a trial program could be started to use the small-scale production of coke-oven coal tar at the Paz del Rio steelworks for replacing asphalt for road construction projects in that area.

An immediate action but for results in the medium and long term will be the establishment and operation of a technical and cost data bank based on historical and current data that will enable new road construction contracts to be awarded with more realistic budgets than heretofore. This should have the result of lessening the discrepancy between actual costs and annual government road building budgets, and thereby avoiding costly shutdowns in construction projects because of unforeseen shortages in funds.

A final immediate action for medium term results will incorporate the information in the data bank, and in addition involve a carefully planned and organized basic data collection program to be used in a limited manner with high-speed analytical tools, namely the two models developed, one by the Massachusetts Institute of Technology for the U.S. Department of Transportation which is concerned with highway costs, and the other by the World Bank which is concerned with the selection of technologies that employ the appropriate mixes of labor and capital. The use of the models accordingly will be limited to determining the accuracy with which quantity surveys are now being made in the design of road and highway projects, to evaluating whether opportunities exist to improve the current Colombian "pick and shovel" rural-road construction program, and to determining the existence of inefficiencies in recent road and highway construction projects.

Based on the experiences thus far, a longer-term action will be to apply the two models more extensively. They could be used to justify changes in the current practices of design and execution of road and highway construction involved in this could be the appropriateness of the construction standards the identification a rational basis for allocating the global cost of road construction project to initial construction cost and deferred maintenance cost, and the responsiveness of construction technologies to the national goals for the employment of labor.

B. BACKGROUND

Table 1 contains a list of areas in which the potential for identifying cost reduction opportunities is probably good. The list of areas is comprehensive, and essentially covers all the activities which are involved in achieving the completed construction, starting at the time a decision is taken to build the road because economic justification exists until the time traffic actually flows. It also covers the activities involved in the maintenance of an existing road network, and also the activities that should be practiced in order to strengthen the Government's contracting position.

The Ad-Hoc project undertook to collect data in the selected areas as they were outlined in the Project Statement (DNP-846-UINF, 22 February 1972), and then to remain alert to identifying opportunities for improvement in the form of specific potential reductions in cost. A summary of the results and the findings form this approach is given in Appendix B. In the time available for the Ad-Hoc stage of work, it was practical to cover only the three items in the list in Table 1, which are:

POTENTIAL AREAS FOR IDENTIFYING COST REDUCTION OPPORTUNITIES

1.0 DESIGN ACTIVITIES

1.1 The Selection of Standards
- 1.11 Related to Expected Traffic Pattern
- 1.12 Related to Import Cost in the Construction
- 1.13 Related to Anticipated Maintenance

1.2 The Estimation of the Quantity Survey
- 1.21 Selection of an Appropriate Alignment
- 1.22 Accuracy of the Survey

2.0 CONSTRUCTION TECHNOLOGY

2.1 Appropriateness of the Methods
- 2.11 Relative Labor and Capital Utilization
- 2.12 Level of Importation Required

2.2 Selection of Specifications
- 2.21 Responsiveness to Appropriate Technology
- 2.22 Amenability to Inspection

2.3 Control Procedures
- 2.3.1 Related to Quantity Survey
- 2.3.2 Related to Unit Costs
- 2.3.3 Related to Finished Quality

3.0 IMPLEMENTATION PROCEDURES

3.1 Contents of Tender Documents
- 3.1.1 Level of Technical Detail
- 3.1.2 Accuracy of Quantity Survey
- 3.1.3 Realism in Cost Units
- 3.1.4 Appropriateness of Technology
  - 3.1.4.1 Standards
  - 3.1.4.2 Specifications
- 3.1.5 Control Principles

3.2 Evaluation of Proposals
- 3.2.1 Degree of Responsiveness
- 3.2.2 Capability of Contractor.
  - 3.2.2.1 Financial Resources
  - 3.2.2.2 Past Performance Record
  - 3.2.2.3 Current Work Load

3.3 Control Practices
- 3.3.1 For Quantity
- 3.3.2 For Cost Units
- 3.3.3 For Quality

4.0 EXISTING ROAD NETWORK

4.1 Maintenance Practices
- 4.1.1 Adequacy of Frequency
- 4.1.2 Adequacy of Methods
- 4.1.3 Responsiveness to Traffic Growth

4.2 Technical Performance Data Bank

5.0 HEAVY CONSTRUCTION EQUIPMENT

5.1 Use Pattern

5.2 Spare Parts Availability

5.3 Import Level

6.0 INSTITUTION ASPECTS

6.1 Budgeting for Progress Payments
- 6.1.1 Availability of Funds
- 6.1.2 Disbursement of Funds

6.2 Experience Bank
- 6.2.1 Up-dated Cost Data Bank
- 6.2.2 Ranking-of-Contractors Roster

6.3 Organizations involved in Road and Highway Construction, for each
- 6.3.1 Contracting Procedures
- 6.3.2 Maintenance Procedures

- Institutional aspects (Items 6.1, 6.3)
- Construction standards (Items 1.1, 3.142)
- Construction machinery (Item 5.0)

The findings from these follow.

Institutional Aspects. The level of coordination of road and highway construction activities among the public organizations involved in this sector is too low to permit effective project planning and implementation in this sector as a whole. As a result, it becomes difficult and requires extraordinary effort to detect cost-reduction opportunities that can readily be implemented. Frequently, the quantity surveys and the unit cost data incorporated in the tenders as the official budget for the project are established without an adequate foundation of accurate design or realistic cost experiences. Since Government investment decisions are based on available funds and the officialproject budgets, cost overruns tend to occur, funds become in short supply, contractors' payments are delayed, construction schedules are then correspondingly delayed, and construction costs rise further.

Construction Standards. The standards currently established for the construction and maintenance of roads and highways are frequently transferred without change from foreign countries. Furthermore, such standards are not universally adopted within Colombia, each public road construction organization tending to adopt its own. Finally, standards are transferred without recognizing their appropriateness to Colombian conditions of the topography, climate, nature of traffic and adequacy of maintenance practices.

Construction Machinery. No centralized record of the construction machinery inventory in the country is available. Thus, there is no knowledge of the effectiveness of utilizing this equipment, nor knowledge that can be used to establish effective Government policy regarding further

imports of equipment or spare parts. Effective utilization of available construction equipment represents a clear opportunity to reduce costs in road and highway construction, because this item accounts for about 30% of the total construction cost and the cost of the equipment itself is almost entirely in foreign exchange.

A number of observations follow from the findings, and from the more detailed contents of Appendix B. They are:

- The method of approach to identify cost reduction opportunities is piecemeal or opportunistic. It attempts within a comprehensive and a complex set of activities (see Table 1) to search for cost reduction opportunities intuitively on the basis that knowledge of the country indicates that such opportunities should exist.
- The results tend to be qualitative rather than quantitative. This tendency is accentuated when the time available for investigation is brief. Records, if they exist, must be found and searched. Patience of people is required while they are busy with other pressing matters.
- The process of isolating and identifying quantitative data may involve vested interests, who could consider that the results of their cooperation may act later against them.
- It is unlikely, even if a reasonable amount of additional time were granted, that quantitative cost-reduction data can be developed to the extent that they can be ranked in a reliable manner in terms of the individual amounts of the cost reductions.
- Finally, an inability to rank cost-reduction opportunities in a reliable fashion will make it difficult to build a strong case for implementation.

The Ad-Hoc project also undertook to investigate and evaluate recent progress in the use of mathematical modeling and simulation techniques applicable to the construction of roads and highways, which can be applied to Colombian conditions and which then seem capable of serving as a high-speed tool for identifying cost reduction opportunities in a quantitative manner. This investigation and the findings that resulted are described in Appendix B. Two distinct techniques were identified that appear suitable for the purposes of the Ad-Hoc project.

The Capital-Labor Model (CLM) has been developed by the World Bank and is now ready for application to specific sets of conditions. It essentially determines the construction technology appropriate for the national goals in a country. Appropriate technology is defined in terms of minimizing social costs as they are affected by different utilizations of labor and capital and by different expenditures of foreign exchange.

The Highway-Cost Model (HCM) has been completed by the Massachusetts Institute of Technology for the U.S. Department of Transportation and it can determine, with certain limitations, the quantity survey as a function of road alignment; and also, given the unit costs developed for the appropriate construction technology and the desired quantity survey, it can develop total costs. It can also explore the effect on total costs of changes in design standards, construction technology, and road alignments. Finally it can provide a basis for allocating global costs for road and highway projects to the initial construction cost and the later maintenance cost.

A number of observations follow from these findings and from the more detailed contents of Appendix B. They are:

- Particularly for the CLM, comprehensive data from the field is required that must be collected and evaluated with care so that they will be reliable and produce realistic results from the point of view of local conditions.
- The stage of model development reached so far and the willing cooperation of the developers permit quick transfer of the methodology and the associated computer programs to Colombia for use as soon as the required input data are available.
- With a proper sequence of activities, and using recently completed road and highway construction projects, prospects seem clear that such modeling techniques could ultimately produce results which define quantitatively the areas where significant cost reduction opportunities exist. It is possible that these opportunities might even be ranked for implementation in order of importance.

Therefore, it appears practical to pursue further investigation of cost reduction opportunities emphasizing mathematical tools. The results will be quantitative, defensible (if sufficient care is taken to collect realistic input data), and accordingly likely to be implemented.

C. OBJECTIVES.

To summarize, there are essentially two approaches that can be taken to achieve cost reductions in road and highway construction; namely one that is "piecemeal" and another that is integrated. One does not exclude the other but rather the results of the former can be used to reduce costs in the shorter term and to provide input data and information necessary to realize the additional cost reduction potential of the latter. The techniques for the integrated approach should be applied in stages, so that useful cost reduction opportunities can be identified as the work proceeds and so that the limits of usefulness of the techniques can be determined without unproductive efforts by personnel.

Accordingly, the objectives of the Action Plan are:

- to realize the cost reduction opportunities so far identified by the piecemeal approach;
- to provide a collection of data related to road building conditions in Colombia suitable as inputs to the two models, HCM and CLM;
- to identify a sample of already-completed road and highway projects to which the HCM and CLM techniques can be applied;
- to identify the construction technology that is appropriate to conditions in Colombia;
- to determine the accuracy of quantity survey data now used in contracting procedures;
- to determine the spread between total field costs estimated for efficiently executed construction projects and the actual contract costs experienced; and finally
- to identify the changes to be made in the activities associated with road and highway construction (see Table 1) so that cost reductions will result because of the use of more appropriate construction standards and construction technology; more effective design procedures; properly revised contracting procedures and execution practices; and recognition of a rational allocation of costs to construction and to later maintenance.

D. ACTION PRINCIPLES

Achievement of the objectives will involve describing a series of actions of a plan on the basis of the following principles:

1. Quickly act upon the opportunities for achieving cost reductions already obvious from the results of the work so far;
2. Narrow the scope of the HCM and the CLM as far as appears practical in order to achieve cost reduction results quickly;

3. Make the change from the "piecemeal" approach to the integrated approach for identifying further cost reduction opportunities in an evolutionary manner; and

4. Recognize that the task of collecting basic data will be a comprehensive one and that the methods employed must be free as far as practical from bias on the part of the observer.

E. ACTION STEPS

A set of coordinated action steps to produce short, medium, and long term cost reduction opportunities in road and highway construction is shown in Figure 1. The set of steps shown constitutes the Action Plan. Numbers in parentheses in the description which follows are those shown in Figure 1.

Heavy Construction Equipment Inventory (1.1)

The objective to be achieved is to establish a centralized record in adequate detail of the heavy construction equipment already in the country; and then to use this information to improve the utilization pattern and to reduce new imports of equipment. Improving the utilization pattern will produce corresponding reductions in the cost of the services of the existing equipment. Thus, the expectations of benefits in the short term (1.11) are:

- a basis will become available on which the Government can select appropriate policies for importation of spare parts;
- a basis will become available on which the Government can, through policy on the importation of new heavy construction equipment, promote standardization of equipment types in the country;

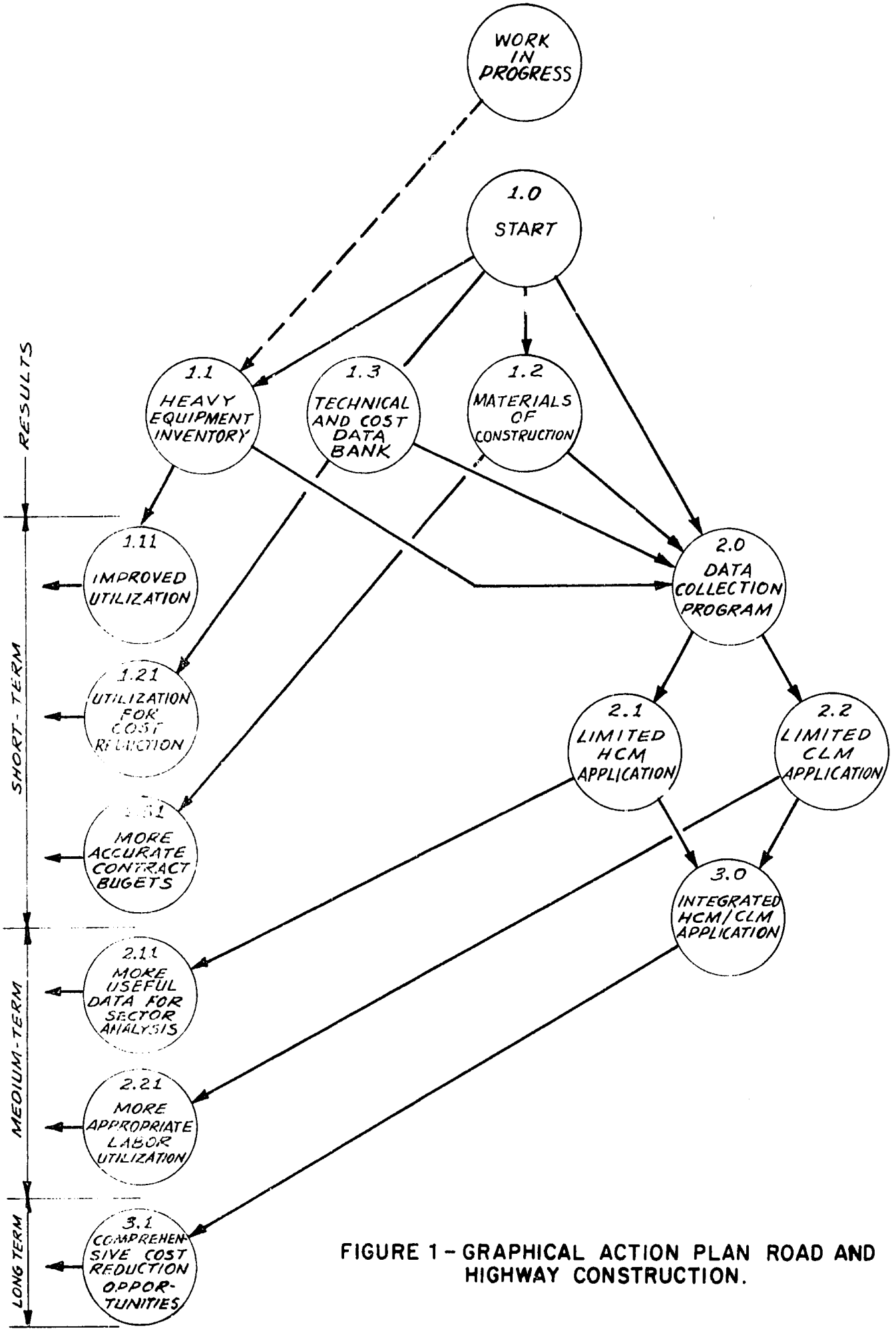


FIGURE 1 - GRAPHICAL ACTION PLAN ROAD AND HIGHWAY CONSTRUCTION.

- it will become practical to review proposals for construction projects with special emphasis on avoiding unnecessary imports of new construction equipment, or on promoting the use of existing equipment that otherwise would be idle;
- the Government could consider a special import of spare parts and equipment components that would permit equipment now considered permanently disabled to be restored to service and,
- a basis will become available for considering the establishment of a "bolsa de equipo" in which the members will have the facility for interchanging the services of equipment registered in the Bolsa.

The methodology envisaged for the inventory is as follows. Details can be found in Appendix B.

1. Establish a directory of private firms and Government organizations who own or control equipment.
2. Undertake a program of field interviews with each firm in the directory and compile the information required for each equipment unit identified in the interview.
3. Evaluate the data collected in a form amenable to high-speed data processing.
4. Publish the results in a format designed to promote the use of the information by the construction industry and by the Government.
5. Develop a method and procedure for updating the results periodically.

Materials of Construction (1.2)

The objective could be to review the usage patterns

- to determine whether justification exists to promote cement-concrete highway construction as a means of encouraging expansion in capacity of the cement manufacturing industry;

- to evaluate the use of coke-oven coal tar from Paz del Rio steelworks as a road-pavement substitute for asphalt, thereby releasing this material at the refinery to residual low sulfur fuel, which can be exported.

The expectations of benefits in the short term (1.21) could be

- the Government can use the knowledge of the proper competitive position of cement pavement with respect to asphalt pavement, if appropriate, to stimulate cement markets in a way that assures the desired rate of expansion of the cement manufacturing industry. For example, it can offer to purchase bulk-cement at the evaluated purchase (opportunity) cost of cement if this should be consistent with the marginal production cost of the manufacturer;
- since coal-tar supplies will increase as the capacity of the Colombian steel industry increases, it can ultimately replace asphalt in appropriate technical applications. Thus, surpluses of asphalt become exportable by itself, or in fuel oil. Coal-tar itself is not exportable.

Data Collection Program (2.0).

This action will be responsive to providing the input-data base suitable for the operation of the CLM and the HCM in Colombia. It will receive inputs from the previous actions (1.1.1.2, 1.3). The collection of data will be designed so that initially they will apply only to rural and secondary roads. On the basis of the results later obtained (2.1 and 2.2) the collection could then be extended to include trunk roads as well as other civil works. The data collection will take advantage of the experience that the Fondo Nacional de Caminos Vecinales has gained so far in the "pick and shovel" road construction program. It will also be oriented to the methodology of analysis developed in the cLM and the HCM.

Limited CLM Application (2.2)

To provide useful results quickly, the scope of the activities for this action will be limited by selecting five rural-road projects having distinct and different approaches as follows:

- The approach in which traditional methods of construction (intensive in machinery) are used.
- The approach in which the "pick and shovel" method, involving individual contracts between the Fondo Nacional de Caminos Vecinales and the workers (for example as in Caldas), is used.
- An approach in which the "pick and shovel" method, involving contracts between the Fondo Nacional de Caminos Vecinales and the local Junta de Accion Comunal followed by secondary contracts between the Junta and different groups of workers (for example, as in Cundinamarca), is used.
- The special approach (now in practice in a community in Cauca) in which the "pick and shovel" method, involving a contract between the Fondo Nacional de Caminos Vecinales and the local Indian Chief who in turn as contractor organizes the workers of the community, is used.
- A new experimental approach for Colombia involving using the designs and alignments established through traditional technology (intensive in machinery), but also involving specific labor-intensive activities using small carts for loading, transporting, unloading, and spreading.

For each of the five approaches adopted, the Fondo Nacional de Caminos Vecinales should organize its activities such that the different approaches are distinct and can be observed individually for data taking;

and such that for each approach there will be some variation in the construction activities between the traditional and the pick and shovel technologies.

Each project should be described in detail and each description should include the physical characteristics of the terrain, the programming of the work, and the financing plan: Also, a flow diagram should be established for the project which shows clearly the manner for breaking down the total effort into its component tasks. Photography could be employed to illustrate the conditions of the project where this appears useful.

The actual field work should consist of collecting and recording data corresponding to each description and flow diagram. The data items described below are illustrative:

- Productivity data taken by direct observations; from inquiries of contractors, foremen, and supervisors; and from the results of analyses of data in files. Disaggregate the data to the maximum for each one of the different activities involved in the project. Design the number of observations to assure that an acceptable level of statistical reliability has been obtained. The objective is to assure that reliable production functions for each technology considered can be computed.
- Descriptions of physical conditions for the project in detail including topography, geology, vegetation, climate, and agriculture.
- Descriptions of special environmental conditions, including local nutrition standards, level of adequacy of living conditions, the existence and nature of social services, quality of tools, forms of payment, construction facilities supplied, and local unemployment levels.

- Descriptions of administrative factors for the project, including factors for the project, including a total number of workers, number of workers per supervisor, types of control, equipment availability, maintenance facilities, and utilization of equipment.
- Descriptions of labor cost factors such as nature of the work, type of contract, form of payment, and daily work hours.

The data collected will be used in the medium term through the CLM to quantify labor/capital requirements in the Colombian "pick and shovel" road building program in order to determine the effects of choice of road-building technology on volume of employment generated, on total costs, and on the amount of the import component. The results can then be used to review the accomplishments of the pick and shovel program and to identify areas for potential improvement. Finally, the experience can be evaluated to determine the feasibility of incorporating the techniques into the integrated application (3.0) for major roads and other civil construction.

Limited HCM Application (2.1)

The data collected will be used through the HCM to produce, in the medium terms, results that can be useful in analysing quantitatively the road and highway construction sector and then identifying areas for improvement. To provide useful results quickly, the scope of the activities for this action will be limited to selecting a sample of recent road construction projects for which data for the topographical and geometrical alignment are complete. The sample should also contain complete data on costs and the analysis of the costs together with the quantity surveys and unit costs used in the contract negotiations. For each project in the sample:

- compute the quantity survey by the use of the HCM, using the original input information and geometrical alignment, and compare the computed result with the actual quantity survey used in the contract;
- compute alternative quantity surveys by the HCM for different geometrical alignments to identify whether there existed an alignment that could have reduced the quantity survey significantly.

From the results, a conclusion will be drawn regarding the cost-reduction incentive (i.e., found by applying costs from the data bank (1.3) to the differences in the quantity surveys) to convert design procedures for new road construction projects from manual to computer based.

The results of the quantity survey comparisons can then be used to estimate the difference between the total construction cost for each of the sample projects and the total field cost (computed by the model from the actual quantity surveys and the actual unit costs). This difference includes in addition to the contractors home-office overhead and profit, the inefficiencies that may have been introduced into the field work because of delays beyond control (weather, for example) and those within control (delays in payments to the contractor, escalation of unit costs, as examples). A conclusion can then be drawn regarding the efficiency of the institutional procedures employed in the execution of the road projects in the sample.

The results of the quantity-survey comparisons and the details of the execution of the sample projects now established will then be used to estimate the construction schedules that could have been followed, and to compare these with the historical schedules. The differences found may relate to the differences already found between total construction cost and computed total field costs, and may also help to explain reasons for the cost differences.

Integrated HCM/CLM Application (3.0)

Once the value of the results from the previous actions (namely; labor/capital relationships; quantity surveys; construction inefficiences; and time delays) are known, and once it can be concluded that justification to continue exists, the CLM and HCM will be integrated and applied to the road and highway construction sector. The objective will be to quantify the incentives to make specific changes in procedures for:

- the design practices for new roads and highway construction;
- the standards to be adopted in the designs;
- the construction specifications to be followed and incorporated in the contract terms such that labor utilization, foreign exchange demands, and total financial costs will be appropriate to Colombian conditions;
- establishing contract terms that will assure that the above prevail;
- making timely progress and final payments;
- controlling completion schedules; and
- adopting appropriate maintenance policies on the completion of a construction project.

The methodology to achieve the objective will be to start with the information and data from the sample of road construction projects, and for each determine

- the alignment for a minimum quantity survey using the HCM;
- the appropriate construction technology using the CLM with the original project cost units (i.e. determine the appropriate use of labor and capital);
- the total field cost from the results above using the HCM with the same cost units used in the CLM; and
- the difference between the actual project cost and the total field cost thus estimated.

These results will quantify the incentives to identify the changes needed in the design, implementation, and institutional practices, and thereby quantify the project cost reductions that can result.

Further work can then be undertaken for typical road construction projects that leads to quantitative data on total costs, labor employment, and import component when the following parameters are varied:

- choice of design standards;
- choice of maintenance policy (i.e., the method for choosing an allocation of the global cost of a road or highway project to the initial cost of construction and to the deferred cost of maintenance).
- choice of policy on the balance of labor and capital intensiveness in road and highway construction.

Comprehensive cost reduction opportunities (3.1) should result.

IV. URBAN MULTIFAMILY HOUSING CONSTRUCTION

A. SUMMARY

This section presents an action plan which ultimately should enable the country in its urban housing construction activities to realize the combination of the following factors that is most responsive to national economic goals:

(1) total financial cost incurred in the construction of urban multifamily dwellings;

(2) the generation of new employment opportunities in the construction activities; and

(3) the avoidance of unjustifiable expenditures of foreign exchange during construction.

At the same time, the plan does not prevent taking action in the short term on opportunities to reduce costs already identified because of the investigation that the Division of Urban and Housing Development has completed as part of the work of the Ad-Hoc project.

The investigation by the Division of Urban and Housing Development was completed with the help of a consultant firm (Londoño y Velásquez of Bogotá), and took advantage of data on costs available from them. As the result, the action plan already has a quantitative base more extensive than the two other areas covered.

The results of the investigations indicate that:

- a number of findings can be implemented immediately.
- a number of problem areas exist in the building construction

sector for which solutions are needed, if costs are to be lowered and the sector is to become more productive. The area lies in the institutional practices, the mobility of construction labor, standardization and quality control of materials, equipment and technological practices.

- the item in the method of approach in the road and highway construction sector which is concerned with the development of analytical tools based on modeling and on simulation has application to the urban housing construction sector.
- the delegation of power by Article 11 in Decree 677 to the Council of Savings and Housing to set standards for the granting of loans for housing construction to assure conformance with national policies for urban development, provides an ideal basis for achieving cost-reduction results arising from the Ad-Hoc project.

Accordingly, the action plan to identify cost-reduction opportunities on such a basis is divided into two stages of activities, namely:

- the immediate actions that can produce cost-reduction results in the short term, medium term, and long term.
- the later action that can produce results in the long term.

For results in the short term, an immediate action is to undertake to solve the institutional problems identified in the work of the Ad-Hoc stage. These problems include contract procedures that act to force idleness on building construction equipment; working conditions that result in a continuing loss of trained labor to other sectors and the need to train new people; and inadequate standardization of materials of construction and ineffective control of quality that increase erection costs.

For results in the short and medium term, an immediate action is to establish a construction service center that will concern itself with technological aspects of systems of construction of buildings and of materials of construction. The center will produce short-term results in the form of qualitative evaluations of appropriate systems and materials for Colombian conditions and in the form of the inputs for the formulation of effective standards. In the medium term it would produce similar outputs but quantitative based.

Work can begin immediately to establish an analytical tool based on rapid computer calculation of load distributions in structural frames and from this cost estimates for multifamily dwelling constructions. The tool will be used to explore the effects of alternative geometric forms of multifamily housing constructions on costs and the consumption of resources, namely materials and labor. The results will then be useful in overall urban planning as one quantified input among others such as population density in the urban area, area of land to be urbanized, land distance from urban center, land cost, land occupancy, and infrastructure requirement.

Finally, the experience in the application of the labor-capital model (CLM) gained in the analytical work in the road and highway sector will be transferred for application to construction activities in the housing sector. The inputs will come from the work on building geometry and the data compilations of the Technological Service Center, supplemented by a data collection program aimed at construction labor productivity. The result will be specific cost reduction opportunities based on appropriate use of technology and materials for Colombian conditions and the adoption and enforcement of appropriate standards and quality control.

B. BACKGROUND

The housing construction sector will be the leading sector in the

implementation strategy of the Plan. Not only will the activities in this sector satisfy a growing demand for housing arising from the increased urbanization of the country, but it will also be the leading generator of more and higher skilled employment, and of increased demand for construction materials. The importance of this strategy is illustrated by the steps being taken by the government to finance it.

Fundamental changes are occurring in the financial structure of the country in order to provide funds for such a purpose. Presidential Decree 677 in May 1972 introduced a constant-value savings and loan system, and later decrees developed details for its implementation and operation. Article 11, paragraph (e) is particularly significant from the point of view of reducing costs in housing construction. It gives a procedure for adopting standards for granting constant-value loans preferentially to those construction projects which are in accord with national policies for urban development. The Council of Savings and Housing would recommend standards for adoption, and it would be expected that the Fund for Saving and Housing (FAVI) will enforce. Since greater productivity in housing construction through reduction of costs is no doubt a desirable national policy, the creation of FAVI offers an opportunity to implement an action plan aimed at cost reduction.

A meaningful start toward identifying cost-reduction opportunities has already been made by the Division of Urban and Housing Development in conjunction with their local consultant. A comprehensive report is now in preparation, the work having been completed. The contents of this report are summarized in Appendix C.

Two sets of findings have resulted from the investigation. The first is a compilation of data analyzing the costs of building construction in a sample of twelve recent constructions in the major cities of the country, including an analysis of costs of construction alternatives. The other is an identification of problem areas in the building construction industry, sufficiently well-defined to enable the remedies to be identified. Both

sets of findings lend themselves to the formulation of an action plan for achieving cost reductions in the activities of the sector.

Specific findings from the investigation in the road and highway construction sector have applicability to the housing construction sector. These are the findings that relate to the use of mathematical modeling and simulation techniques to develop tools for effective analysis of sector operations. The CLM of the World Bank (See Section III) seems useful almost without change to analyze the labor-capital relationships in housing construction in terms of financial costs, labor employment opportunities, and import needs as alternative mixes of construction technologies are employed. Computational procedures for analyzing complex frames to distribute loads among the members of the structure can be adopted to computer processing, and at the same time expanded to provide total cost data and cost distributions.

Such a capability will be useful in providing useful inputs for urban planning. The emphasis in the Plan on the construction of urban multifamily housing should lead to the development of new planned urban areas in or near the intermediate and large cities of the country. Some of the significant factors that influence the design of new urban areas in terms of achieving a combination that represents a minimum demand on the resources of the country are: population density in the urban area; area of land to be urbanized; distance of land from the urban center; cost of land; occupancy of land; infrastructure requirement; and height of building structures.

Some of the parameters are independent but all relate among themselves so as to produce a complex interrelationship whose proper management will in turn produce an optimum overall cost for a new urban area. Costs for the building of different geometrical shapes would be a significant contribution to the management of the different parameters.

C. OBJECTIVES

Accordingly, the objectives of the Action Plan are:

- to take advantage of the analytical work so far accomplished by the Division of Urban and Housing Development to identify cost reduction opportunities which can be immediately implemented through examination of the institutional and technological problems;
- to assist in the implementation of the provision in Decree 677 which in effect will give the Fondo de Ahorros y Vivienda the authority to set standards for the construction financed by them; and
- to assist in achieving the labor-employment objectives of the National Development Plan.

D. ACTION PRINCIPLES

Achievement of the objectives will involve selecting a series of actions for the plan on the basis of the following principles:

- Limit the definition of building construction cost to include only the components of the total support structure, the peripheral enclosure, the internal partitioning; and to include labor, overhead, supervision, temporary field construction, and use of equipment that is directly related to the geometry of the structure.
- Develop analytical tools that will enable (1) the cost effect of building geometry to be evaluated among the other significant cost factors involved in planning urban housing and (2) the appropriate use of labor-intensive construction methods to be identified.
- Base the development of the analytical tools on the work to be undertaken of a similar nature in the road and highway construction sector.

E. ACTION STEPS

A set of coordinated action steps to produce short, medium, and long term cost reduction opportunities in urban multifamily housing construction is shown in Figure 2. The set of steps shown constitutes the Action Plan. Numbers in parenthesis in the description which follows are those shown in Figure 2.

Sector Institutional Problems (1.1)

The sector problems have already been identified by the Division of Urban and Housing Development, and these are summarized in Appendix C including the indicated remedies. The problem of labor instability and excessive training activities by the sector needs solution or resolution from a viewpoint broader than the sectorial cost reduction viewpoint of the Ad-Hoc project, and accordingly no action is specified here.

The remaining problem of ineffective communication channels among the different organizations involved in the sector, inconsistent quality of materials of construction, equipment utilization, and appropriate technology will be attacked by giving the sector an opportunity to air them in detail at a conference designed for the purpose. To give such a conference a meaningful image in terms of promise of useful results, the sponsorship should be the responsibility of the Council of Savings and Housing as part of the authority they have received to propose standards for adoption. The remedies indicated by the Division of Urban and Housing Development should be presented as the basis for discussion. The goal of the conference should be the identification of the details of the plan which can then be used for proposal and recommendation as the Decree States (1.11).

Technological Service Center (1.2)

As a second phase for the conference just specified, a second conference should be convened with an appropriate participation and

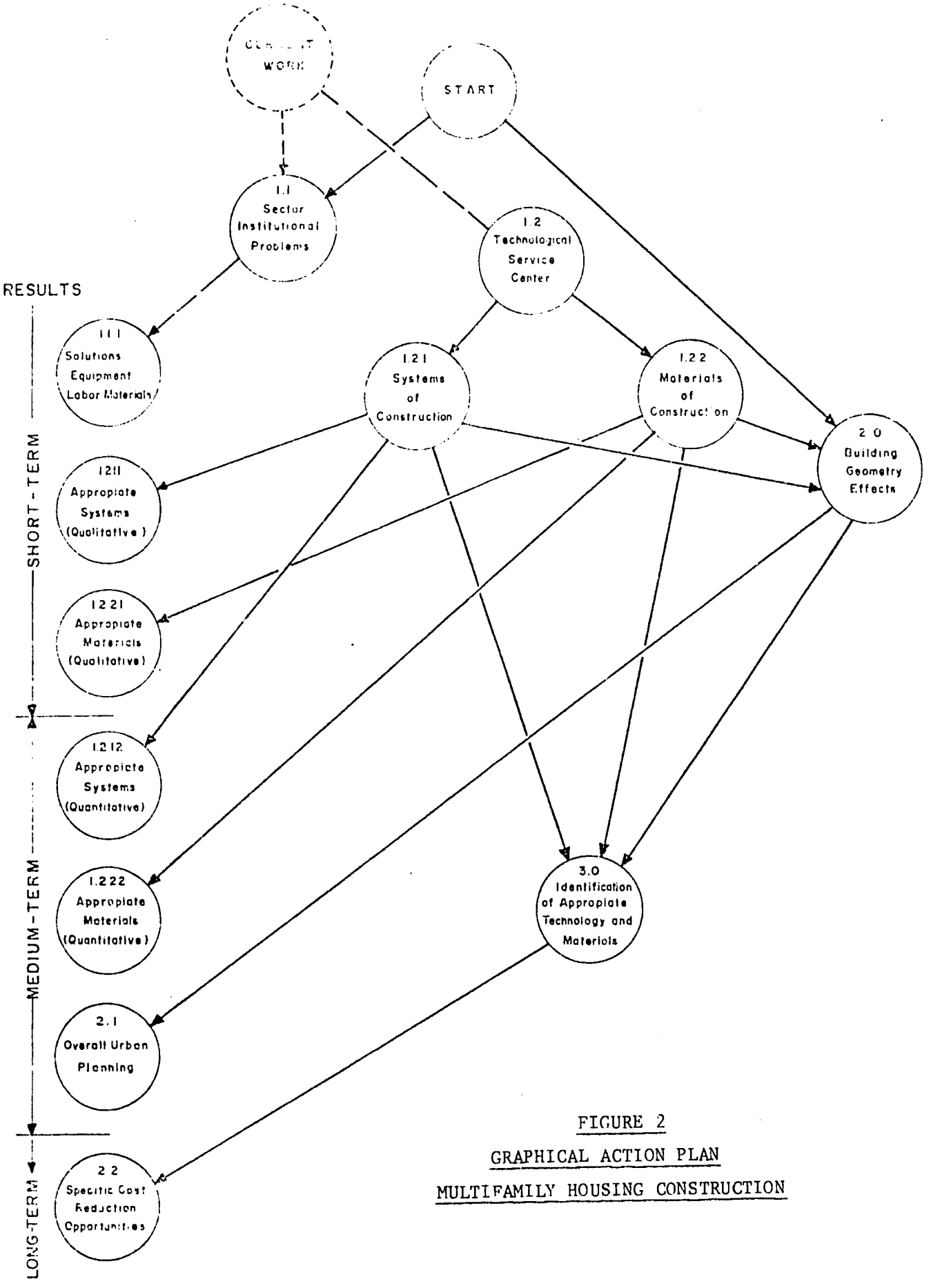


FIGURE 2

GRAPHICAL ACTION PLAN

MULTIFAMILY HOUSING CONSTRUCTION

under the same sponsorship but organized to consider the method of establishing a technological service center for building construction. Its objective will be the collection of data related to the Colombian building construction activities covering systems of construction (1.21) and materials of construction (1.22), and their evaluation in a manner that identifies (a) the technical problems which act to reduce the productivity of the sector and (b) the alternative solutions that are practical to consider for use by government and private organizations. A review of past efforts of a similar nature and an evaluation of reasons for ineffectiveness should be available to the participants in advance of the conference.

Operation of the Service Centre can produce in the short term qualitative information on appropriate construction systems (1.211) and on appropriate materials of construction (1.221). In the medium term, quantitative results will be available (1.212, 1.222).

Building Geometry Effects (2.0)

The approach used in the road and highway construction action plan will be adopted by developing an analytical tool based on a model of the building construction process having the following character.

(1) The use of one of the computer programs which performs the matrix computations resulting from the analysis of the load distributions within structural frames.

(2) An extension of the scope of such a program to permit the size of each member of the frame to be established, and the quantity survey of materials established.

(3) A further extension of the scope by introducing unit costs and the simulation of the construction process, so that the cost of building may be obtained as the action principles specify this cost.

(4) The development of a computer program that can perform a similar function for low-height buildings that do not involve structural frames.

The analytical tool thus developed will use input data developed by the Technological Service Center and produce as the output data effects of building geometry on total costs and employment based on conventional construction methods currently employed in the country. The data will be a significant input to overall urban planning (2.1).

Identification of Appropriate Technology and Materials (3.0)

As the appropriate time, when the value of the labor-capital intensiveness analyses has been demonstrated in the road and highway construction sector, the methodology will be applied to building construction. The aims will be the identification of systems of construction and patterns of material usage that are appropriate to the local conditions of labor and capital availability in Colombia, and thereby results that are responsive to national goals. At this point, a field effort will be required to collect labor and equipment productivity data of the scope similar to that in the action plan for road and highway construction. The final result can be an analysis of standards, specifications, systems of construction, and usage of materials (e.g. the possible use of lightweight aggregate) that lead to specific cost-reduction opportunities not previously identifiable.

V. MATERIALS OF CONSTRUCTION

A. CEMENT

This section presents an action plan to assure adequate national supplies of cement in the future. Its principles are based on the results of intensive investigations of current cement-industry operations, and of future national needs for cement in the light of the goals of the Development Plan.

1. Summary

One investigation included a visit by a Government mission to each cement factory in the country during which up-to-date observations were made of the operations and the production capability. The results were used to establish a definitive forecast of domestic cement supplies.

Simultaneously, another investigation attempted to forecast the future national and regional demands for cement. This work took into account the country's cement export position and the recent Government actions to encourage public savings in order to finance the housing construction and the secondary construction of associated infrastructure that are foreseen for the National Plan. The forecasting attempts required that fundamental assumptions be made, namely: the annual rate of growth of investment in construction that will result from the Government policies to stimulate savings; the distribution of such investment growth by region and by the allocation to building and infrastructure construction; and the proportion of such allocated investment growth that represents cement purchases. Because of these, the forecasts of demand that resulted are indicative of the future rather than conclusive.

Nevertheless, the results of the two investigations lead to specific conclusions regarding the future balance of demand and supply

in the country, which are:

- If desirable progress in implementing the National Development Plan is to be achieved, the country will be short of cement supplies to support the construction volume involved.
- Regardless of the existence of the Plan, the precise extent of shortages, nationally or regionally, is difficult to estimate but indications are that shortages may be chronic and extensive enough to reduce significantly the rate of completion of construction projects and to add to their costs.
- Shortages resulting from the implementation of the Plan will occur before new construction of cement production facilities can be completed.
- Because of high internal transport costs, the diversion of the country's current exports of cement to internal markets will not provide a practical solution in order to alleviate regional shortages when they occur.

Thus, it is clear that a mechanism is needed whereby the country can assure itself in the short term of adequate cement supplies in advance of growth in demand.

An opportunity exists to provide such a mechanism through the use of the existing railway infrastructure in a manner that takes maximum advantage of recent technological developments in the transport of bulk commodities by unit-trains which shuttle back and forth between terminals. Much general experience with respect to coal transport exists in the United States. Specialized experience with respect to cement transport, which can readily be transferred to Colombia exists in Great Britain. A proper transfer of this experience could convert the demand/supply pattern in Colombia from one of regional character to one of national character, and thereby eliminate a situation where there is surplus production capacity ine one region of the country, while shortages of cement exist in another.

Specific actions, required imemdiately to avoid expected (but unpredictable in quantity and location) shortages in cement supply, are the following:

- Increase the effectiveness of the present pattern of utilization of cement in the construction industry by developing and introducing into the market (a) non-portland cement products for masonry construction and (b) slag/cement products for foundation construction. Also undertake to increase the efficiency of brick production to increase the competitiveness of this product with cement block (See Section B following).

- Establish a demand-monitoring function to operate in a manner that can quickly detect imminent regional deficits in cement supply. Use the results (a) to foresee and anticipate the longer-term need for the construction of new cement manufacturing capacity, (b) to identify the manner in which new capacity should be constructed for long-term supplies, (c) to identify the actions the cement industry can take to increase supplies in the short term, and (d) to determine whether or not a need exists for temporary imports of cement or diversion of exports to domestic markets.

- Use specific present cement-industry operations as a basis for establishing simultaneously two pilot railway unit-train programs; one involving the transport of bulk cement from the factory at Nobsa (Boyacá) to Bogotá, and the other the transport of clinker from Nare to Bogotá for grinding there to cement. The objectives of the two pilot schemes should be (a) the generation of cost data on which realistic transport rates can be later established, and (b) the demonstration that the transport will be reliable.

- Use the results from the actions described above to establish a quantitative indicative plan for the cement industry that will specify the recommended locations for new plant construction, the capacities at each location, the schedules for completion,

and the projected investments and production and distribution costs. The objective of the indicative plan should be to provide cement to the construction sector of the country at the lowest prices permitted by modern technology and local conditions.

2. Background

In Figure 3 the cement consumed nationally versus installed capacity is shown for the period between 1953 and 1971. Also shown is the expansion in production capacity now under construction. Production capacity on a national basis has always been above consumption as would be expected when no import of cement exists. On the other hand, shortages of supply on a regional basis have always existed at times, and the unsatisfied demand that existed as a result is not reflected in Figure 3. If the assumption is made that the pattern of demand and supply in the future will remain regional, then forecasts of future demand should be undertaken on a regional basis.

Three alternatives of rates of increase of investment in urban housing resulting from government policies on savings and loans were chosen in order to forecast regional growth in cement demand. The details for the three alternatives are given in Appendix D, Section 1. The alternatives are:

1. The base year for total national consumption is taken as 1971. For subsequent years, a ten percent constant growth rate is assumed nationally. The total national consumptions thus forecast were then allocated to the regions of the country in proportion to the percentage of total consumption in each region, calculated as the average for the years 1969, 1970, and 1971.

2. Two methods were used and the consumption forecast which was the larger of the two results was adopted. This result was based

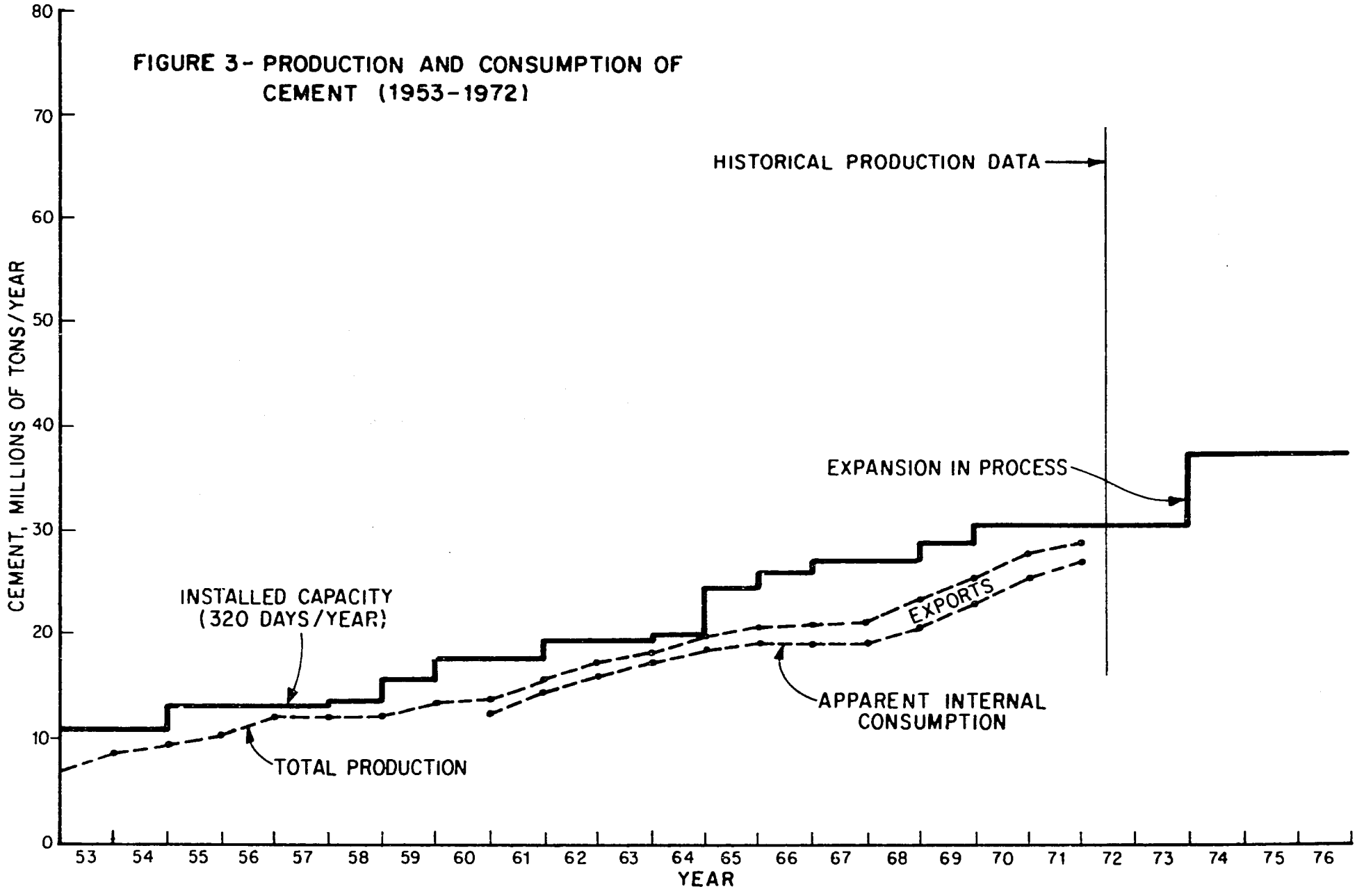


FIGURE 3- PRODUCTION AND CONSUMPTION OF CEMENT (1953-1972)

on using a projected increase in investment in building construction and input-output tables available in the Unit of Global Programming (UPG). The increase in investment was established by UPG from the results of a study they recently completed to forecast the growth of savings to be expected from the new constant value system.

3. The forecast is based on adding to the investment in housing in 1972, an annual increase of 1,825-million pesos of 1968 value in each of the years 1973 and 1974; and 2,500-million pesos for 1975. Then the proportion of the increment that represents purchases of cement is taken at 7.5 percent. A national average price for cement is used to convert the purchases of cement to tonnages. The tonnage figures are allocated to the regions in proportion to the historical allocations. Infrastructure construction increase is based on historical expenditures and projected to increase annually at about 9 percent. The proportion representing cement purchase is 5 percent. The historical allocation to regions is used.

The results are summarized in Table 2 for each alternative. Cement productive capacities by region are taken from the findings of the field work in early 1972, when each factory in the country was visited. A summary of the findings is given in Appendix D, Section 2.

It will be noted that the largest deficits could occur in the Central Region, which represents around 35% of the national consumption. The Atlantic Coast region, at about 17% of the national market, is the best served especially since exports of cement also occur from this region. The present level of cement exports is 200,000 tons annually, and the Caribbean coast producers believe this level will rise to 400,000 tons within a few years. This export capability would be jeopardized, if it were required that domestic needs for cement take precedence over exports. Finally, it will be noted that the Northeast region, at 7% of the national market, could represent the region where shortages will occur at the

TABLE 2

ALTERNATIVE PROJECTIONS OF REGIONAL DEFICITS

(Thousand of Tons)

REGION		Alternative 1	Alternative 2	Alternative 3
Atlantic Coast	1973	-	-	-
	1974	-	-	-
(17%)*	1975	-	10	61
Northwest	1973	-	-	-
	1974	-	47	73
(19%)	1975	35	163	220
Southwest	1973	-	-	-
	1974	-	-	-
(22%)	1975	-	88	154
Central	1973	-	17	29
	1974	41	189	237
(35%)	1975	165	402	507
Northeast	1973	20	38	41
	1974	43	72	82
(7%)	1975	68	115	136
TOTAL	1973	20	55	70
	1974	84	308	392
	1975	268	778	1117

* The percentages in parentheses indicate the regional participation in total national sales of cement.

earliest time. No new capacity is currently planned for this region.

New production facilities could easily require a period of three years or more to justify, construct and commission. Thus, there seems to be a clear indication that the country could be short of cement in the meantime. It is less clear, however, how extensive the shortages will be. The attempts above to estimate the growth of investment in construction can raise more questions than they answer because of the fundamental assumptions needed in order to make the calculations. Thus, any plan designed to assure adequate cement supplies must not only provide for the long-term needs as soon as they occur, but also provide for short-term needs that are at present difficult to estimate.

The two alternatives for the further expansion of the Colombian cement industry are discussed in Appendix D, Section 3. One is based on choosing a suitable central location with a large productive capacity per unit and employing a modern rail-based cement distribution system. The other is based on increasing capacity in selected existing regional locations. A production increase of the latter type is now being planned near Belencito by both Cementos Boyacá and Acerías Paz del Río as alternative projects to use surplus locally available blast-furnace slag. Another is an increase in production from existing capacity which is being considered by Cementos del Nare through the transport of clinker to Bogotá for grinding to cement at that location.

A modern rail-based cement distribution system is the key to transforming the Colombian pattern of demand and supply from a regional character to a national character. It would have the effect of transferring supplies from regions of surplus production capacity to regions of deficits in cement supplies at a cost low enough to meet the prevailing market prices. The reasons for this potential are that the railway infrastructure linking the regions already exists, and that the technology to reduce transport costs also exists in the form of unit-train haulage of bulk cement on a shuttle basis.

The experiences in Great Britain are particularly appropriate, and they are described in Appendix D, Section 4. The use of the existing railway infrastructure in this way seems to be an excellent prospect to consider for alleviating future shortages of cement in the short term through the diversion of exports to the national markets or the distribution of imports of cement to the national markets.

3. Objectives

Thus, it can now be seen that in the past periodic cement shortages have occurred regionally, particularly in the Central Zone. The indications are such shortages have occurred because of the difficulty, or the cost, of moving cement internally over long distances. Furthermore, industry policy has been cautious and conservative when expansion plans were being considered. Because of this, the consumption figures represented in Figure 3 most likely do not reflect unsatisfied demand.

Policies that tend to be conservative in increasing expansion of capacity at the same pace as demand increases, tend to raise the cost of public construction in two ways, namely:

- tight supplies produce strong pressure to raise cement prices; and
- shortages lead to unnecessary increases in construction costs because delays are introduced into completion schedules and construction labor becomes less productive.

Thus, from the broad point of view of National Plan implementation, new productive capacity should be built in a manner that will assure achieving two objectives, namely:

- that the cost of the new cement at the markets is the minimum reasonable considering the appropriate use of available technology; and

- that the quantity produced is adequate to avoid shortages, nationally or regionally, as the volume of new construction increases, or as export markets grow.

Incentives should be identified such that the condition established for attaining the two objectives are preserved. Achieving the objectives in this manner will then act to reduce costs in public construction, and through this provide greater productivity from the national resources to be devoted to it. Moreover, there will be less of a threat of loss of export opportunities for cement that would impair the country's short or long term foreign exchange position.

4. Action Principles

Five principles should guide and determine any action that can achieve the two objectives simultaneously. They are:

- three years is a minimum period for justifying, constructing, and commissioning new cement production facilities;
- because of foreign exchange restrictions, the simple alternative of a direct import of cement to meet shortages that arise before new production facilities are available should be avoided;
- the country's growing position in the export of cement to its natural market should not be harmed;
- an acceptable solution must be found to supply the short-term cement needs before new production facilities become available; and
- the present regional character of the pattern of demand and supply of cement should be eliminated in favor of a national pattern.

5. Action Steps

A set of coordinated action steps to meet the nation's short-term and long-term needs for cement is shown in Figure 4. The set of steps shown constitutes the Action Plan. Numbers in parentheses in the description which follows are those shown in Figure 4.

The present supply position for cement in the country is now well known (See Appendix D, Section 2). Three opportunities were found to increase supplies quickly without significant investment of time delay. One is based on using by-product slag from the blast furnace in the Belencito plant of Acerías Paz del Rio in the facilities of Cementos Boyacá. Another exists at Tolcementos, and concerns the inadequate design of the suspension-preheater system. Gas passages in crucial locations are too narrow, and plugging by condensed sodium and potassium salts frequently occurs, requiring the shut-down of plant for cleaning. Only by careful selection of raw materials low in these elements can the plant operate as much as 280 days per year. Normal operation would usually be 330 to 340 days per year. A redesign of the preheater is indicated. The third is the prospect that surplus clinker manufacturing capacity at Nare can be utilized by shipping clinker to Bogotá (the zone of periodic shorgages) by rail and there grinding it to cement. A surplus mill for this purpose already exists in the country.

A task-force approach will be used (1.0). This group will be given the responsibility for accomplishing the action steps specified below and the corresponding authority to proceed as it sees necessary. Its mission will begin immediately upon its establishment, and will end when the then existing cement production capacity is (a) clearly adequate to meet domestic and export needs, and (b) this capacity operates so that the two objectives of minimum price and adequate supply are achieved (4.0).

A demand-monitoring scheme taking advantage of high-speed data processing techniques will be launched (1.1). It will be designed to

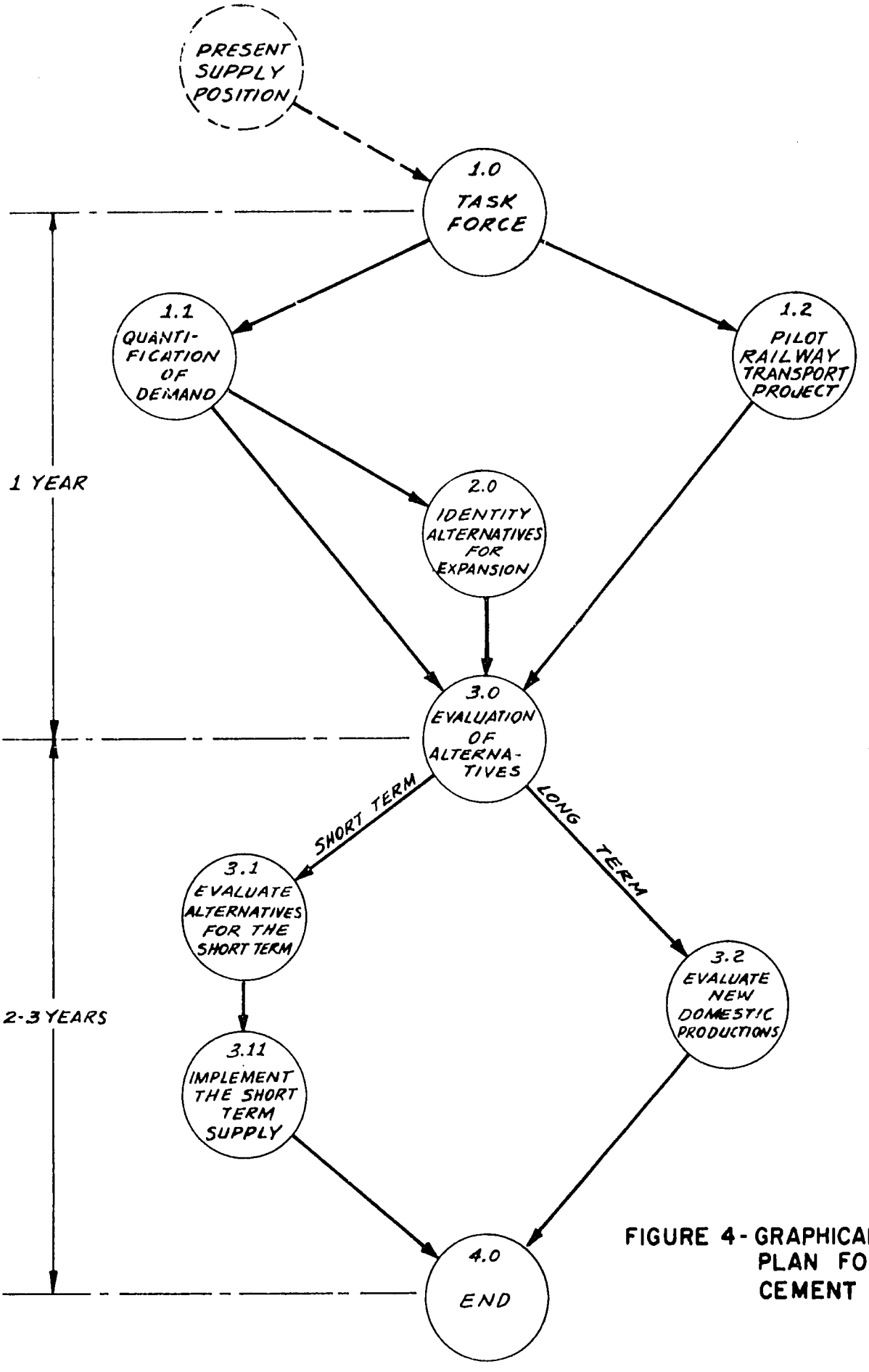


FIGURE 4 - GRAPHICAL ACTION PLAN FOR THE CEMENT INDUSTRY

monitor growth in cement demand and to detect trends in demand growth on a regional basis through correlation with selected indicators. These indicators may include the current levels of savings and of granting construction loans and the current volume of construction contract awards, as examples. Primary sources of cement supply in the country can be monitored, as well as the activities of all major savings institutions which serve as a source of construction funds.

The objective will be to design, establish, and operate a fact-gathering system that will be capable of monitoring cement demand at frequent intervals (perhaps monthly or quarterly), and to compare this demand with the industry's actual supply position. The comparison will detect imminent cement deficits, the timing of their occurrences, the quantities involved, and the market centers affected. Each periodic set of such data, together with historical data, could be continuous inputs to a forecasting model, whose coefficients could be corrected as each new set of data points becomes available.

The output of the system will be used for two purposes, namely:

- the determination of short-term deficit quantities, and
- the determination of the desirable level of domestic cement production.

A pilot transport scheme (1.2) will be established for two different railway lines, in which one train (at least at the beginning) will be occupied full time shuttling back-and-forth transporting cement. One scheme will operate carrying cement in bulk between Cementos Boyacá at Nobsa and their cement depot in Bogotá. The other scheme will operate carrying cement clinker between Cementos del Nare and a new clinker grinding plant to be established in Bogotá. The objectives should be (a) to determine the actual costs for each operation as the basis for establishing the realistic rate to be charged ultimately, and to demonstrate the reliability of the operation. Some investment will be required

for connecting the rail line at Sogamoso to the cement plant, for altering rolling stock, and for terminal facilities. In addition, investment in a clinker grinding facility in Bogotá is required. The investment will be sensitive to the initial train capacity selected. The cost data thus developed from the experience can later be evaluated to determine realistic rates to cover such transport of cement between locations through the country. In addition, technical designs for the rolling stock and terminal equipment will be proved, or improved.

The cost of the pilot scheme for the transport of bulk cement from Nobsa to Bogotá should be financed primarily by the elimination of the cost of the corresponding road transport for the quantity of cement shipped by rail; and secondarily by the granting of a loan to the railway by the Government with appropriate terms. The cost of the pilot scheme for the transport of cement clinker from Nare to Bogotá should be financed primarily by reaching an agreement on the cost of transport of clinker that can be tolerated in view of a number of factors such as clinker production costs at Nare, grinding costs at Bogotá, and the market price for cement in the Bogotá area; and secondarily by granting of a loan to the railway by the Government with appropriate terms. Also, both pilot projects should be evaluated as a unit to determine whether the need for secondary financing can be reduced.

The justification for the Government to consider secondary financing arises from a number of foreseeable benefits. First, as already noted the experience and knowledge of costs for the unit-train technology can lead to the conversion of the pattern of demand and supply for cement in Colombia to a national rather than a regional one; and surplus cement production capacity in one region while deficits exist in other regions can be eliminated while reducing the need for investment in new production capacity. The concept can be extended to other commodities such as coal, particularly with respect to the present plan to increase the export of Colombian metallurgical coal. Rail transport of commodities now moving by road could be stimulated because of the potential thus generated to reduce rates.

As knowledge of the demand and supply trends is developed, a stage will be reached when it becomes obvious that new production capacity should be considered. In Tasks (2.0), the alternative locations where such new capacity should be built will be identified. For each alternative, and from the knowledge of distribution costs developed from the railway pilot schemes, an evaluation of the cost of production and distribution will be made (3.0) to select the appropriate project for construction. At the same time, the position for short term supply will be reviewed to determine whether it will be necessary to import cement during the construction period.

If a decision is taken to import cement, the two alternatives (3.1) are a straight forward import which would require an expenditure of foreign exchange, or a diversion of exports which would reduce foreign exchange earnings. The decision between the two would be implemented (3.11).

Regardless of the decision regarding import of cement or diversion of cement exports (3.0), arrangements will be made for new domestic cement production (3.2). It appears at this time, that planning for basic new capacity should be based on the utilization of the large high-quality, easily-accessible limestone reserves that exist along the Rio Nare near its confluence with the Rio Magdalena, as the most promising candidate to achieve the two objectives of minimum production cost and adequate supplies. These reserves are only superficially used by Mármoles y Cementos del Nare, and the prospects for low-cost rail transportation from that location to the major market centers could be promising.

Planning based on the Nare limestone reserves should focus on the following factors:

- The use of modern cement manufacturing technology, appropriate for Colombian conditions.

- The use of nearby reserves of natural gas and coal that could be delivered at a low cost. Residual fuel oil, although also readily available nearby from the refinery at Barrancabermeja, should be avoided because it is an export commodity due to its low sulfur content.
- The selection of a location accessible to the Colombian railway network. The network reaches all the major cement marketing centers.
- The selection of a location on the Rio Magdalena which permits the plant output to be exported.
- The use of the technology for low-cost rail haulage in bulk by shuttle-train over long distances based on the experiences to be developed from the two railway pilot schemes (1.2).
- The use of a maximum unit-size of kiln for the total plant capacity, indicated to be about 2,000 tons/day.
- The probable use of the wet-process if the limestone is to be transported from quarry to plant as a slurry pumped through a pipeline.
- A design of the distribution system to take advantage of the central location such that the different market centers can readily be served as regional demands vary.

B. BURNED-CLAY PRODUCTS

This section presents an action plan for the Colombian burned-clay products industry to assure that it can preserve its labor-intensive character and still compete in the markets for its products in new housing construction.

1. Summary

The action plan is based on the results of an intensive investigation of the operations of the sector in the major producing centers of the

country. On the supply side, the investigation included a visit by a Government mission to a representative sampling of enterprises in the Bogotá, Medellin, Cali, and the Manizales-Pereira-Armenia-Cartago (MPAC) area; during which up-to-date observation of the operations and productive capability of the industry were made.

Brick/tile products differ from cement since substitution is possible by cement block, for example. This substitution is particularly prevalent along the Atlantic Coast area of the country where clay deposits, and hence locally made brick/tile, are scarce. The product is low-valued, of high density, and difficult to handle. Hence, producers typically ship their products over a limited geographical area, and are usually located so as to serve a single large urban center, or several medium-sized centers within the area.

The technical problems of the sector have recently been investigated and identified by the Institute for Technological Investigations (IIT) so that the technical means for improving production efficiency are now known.

A trial projection of demand for brick/tile, subject to the same limitations as in the case of projecting demand for cement, shows shortages developing with one or two years depending on the regional center. However, a certain amount of substitution is possible for brick/tile products by cement block assuming that adequate cement supplies are available, and depending on the production capability of the cement-block industry in the regional centers.

Considerable opportunity exists to increase the output of the brick/tile sector as it now exists with nominal investment in physical equipment, by increasing the efficiency of production of the medium and smaller producers. This would help the sector to meet market demands, and thereby avoid a usage of cement which is expected to be in short supply.

Thus, the overall conclusion of the investigations is that the brick/tile products sector should be encouraged to increase its efficiency, and to increase its production capability, at the appropriate time when market growth occurs.

A plan to achieve such a result is based on a two-stage series of actions. In the first, the objective is to know precisely the difference in installed cost and performance of three alternative exterior building wall and interior partition constructions, namely: brick/tile; cement block; and a more capital-intensive shop-fabricated pre-assembled construction. In the second step, the objective is to use the results to guide the brick/tile product sector into a position of maximum competitiveness with alternative construction technologies, consistent with a level of profitability that encourages expansion to meet demand.

The means to achieve the second-stage objective is emphasis on

- Increasing production efficiency;
- Improving quality control; and
- Introducing the manufacture and distribution of a non-portland masonry cement, which will reduce the cost of erecting brick walls more than for erecting cement block walls.

2. Background

The significant brick/tile manufacturing regions of Colombia are centered on

- Bogotá
- Medellin
- Cali
- Manizales-Pereira-Armenia-Cartago (MPAC).

In each region, distinct manufacturing enterprises exist characterized by size of output as follows:

- Large - more than 2-million units/month
- Medium - 800,000 to 2-million units/month
- Small - 100,000 units/month
- Chircales - up to 100,000 units/month

The producers in each region seldom, if ever, ship their output outside of the region.

The technical operations of the brick/tile manufacturing industry, particularly the smaller enterprises, have been the concern of the Institute for Technological Investigations (IIT), which completed a study of its operations in April 1972. They found numerous technical opportunities whereby the efficiency of production could be increased, i.e. by obtaining more units of output from the existing facilities through introducing technical change. A summary of the findings is shown in Table 3.

Appendix D, Section 5, contains a description of the present situation in terms of markets, technological and industrial structure, distribution and trade, and the factors in production; and also in terms of production, installed capacity and expansions in progress. The actual situation is one of variable levels of utilization of existing capacity, e.g. Bogotá 82% average and MPAC 66% average. Over capacity where it exists could disappear within one year.

Quality levels are probably set by the largest producer (in Bogotá) whose output can reach 12-million units/month. His plant is automated, and products are uniform in size, color, and strength. The two large plants in Cali can produce 1.5 million units/month. Dimensions may vary with the producing region. Colombian national standards for brick and tile are currently being developed. The smaller plants and the chircales frequently offer unevenly burned, warped, and generally poorer quality brick and tile. Brick and tile walls are set in portland-cement mortar; no masonry cement or mortar is produced or used in the country.

TABLE 3

AREAS OFFERING OPPORTUNITIES TO I
EFFICIENCY OF MEDIUM AND SMALL MA
Identified in IIT Report (April 1972)

1. Raw Materials

The improvement of mining techniques to overcome seasonal high underground-water levels that interfere with the extraction of clay.

The emphasis on mass collection and storage of raw material at one time in preference to day-by-day mining in small quantities. This technique provides the aging time needed to improve clay workability, and could help overcome poor mining conditions because of seasonally high underground-water levels.

A better knowledge of the variations of clay quality within a given pit to enable proper blending techniques to be identified and practiced

The selective mining of the clay to avoid undesirable inclusions such as tree roots and pebbles.

2. Forming and Shaping

The encouragement of the production and greater utilization of locally-made forming and shaping machines with ready availability of spare parts and service. These might be based on designs of imported machines.

The proportioning of the composition of a clay batch and soaking the batch in water for some time before feeding the machines, especially when only small moulding machines are available.

The use of a conveyor system to feed the machines, and a pneumatic-tire cart for conveying the formed shapes to the drying area in a careful manner.

3. Drying

The introduction of drying chambers of local design to replace open-air drying practices now in wide use.

4. Firing

The improvement of firing equipme
formly burned bricks. This could
of the updraft firing system, and
of either a continuous tunnel kil
through a continuous and steady f
of furnace in which the brick rem
moves. A less desirable alternat
the use of the downdraft rectangu
but this is perhaps the only meth
are less than 100,000 units/month

The improvement of firing techniq
coffee shells by admixing measure
oil, to provide the proper flame
process. If this requires high p
mix the cost incentive to use cof
reviewed.

5. Quality Control

The establishment of regional imp
laboratories near brick-making ce
certify, conformity of periodic s
standard, size, strength, and app
Also, the laboratory could assist
materials extracted from the pit.

Performing in-plant testing of br
detect deviations from specificat
and thus enable corrections to be

BLE 3

NITIES TO IMPROVE OUTPUT
ND SMALL MANUFACTURERS
pril 1972) by BM Sedalia (UNIDO)

ing equipment to produce more uni-
This could involve avoiding the use
system, and the gradual introduction
tunnel kiln in which the brick moves
nd steady fire zone, or the Hoffman-type
e brick remains stationary and the fire
le alternative in terms of rejects is
ft rectangular furnace with chimney,
e only method when production levels
units/month.

ing techniques where the main fuel is
ing measured amounts of coal, or fuel
oper flame conditions for the burning
ires high proportions of fuel in the
to use coffee shells should be

egional impartial quality-control
k-making centers to pass on, or
periodic samples with the established
th, and appearance would be measured.
ould assist in evaluating the clay
om the pit.

sting of brick in production to
specifications and standards quickly,
tions to be made early.

6. Institutional

Emphasis on increased training of the operating personnel, and the training of new personnel, in terms of giving them understanding of the technological practices involved and of the proper maintenance of equipment.

Instilling in the entrepreneurs the desire to improve the product quality and to penetrate the more sophisticated markets where consistent quality and standardization are important.

Encourage investment in new brick and tile manufacturing capacity but only at the medium-sized level.

Encourage specialization of products for a more appropriate balance of capital and labor by restricting perforated brick and hollow tile manufacture to the more-mechanized plants and solid bricks to the less-mechanized plants.

Introduce mechanization into the small producers, for example by grouping them into cooperatives to utilize a single forming machine in connection with the operation of the members' individual furnaces.

A brick-making facility of standard size will produce about 1 million solid bricks per month in a one-shift operation. The investment to construct such an activity may be in the order of 10-million pesos. The smaller enterprises have developed from the use of extensive labor and from the use of second-hand machinery and equipment that in many cases can be described as "makeshift".

Distribution practices include direct delivery from the factory to the contractor's construction site, pick up by the contractor's trucks at the factory, and distribution from dealer's stocks to the contractor. Prices are established either at the factory-gate or at warehouses, with transport costs to the construction site paid in addition.

In summary, clay resources abound in the country. Brick and tile products manufactured from them are widely used in construction of building in all regional areas except the Atlantic Coast (where the clay resources are poor). The industry is labor intensive, although the quality of the products tend to deteriorate as labor intensity increases. Technological problems in the industry bearing on competitiveness and quality control are now well known. Because an action plan for the cement industry to assure adequate supplies of cement is now identified, substitution by cement block products should become practical, if shortages develop in brick/tile supplies.

3. Objectives

Thus, the objective to be achieved is to avoid the substitution of brick/tile products with products based on cement, by undertaking technological actions to increase supply of burned-clay products while reducing the cost of production. In this way, some of the demand for cement would be relieved, and corresponding new capital-intensive investment in the cement industry would be avoided.

Achieving such an objective would also, in effect, reduce costs in public construction (particularly in building construction) through

the introduction of an unrestricted competition between two totally different technological approaches to the construction of exterior and interior building walls and partitions.

4. Action Principles

Four principles should guide and determine the set of actions that can achieve the objective. They are:

- Focus on a comparison of total costs at the level of finished wall and partition installations;
- Concentrate as a first step on the medium and small industry enterprises and on the chircale producers using the results of the technological investigations of the IIT; and
- As a second step, should the rate of progress not be adequate to support the rate of implementation of the National Plan, concentrate on constructing new large modern brick manufacturing facilities, and/or cooperate with medium producers who are willing and able to expand with the technology identified by IIT.

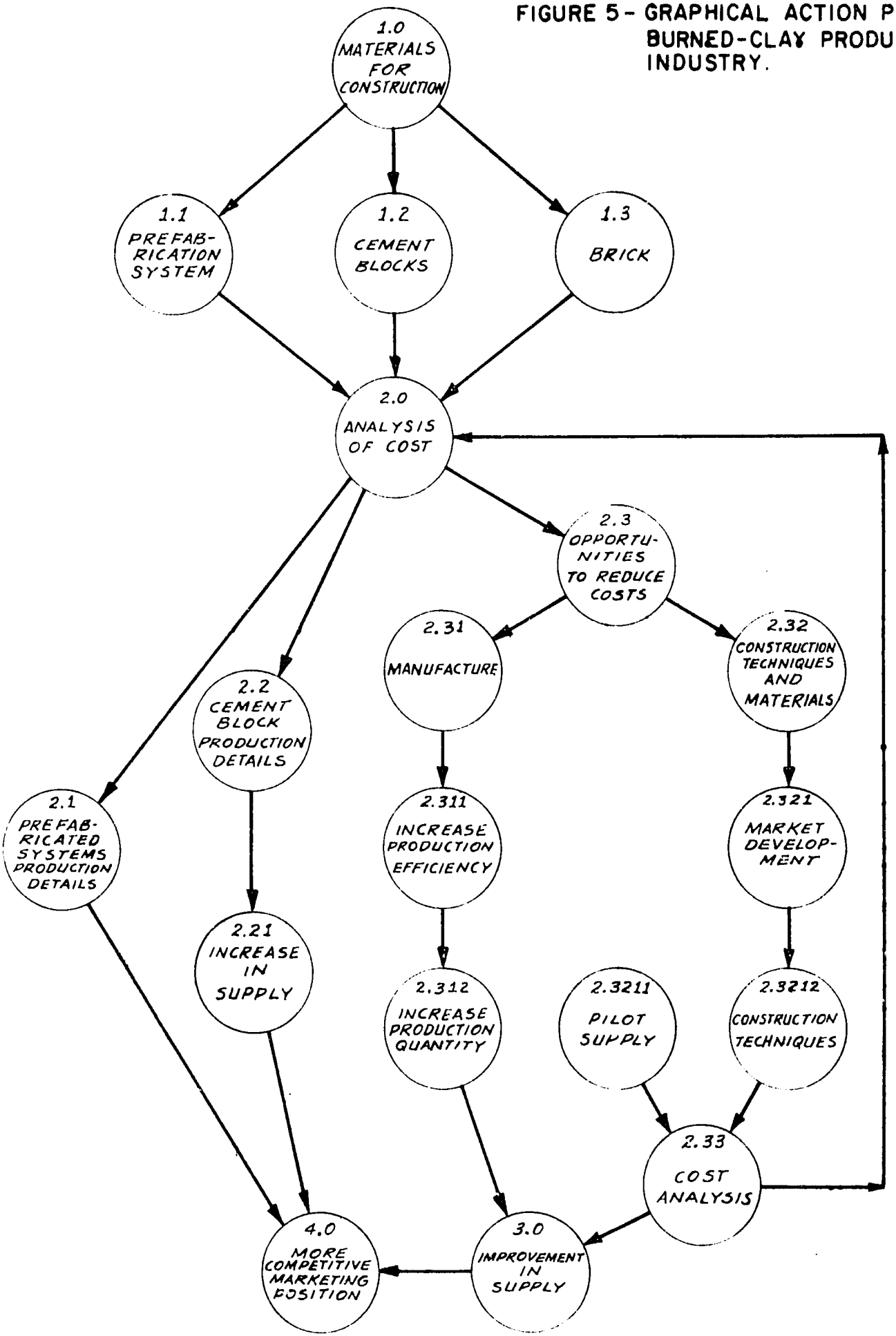
5. Action Steps

The individual actions in the plan are shown graphically in Figure 5. The actions group into two sets, one to be accomplished before the other. Figures in parentheses correspond to those in Figure 5.

a. Step One

The objective in this step is to have a comprehensive and detailed comparison of the performance and the installed costs of alternative interior partition and external wall constructions for buildings based on current practices. The three candidate constructions are:

FIGURE 5 - GRAPHICAL ACTION PLAN BURNED-CLAY PRODUCTS INDUSTRY.



- shop-assembled prefabricated systems that probably require some acceptable level of foreign exchange, and that act to reduce field labor by substituting shop labor and capital investment (1.1).
- cement blocks of various sizes, shapes, and compositions laid-up in portland-cement mortar (1.2), and
- brick/tile of various sizes and shapes laid up in portland-cement mortar (1.3).

The specific result of the comparison of installed costs will be the knowledge of how much reduction in production cost for brick/tile manufacture is needed, if any, in order that the installed cost of brick walls is not greater than that for concrete block walls. Another result will be to know whether the installed costs of either brick/tile or cement block walls need to be reduced in comparison with that for prefabricated constructions. Considerable data for this step may already by available through the work of the Division of Urban and Housing Development (See Appendix C).

b. Step Two

The objective in this step will be to produce a situation of competition in marketing between cement block and brick/tile by completing a number of actions as follows:

- Identify the position of prefabricated-wall systems in Colombia in terms of present scope of supply, import needs, performance of the installation; and evaluate this position as a guide to actions for the alternatives (2.1).
- Identify the present position of supply of cement block products, presuming adequate availability of cement (2.2), and determine the need for new investment to assure adequate supplies in the regional markets (2.21).

- Undertake to implement the cost-reduction opportunities in the brick/tile sector (2.3) on two fronts namely: in the manufacturing process (2.31); and in the technology of the construction itself (2.32). In the latter, consider the introduction and the use of non-portland cement mortar. Such a product will rely on the slag produced at the Paz del Rio steel works as a raw material.

- Implement the opportunities to increase production efficiency, including quality improvements guided by the cost picture developed in Step One and the opportunities shown in Table 3 (2.311).

- The incentive of the entrepreneur to extend his cooperation on should be recognition of the potential to increase the profitability of his activities at current production levels.

- As the result, production in existing facilities may increase, and the improved profitability picture encourages new investment for expansion (2.312).

- Identify the problems involved in introducing the developing markets for non-portland cement mortars (2.321).

- Arrange for the manufacture of pilot quantities of mortars in selected specifications (2.3211). Cementos Boyacá is probably a logical source to manufacture small quantities for use in development works.

- Arrange for experimental development work on the technology of construction of brick walls with the mortar samples, and for the collection of data for cost analysis (2.3212).

- Undertake cost analyses to evaluate the incentive to manufacture the mortar product selected, and to overcome the problems and resistances to creating the markets (2.33). Feed back the results to the Step One cost analysis (2.0)

to reassess ultimate relative competitive prices between cement block and brick/tile products.

The result is then a technical and cost improvement in the brick and tile supply position (3.0), and the achievement of the objective (4.0).

VI. STEPS TO ACHIEVEMENT

A. RESPONSIVENESS TO GOALS

The goals for the activities of Ad-Hoc project were set in the Project Statement (Appendix A). The goals and the means foreseen to accomplish them may be restated in the following manner.

- Definition of costs. This was established in a broad sense. The implications of reductions in financial costs on labor employment, on foreign exchange procedures, and on the aspects of value in the engineering practices on which the construction activities are based, were to be considered.

- Scope of Orientation. This was established in the sense of being responsive to the goals of the National Development Plan and to the prevailing commitments to continued infrastructure development.

- Continuation of the Work. This was established as recognizing the long-term nature of the cost-reduction effort, but also on recognizing that results of immediate usefulness continually require justification to continue toward the long-term goals.

- Completion of Ad-Hoc Stages. This was established as the conducting of a conference/seminar for the project for a selected audience in order to obtain reactions and comments of a practical nature for incorporation into the final report for the Ad-Hoc stage.

- Participation. This was established see Page 22 of the Project Statement, Appendix A, as full-time for selected government organizations and as periodic specific assistance from a list of 21 organizations.

The Ad-Hoc Group was able in the time available for the project to achieve the goals, completely in some cases, and with varying degrees of achievement in other cases.

1. Definition of Costs

The Group consistently responded to the need for a broad viewpoint. The analytical tools that have been identified for use in the road and highway construction sector ultimately will produce a quantitative basis for policy formulation that can assure the nation of the use of construction technology that is effectively practiced, and which is most responsive to national desires concerning actual cost, labor-employment opportunity, foreign exchange demand, and balance between current and deferred costs of construction practices (i.e., maintenance policy formulation for roads and highways).

At the same time, where appropriate, the Group took a narrow view of costs in order to identify immediate practical actions to reduce costs which could have longer-term implications to reduce costs in the broader sense. A good example is the emphasis on the transfer of unit-train-shuttle technology to Colombia for use in the transport of cement. A concerted and consistent effort on managing properly the two pilot schemes defined in the cement Industry Action Plan can eventually serve as a means of converting the patterns of demand and supply for cement from a regional one to a national one. The result would be a relief from pressure to raise cement prices whether because of the commercial and business practices of the industry or from inflation, and also a better utilization of existing productive capacity with the consequent reduction of demand on foreign exchange for new construction of capacity.

2. Scope of Orientation

The three action plans covver the areas of major interest for the implementation of the National Development Plan and essentially all the aspects that have been described in the Project Statement. One exception is the work program that has been foreseen for the technological and cost aspects of future urban infrastructure construction (Item 3.5-Appendix A). For this program, a start has been made in the Housing Action Plan (Section IV) in the action to identify the implications on costs of housing geometry as a major input to the complex analysis involved in planning future urban infrastructure,

3. Continuation of the Work

The sum total of the actions in the three plans established by the Ad-Hoc Group show a number of actions that can be taken immediately to produce immediate or short-term results. Examples are the railway pilot scheme for unit train transport of cement, the conference-seminar to help identify where problems may exist in the housing construciton sector, the establishment of a national inventory of heavy construction equipment, and the improvement of the technological efficiency of burned-clay products manufacture. The results from these actions warrant the continuation of efforts for longer-term results, such as are represented by the development of analytical tools to improve the productivity in both the road and highway and the building construction sectors. Additional examples are the actions to forecast future cement demand more accurately, to identify low cost and adequately large new cement production facilities, to introduce new lower-cost cement products to the construction industry.

4. Completion of the Ad-Hoc Stage

The plan has been to conclude the Ad-Hoc Stage after organizing and conducting a conference and seminar in Bogota during which the findings, conclusions and recommendations would be presented and discussed. The

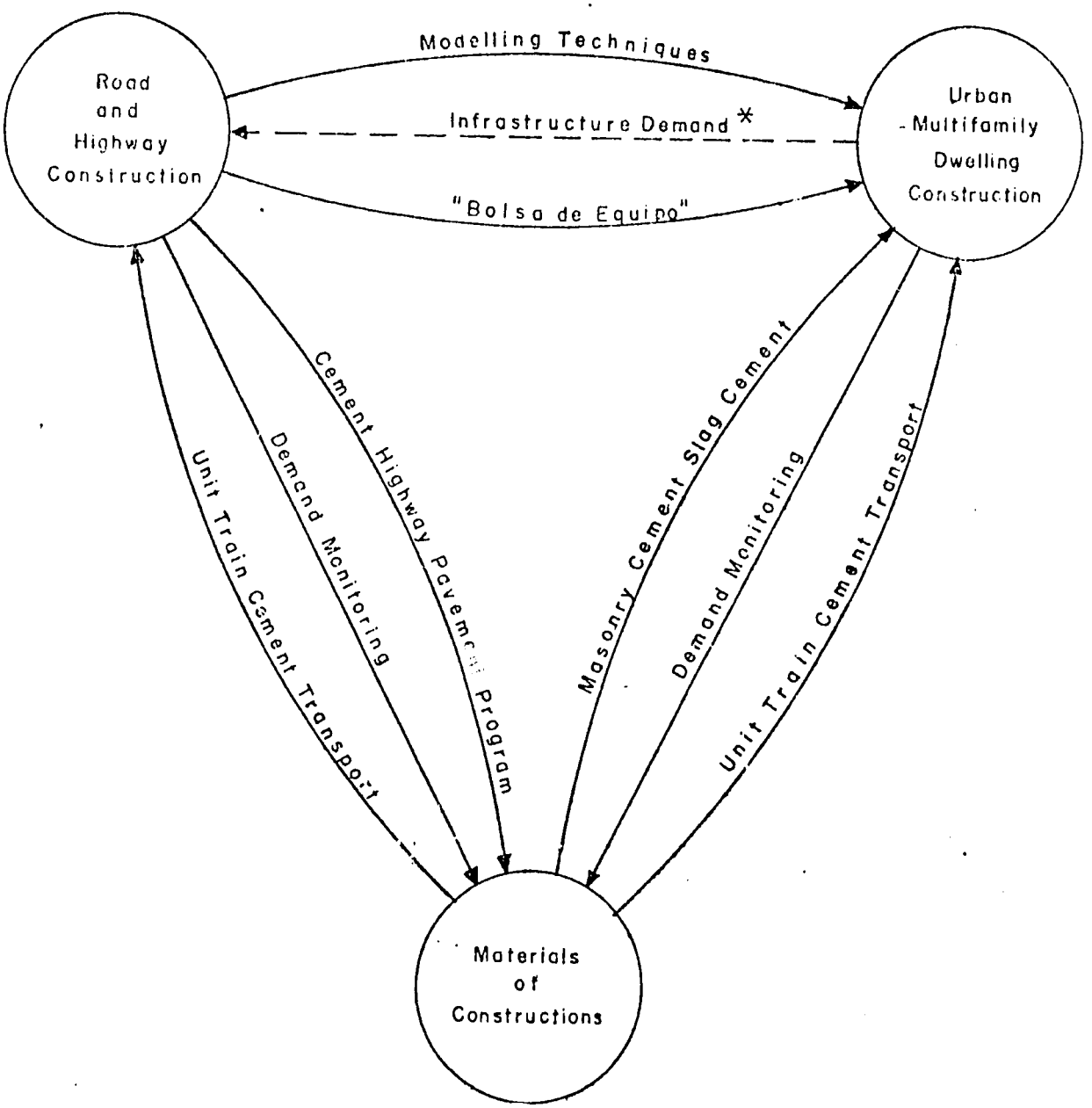
Ad-Hoc Group reached the conclusion that such a conference/seminar would not be practical, should preferably be considered as the first stage of implementation and then probably as a number of individual conferences pointed at specific topics. The reasons are the following:

- The conference would be a public affair even though limited to selected audiences. The topics represent sensitive areas in present government activity to implement the Development Plan. The direction of Planeacion should have the opportunity to review and approve the results of the work in the Ad-Hoc phase before they are made available to the public during a conference. Accordingly, the final report of the Ad-Hoc Phase is needed in advance of any conference-seminar.
- The findings are assembled as three action plans which, although there are elements in common, require specialized blends of participation in a conference. Thus, the number of participants in a single conference would become large and many participants would have little or nothing in common with each other. The effectiveness of the effort would be reduced.

B. ORGANIZING FOR IMPLEMENTATION

Figure 6 shows the linkages among the three action plans that can be readily identified at this time. These linkages represent prospective interchanges of information or results. The generation of data from infrastructure construction and from housing construction as inputs to the cement-demand-monitoring action is an example. Another, not in the scope of the Ad-Hoc project, is the infrastructure demand that will be generated by the housing construction activity.

The linkages also represent a community of disciplines that will exist. The example is the experiences gained in the techniques of modeling and their application, which will be accumulated in the action



* Not in Scope of Ad-Hoc Project

FIGURE 6

LINKAGES AMONG THE ACTION PLANS

plan for roads and highway construction and which will largely be applicable to the action plan for the housing construction sector.

The development of new cement materials resulting from the materials of construction action plan will benefit the housing construction sector, and no doubt an understanding of this sector will be necessary in order to plan for market-penetration efforts. The action to introduce unit-train-shuttle concepts for cement transport will benefit both construction sectors by tempering rises in cement prices. Finally, the action to establish a national inventory of heavy road construction machinery may through the "Bolsa de Equipo" concept be useful for a more efficient utilization of equipment in housing construction.

One should then expect that the existence of such linkages lead to an immediate conclusion to organize a single effort to coordinate the three action plans and make efficient use of personnel and funds. But this is not yet practical for the reason that the linkages cannot be considered simultaneously. Some linkages will be effective in the medium to long term, and some immediately. The effects of the rest cannot be foreseen at present.

Thus, the organization for implementation of the findings of the work so far should be considered in two phases. In the first phase, the three separate efforts which have characterized the work of the Ad-Hoc Group so far should be continued. The Unit of Infrastructure should confine itself to the action plan for road and highway construction, the Division of Urban and Housing Development to the housing-construction action plan, and the Unit of Industrial and Agrarian Studies to the materials of construction action plan. A loose coordination should remain, as has been the case so far, to encourage the interchange of ideas when this seems appropriate.

Ultimately, after adequate work has been accomplished, and particularly after the results of the individual conferences and seminar have been evaluated a more formal and more unified organization should be considered.

C. ESTIMATION OF COSTS

Thus, it is more realistic at this time to defer attempts to estimate the overall costs of implementing the action plans that have been developed so far. The reasons are that costs will depend on the nature of the organization ultimately established in a second phase and the manner in which the organization chooses to operate. Some cost sharing may occur, with nongovernment organizations so that all applicable costs need not be accounted for budget planning. The cost of the work efforts can be affected by changes in the action plans as they are now formulated, particularly if the results of conferences and seminars (see following section) are significant.

However, two cost items were identified and evaluated in the work and should be reported. The first relates to the unit-train cement transport pilot schemes described in the action plan for the cement industry. The second is the action to establish a national inventory of heavy construction equipment described in the action plan for the road and highway construction sector.

The bulk-cement unit-train scheme for transport between Nobsa (Boyaca) and Bogota is thought to require a total investment of 15-million pesos between the new or revised facilities required by Cementos Boyaca and the facilities required by the railway. The cement company from its point of view would provide the cost of the investment in its own facilities and expect that the transport rate charged by the railway during the pilot stage will be sufficiently lower than current road transport costs to

enable them to recover the capital expense within a time period it considers reasonable. The railway, on the other hand, will take a greater risk to provide the difference between the costs it will incur for the transport service and the income it will receive in order to recover its share of the capital cost within a time period it considers reasonable. The fact that the costs to provide the transport service are not clearly definable for estimation in advance (hence the need for a pilot scheme) is the cause of the greater risk. Because of the potential benefits to the economy from a successful pilot scheme, the Government should consider sharing the railway's element of risk through appropriate financing.

A detailed estimated of the cost of establishing the national inventory of heavy construction equipment was made. It is presented as Table 4 in a self-explanatory form. The total cost is estimated to be 980,000 pesos.

D. THE KEY TO ACHIEVEMENT

Now that the findings from the work program are available and the responsiveness to national goals can be judged, the significant factor to be reckoned with becomes the practicality of putting the results into effect within the framework of the current practices of the public and private organizations involved in public construction. Such organizations hold individually well-defined view points consistent with their own individual goals, and they may not necessarily accept the findings of a primarily technological effort which have resulted in a different context of the concept of cost from that which they customarily understand.

A promising approach to reconcile such differences in points of view is still the original plan to provide a forum in which the differences can be aired and evaluated through discussion and argumentation. A secondary set of results would thereby be generated as a "feed-back"

TABLE 4

ESTIMATION OF COST FOR THE NATIONAL INVENTORY

BASIS			
Number of sources to be interviewed:		1,000	
Number of machines to be recorded:		50,000	
Private sector -	20,000		
Official sector -	30,000		
STAGES			
A. Collection of Data			
(1) 10 machines daily per person over a 4-month period			
53 enumerators at $2,100 per month			445,200
(2) Social Benefits (20%)			89,040
(3) Travel Expenses			127,200
	Sub-Total		661,440
B. Evaluation and Codification			
(1) Salaries: 10 persons during 4 months $2,100 each			84,000
(2) Social benefits (20%)			16,800
	Sub-Total		100,800
C. Printing of Materials			
(1) 70,000 form sets for machines at 0.15 pesos each			10,500
(2) 2,000 form sets for register at 0.20 pesos each			400
(3) 1,500 instruction manuals at 2.00 pesos each			3,000
(4) 50 critic manuals, at 50 critic manuals, at 5.00 pesos each			250
	Sub-Total		14,400
D. Card Punching and Verification			
Number of register cards per source: 3		3,000	
Number of cards per machine: 1		50,000	
	Total cards:	53,000	
Unit value of a punched and verified card: 0.70 pesos. (Includes expenses of renting of machine, salaries and social benefits for operators, services, local renting, etc.)			
53,000 x 0.70 pesos			37,100
	Sub-Total		37,100

BASIS
E. Progra
(1) Sa at
On at
(2) Sc
F. Comput
(1) Pr
(2) Pr
(3) De
Co Va
G. Techni
H. Public
(500 c
I. Contir

TABLE 4

COST FOR THE NATIONAL INVENTORY

	BASIS		
	E. Programming		
	(1) Salaries: One programmer at 5,450 pesos for 4 months		21,800
	One programming assistant at 2,540 for 4 months		10,160
	(2) Social benefits (20%)		6,392
			38,352
	F. Computer		
	(1) Program Proofing	3 hours	
445,200	(2) Program Inconsistencies	9 hours	
89,040	(3) Definition of Tabulations:	2 hours	
127,200	TOTAL	14 hours	
661,440	Cost of a computer-hour: Value: 3,000 x 14	3,000	42,000
	G. Technical Supervision		30,000
84,000	H. Publication		
16,800	(500 offprints at 10,000 pesos each)		5,000
100,800		Sub-Total	929,092
	I. Contingency (about 5%)		50,908
		Total	980,000
10,500			
400			
3,000			
250			
14,400			
37,100			
37,100			

84/A

for amending the primary results of a primarily technological effort. Thus, the key element in the project which would provide the first step in implementing the results, is to organize and conduct one or more conference-seminars. These could have the following character:

- the invitation list should include all shades of constructive opinion relevant to the topics in the work program, and the individuals should be selected from public and private organizations.
- the invitees should be provided beforehand with a set of papers reporting the details of the findings from the work program that are factual and noncontroversial. The purpose here is to provide background and a foundation upon which discussion and argumentation will be effective and efficient in generating needed feedback.
- the appropriate action plan which has resulted from the completion of the work program should be prepared beforehand and presented publicly for the first time at the conference.
- sufficient number of objective "listeners" should attend the conference to cover all of the activities, and then be able to identify and evaluate the feedback information in the detail needed to justify revisions to the action plan.
- the organization of the conference should provide for subdividing the conferees into groups according to the individual topics to be covered and according to the need to avoid mixing divergent and unrelated interests in the discussions.
- the organizer of the conference-seminars should be the groups given the responsibility for the implementation of the findings of this Ad-Hoc project, some of which have already been identified in the action plans.

APPENDIX A

THE PROJECT STATEMENT

DOCUMENT DNP - 846 - UINF

DEPARTAMENTO NACIONAL DE PLANEACION

22 February 1972

Republic of Colombia

NATIONAL PLANNING DEPARTMENT

IDENTIFICATION OF OPPORTUNITIES FOR COSTS REDUCTION OF CONSTRUCTION IN PUBLIC WORKS

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22 February 1972

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1. INTRODUCTION

1.1 Background.

The Government of Colombia, through the Departamento Nacional de Planeación and other official organizations, is interested in undertaking a study to identify the ways and means to reduce costs in the construction of public works. These costs may be distorted because of the use of technologies inappropriate to Colombian conditions, or because of the existence of institutional practices that lead to inefficiencies in the implementation of public construction projects.

Distortions may arise, for example, from an excessive reliance on imports, or from a level of coordination among the individual construction activities that is inadequate to produce a high overall efficiency in the realization of construction projects. Also, costs may be distorted because prevailing orientations of government and private organizations are polarized, that is, each organization operates in its own well-defined channel of interest and activities.

At the same time, the U.S. Agency for International Development has shown interest in undertaking a prototype study of a similar nature. This mutual interest led to an agreement wherein the Departamento Nacional de Planeación will organize and carry out a project in which AID will participate along with other Colombian organizations. Although the emphasis in the work will be on public construction, the results no doubt will be useful in private construction.

In order to coordinate effectively the efforts of the various participants in the work to be undertaken, a Project Statement has been prepared. It includes the terms of reference for the individual programs of work and the general method for accomplishment. If found desireable during the work , the Project Statement may be revised.

The Project Statement follows.

1.2 Basic Procedure.

The National Plan of Development for Colombia, adopted by the Government in 1971, emphasizes construction activities as one of the strategic sectors for development. The aim of this emphasis is the generation of more and better paying jobs, consistent with a policy of redistributing income. A translation of the official Summary of the Development Plan is attached as Appendix A.

The project, concerned with the identification of opportunities to reduce costs in construction, is designed to be consistent with the policies and objectives in the Plan. This project will be a tool that should identify the quantitative measures which Government might adopt in the future for implementing the development strategy for increasing construction, for example. Findings from the project can also serve to stretch national resources for more productive construction with the desired generation of employment opportunities.

In order to implement the Project, the Government through Planeación Nacional, has formed an "Ad-Hoc" Group comprising representatives of official organizations interested in the subject, both Government and private. AID has delegated its participation in the Group to the firm of consultants, Arthur D. Little, Inc. of Cambridge, Massachusetts.

Since the construction sector represents a vast and diverse field of activity, the project will focus on the field of public works in which will be the construction of housing and highways and roads, in the broadest sense.

The work program which this project will represent, is seen to be the initial effort of a long-term effort that, ultimately, will provide detailed analyses of specific activities within the construction sector, e.g. the planning, the programming, and the design stages through to the actual construction efforts. Therefore, the Project does not pretend to provide an exhaustive treatment of the topics to be proposed at first, but rather to set forth the primary basis for continued work of investigation and evaluation of the various aspects of construction. The ultimate aim will be to have a better knowledge of the needs and the resources, and of the procedures and the problems that are susceptible to correction by means of coordinated efforts and better information. The immediate aim will be to select work programs that will produce results of immediate usefulness.

The first stage of the project is expected to require about five months for completion.

2.0 OBJECTIVES AND SCOPE.

The objectives in the first stage of the Project are the following:

2.1 To set forth the initial investigative efforts to identify opportunities to reduce costs in public construction, using an orientation broad enough to encompass the various activities in Colombian public works construction as envisaged in the Plan.

2.2 Fron the results of such initial efforts, to determine whether further efforts should be undertaken in the future, and if so, the nature of these efforts;

2.3 If the results are affirmative, to recommend the form of organization that should be established to take the responsibility for continuing the efforts; and

2.4 To establish the work program for the organization recommended, which promises maximum realization of savings in the costs of public construction consistent with the objectives of the Plan.

The scope of the efforts to be undertaken during the first stage of the project to meet the objectives above, is the following:

2.5 The level of detail to be undertaken in each work program will be selected so that the first stage of the project can be completed by about June 1972.

2.6 The specific topics to investigated will be the following:

- The Colombian Cement Industry
- The Production and Distribution of Burned-Clay Products in Colombia.
- Road and Highway Construction and Maintenance.
- The Technological and Cost aspects of Vertical, Multi-Unit Housing - A Case Study.
- The Technological and Cost Aspects of Future Urban Infrastructure Construction.

2.7 Costs will be considered in a broad sense, i. e. in the sense of understanding the implications that savings in costs will have for the generation of employment opportunities, for the levels of skills involved in these opportunities, and for reduction in the importation of construction materials and technology.

3.0 WORK PROGRAMS.

The terms of reference for each of the topics noted above will tentatively be as given below. Two of the topics are in the field of construction materials, one in road transport, one in housing construction, and one as a planning tool to help optimize future urban infrastructure costs.

With respect to construction materials, the manufacturing industries involved provide an input to the construction process. Activities in these industries represent a field of investigation to identify potential cost reductions, either because shortages in the future will affect the stability of prices and/or will raise costs because of construction delays; or because the adoption of alternative manufacturing technologies that are more appropriate to national objectives (as specified in the Plan) can make better use of available national resources; or because of a combination of both reasons.

3.1 The Colombian Cement Industry.

The foreseeable requirements of the Plan for cement and the present productive capacity of the Colombian Cement Industry (both installed and now under construction) point to a serious shortage developing as the Plan is implemented. A recent study bassed on projecting cement demand national using the conventional economic parameters of growth. Indicated that supply would be able to meet

demand through about 1976. But , the general development plan of 1971, through its focus on construction activity, is expected to change the forecast of cement demand. At the same time, although national supply/demand has been in balance, regional shortages of supply have frequently ocurred.

Accordingly the objective of the work program will be to identify the alternative technical-economic methods by which the industry can expand its capacity and the implications of each method with respect to the objectives of the plan.

The following individual tasks will be undertaken in order to objective of the work program.

3.1.1 Visit, as far as practical, each cement manufacturing facility in the country, and determine for each :

- the present installed productive capacity.
- the total production from the facility in 1971.
- whether new capacity is under construction, or planned, and, if so, how much.
- the market areas being served, and the distribution method to reach these market areas.
- the specifications of the products marketed.
- the reserves and locations of raw materials to support present and planned capacity, and the method of procurement of the raw materials.

- the physical condition of the facilities and probable useful remaining productive life.
- the existence of problem areas with respect to electricity supply, parchase of electricity and fuel, and labor.
- an independent estimate of production cost.
- the nature of the technology employed and its effect on quality control.
- total investment to date and depreciate practices.

3.1.2 List the limestone resources of the country that are not now (or are not planned to be) utilized in the foreseeable future.

3.1.3 Identify as far as practical, opportunities for technological change that offer a labor utilization pattern more in conformity with the objective of the Plan.

3.1.4 Identify alternative specifications for cement products that meet the future needs and avoid using a superior product for an inferior use.

3.1.5 Evaluate the findings in order to identify opportunities to construct new (presently unplanned) productive capacity: to project the viability of such new facilities under alternative marketing policies;

and to organize these results for a moderate, and for a major, increase in productive capacity.

3.2 The Production and Distribution of Burned-Clay Products.

Burned-Clay products, i.e. brick (and hollow blocks) and tile (roofing and paving) are produced in Colombia by large (capital intensive), medium,or small industries (labor-intensive chircales) To meet the objectives of the Plan, the production levels of these products must increase significantly. The question inmediately then arises as to what policies are favorable to achieving the goals of the Plan, for example, by emphasising expanding the large, medium or the small industries, or a combination. Accordingly, the objective of the work program will be to identify alternative policies within which the expansion of this industry may occur, and the implications of each to achieve the objectives of the Plan.

The following individual tasks will be undertaken in order to meet the objective of the work program.

3.2.1 Undertake a survey of the industry, such as is already completed for bricks in Bogotá by the Division of Industries-Planeación, in the remaining burned-clay manufacturing areas of the country, namely Cali, Medellín, and Barranquilla.

3.2.2 Compare the quality and the control methods for the produced in the small industries with those for the large and medium industries.

3.2.3 Identify and compare the marketing and distribution practices observed by each type of manufacturer.

3.2.4 Assess the technological deficiencies that may exist in the facilities of the large, medium, and small manufacturers and identify the solutions to such deficiencies.

3.2.5 Presume the investment required to achieve a comparable product quality among the large, medium, and small manufacturers, and also a comparable quality control by all manufacturers, and compare production costs and labor utilization among them on such a basis. Specify the quality that the manufacturers can then achieve.

3.2.6 Analyse the technological and production-cost position of the manufacturers then achieved, at each level of productive capacity and determine whether product specialization among the manufacturers is justified in terms of the objectives the Plan. For example, production of solid bricks may be desireable as an activity of the small manufacturers, leaving more complex products (i.e.hollow tiles) to the large or medium manufacturers.

3.2.7 Postulate alternative marketing and distribution practices that could enable the small manufacturers to penetrate the large markets now available to the large and medium manufacturers.

3.2.8 Evaluate the findings so far in terms of differences in market prices between small, medium, and large manufacturers, and terms of the differences in the opportunities provided to generate new employment, in order to establish and justify alternative policies that may be considered in connection with future expansion of total productive capacity.

The final task, in effect, meets the objectives of the work program.

3.3 Roads and Highway Construction and Maintenance.

Since the decade of the 50's, investment in road and highway construction has been one of the major expenditures in the national budgets of the Government of Colombia. The combination of unstable soil characteristics, high rainfall densities, and mountainous terrain results in severe problems in the adequate maintenance of these roads and highways.

There exist by law resources that must be allocated to road and highway construction. Also, there are existing commitments to international financial organizations to provide for counterpart funds for road construction projects requiring foreign financing. Moreover the demand for funds to maintain existing roads will not disappear. Therefore, to the extent that road construction and maintenance practices can be improved to reduce costs from the national point of view, significant funds can be released to help improve productivity

in the road sector, given the amount of direct expenditure in this sector.

A complete visualization of the sector with respect to the possibilities for cost reduction in construction and maintenance activities requires considering a large number of areas which comprise the sector. The terms of reference for this project are accordingly quite ambitions and broad. Obviously in a first effort, because of the restriction of time and manpower the accomplish the work, each of the different areas can not be covered with equal depth of detail, nor can any be covered completely. Nevertheless, the work topics have been selected as those appearing most urgent with the aim of investigating each in as much detail as practical and of identifying the nature of those topics needing further study in the future.

3.3.1 Technological. The work will involve the evaluation of alternative technological systems in the construction and maintenance of roads and highways with special emphasis on the relationships between labor and capital requirement in each and on the need for importation. The work will include the following aspects.

3.3.1.1 Analysis of design specifications in use at the present time. A review and recommedation of modifications to make them conform better with the physical characteristics of the country and the objectives of the Plan.

3.3.1.2 Analysis of the technical practices in the

maintenance of roads, such as frequency and utilization of machinery, and a review and reconmendation of modifications to make them conform better to the characteristics of the country, and the available resources and objectives of the Plan.

3.3.1.3 Analysis of construction in stages to anticipate the growth of traffic and to avoid premature investment. In this respect, differents alternative policies in the maintenance of roads will be analysed, namely; routine maintenance, such as to keep the road character just as originally constructed; and special maintenance, such as to improve the road character in stages beyond the quality originally constructed in order to anticipate future traffic growth.

3.3.1.4 A review of machinery maintenance practices with the aim of increasing the availability of existing machinery, such providing an effective and appropriate inventory of spare parts, a better utilization of equipment at the national level , and reducing the need of imports in this category.

3.3.2 Institutional. The work will describe the present institutional practices in Colombia that govern the construction and maintenance of the nations roads and highways with the aim of identifying opportunities to reduce costs, or to improve the utilization of labor. The work will include the following aspects.

3.3.2.1 Methods actually used in the design and Scheduling of new construction projects.

3.3.2.2 Estimating project costs for official budgets, and for managing "overcosts" arising during construction works such as from construction inefficiencies and from inadequate financing.

3.3.2.3 Procurement in all its component activities, such as the criteria for the selection of consulting firms contracting and subcontracting practices, bidding procedures, and the award of contracts.

3.3.2.4 Administrative practices in the implementation of a project, such as organization of construction firms and an analysis of the need for more specialization in the official executive bodies responsible for managing road construction.

3.3.2.5 Financial practices, particularly policies that influence the need by a construction firm for working capital, and the difficulty in securing working capital loans.

3.4 The Technological and Cost Aspects of Vertical, Multi-Unit Housing - A Case Study.

The construction sector, specially housing, will be the leading sector in the development strategy of the Plan. Not only will the activities in this sector satisfy a growing demand for housing arising from the increasing urbanization of the country, but also it will be the leading generator of more and higher skilled employment and of increased demand for construction materials, such as cement and burned-clay products. The Plan specifies a broad series of objectives with respect

to urban housing, involving the role of the State in land ownership in urban areas; in the construction industry at all levels; in strengthening the position of public-housing agencies to generate change; in strengthening the methods of financing as they affect the construction industry; purchasing ability of low income families; and in the creation of saving and loan institutions. Thus, it becomes of interest to identify the present role of the state in these respects, and thereby provide a basis for analyzing the effects of alternative roles for the state in these respects.

Therefore, the objective of the work program is to analyse actual examples of urban-housing construction and to determine the role played by the state in the implementation of these examples of construction. A further objective will be to evaluate the results to identify alternative roles for the State , and the implications of each on the objectives of the Plan.

The individual work tasks, will be the following :

3.4.1 Select two examples of urban vertical multi-family housing projects completed in recent years, one of which appears to be of high cost and the other of low or moderate cost; and consider for each only the construction of the structure, the enclosure to protect against the weather, and the interior partitioning to provide the marketable living space.

3.4.2 In each case, analyse the costs of construction from the point of view of the technological methods used, the components of

labor and importation as represented in the costs, and the institutional practices that were followed in implementing the projects.

3.4.3 Identify the systems of construction used, compare them with recent advances in systems for constructing similar housing, and evaluate the results in terms of the technological principles, the labor capital relationships, and the need for importation.

3.4.4. Establish a model which will represent an "ideal" method of approach to the construction of large urban multifamily housing projects; and, in which the role of government, the use of appropriate technology, and the institutional practices combine in a way that best helps to achieve the objectives of the Plan. The completion of this work task will achieve the objective of the work program.

3.5 <u>The Technological and Cost Aspects of future Urban Infrastructure Construction.</u>

The emphasis in the Plan on the construction of urban multifamily housing should lead to the development of new planned urban areas in, or near, the intermediate and large cities of Colombia. Some of the significant parameters that influence the optimum design of new urban area in terms of minimum demand on the national resources are the following :

- population density in the urban area
- area of land to be urbanized
- land distance from urban center.

- land cost
- height of building structures
- land occupancy
- infrastructure requirement.

Some of these parameters are independent, but all relate among themselves so as to produce complex interrelationships whose proper management will in turn produce an optimum cost for a new overall urban area.

One way to approach the task of managing such a complex interrelationship is to provide quantitative tools for each parameter that can be manipulated to produce analytical models of prospective projects, and that (if the tools are sufficiently quantitative) can permit solutions of these models through the use of electronic computers.

It appears that the results of the work Program 3.4 (Housing Construction Analysis) can already provide the beginnings of the parameters listed above. It also apeears that some of the findings and conclusions of Work Program 3.3 (Roads and Highways) may be further developed to provide such as tool with respect to the Infrastructure Requirement parameter.

Therefore, the objective of the work program will be to produce a compilation of technological and cost data concerned with urban infrastructure construction for use, as far as practical, as a quantitative tool in the analysis and optimization of new urban housing project.

The individual work tasks will be the following:

3.5.1. Isolate the tecnological, cost, and institutional data from the work in Project 3.3. that can have application in the construction of urban infrastructure.

3.5.2 Compare the institutional practices for roads, streets, and highway construction used by municipalities with those used by the national government, to determine the practices which promise cost reductions in the construction of new urban infrastructure.

3.5.3 Adopt three qualities of road and highway construction, namely gravel-surfaced, asphalt-surfaced, and concrete-surfaced and estimate for each the probable traffic densities on level and on inclined rights of-way in relationship to different alternative maintenance practices.

3.5.4 Identify alternative systems for construction in terms of labor capital utilization and the need for importation. Use as a case study, for example, the experiences from the construction of Ciudad Kennedy in Bogota in the early 1960's.

3.5.5 Evaluate the findings quantitatively, as far as practical, in accordance with the objectives of the Plan, to establish such relationships as

- The "ideal" institutional approach to the construction of urban infrastructure.
- The cost of urban streets and highways as a function of road width, road length, and design specifications.

The completion of this task should achieve the objective of the work program.

4.0 METHODOLOGY

4.1 The set of work programs described above will be carried out in accordance with the policies and objectives set forth in the Plan. In addition, cost reduction opportunities will be identified solely from the point of view of the national economy. Thus, the expectations are that their results will be useful in the implementation of the Plan.

4.2 The set of work programs described above have been selected using criteria that enable immediate application of the results to relevant problems, while at the same time indicating an ultimate thorough and complete analysis of cost reduction opportunities in the construction sector.

4.3. In the execution of the work programs described above, the level of detail will be selected to enable completion of the project within the time period available. Best efforts will be exerted to provide maximum detail and useful findings in the time available.

4.4 The execution of the work programs described above will be the responsibility of a single individual designated for the purpose, who will be assisted by personnel from public and private organizations invited to participate.

4.5 The execution of the work programs described above will be carried out in four phases.

4.5.1. The first phase will have a duration of approximately two months during which the work of data collection, interviews,

visits and meetings with persons or organizations will be undertaken. At the end of this phase, a preliminary report for each work program will be prepared.

1.5.2 The second phase will have a duration of approximately one month during which a detailed analysis of the information collected will be done by the responsible individuals in charge of each program. The analysis will include a review of the preliminary reports, the formulation of conclusions and recommendations, and a simulation of a conference and seminar to be conducted later during phase three.

1.5.3 The third phase will be the organization and the conducting of a conference and seminar in Bogotá during which the findings, conclusions, and recommendations will be presented and discussed. Persons and organizations involved in the work and interested in the subjects will be invited to this meeting. Each subject will be analysed in a separate seminar with the persons directly concerned with the subject, with the aim of obtaining reactions and comments to the results presented. Four seminars will be conducted simultaneously as follows

- The Cement Industry (Work Program 3.1)
- The Brick and Tile Industry (Work Program 3.2)
- Roads Highways and Urban Infrastructure (Work Program 3.3. and 3.5)
- Urban Vertical Housing Construction(Work Program 3.4)

1.5.4 In the fourth phase the results of the conference and seminary will be incorporated in the final report for the Ad-Hoc Project.

BEST AVAILABLE DOCUMENT

5.0 PARTICIPATION

The Departamento Nacional de Planeación will sponsor the work through a project director who will have overall charge and Ad-Hoc Group, comprised of members from Planeación, Ministry of Public Works, Ministry of Development, Instituto de Crédito Territorial (IC) and the consultant firm. These members will serve full time. In addition there will be partial participation of other organizations having interest in the different work programs.

Each Work Program will be directed by a responsible person-in- charge who will lead and coordinate the various tasks in each program. These project leaders will report periodically to the Project Director concerning progress and problems.

Table 5.1 presents the list of organizations expedted to participate in the work programs.

Figure 5.1 presents the proposed pattern of participation. In this figure, the responsible organizations are designated with an "R", and the participating organizations with an "X".

Table 5.1

DNP	Departamento Nacional de Planeación
MOP	Ministerio de Obras Públicas
MDD	Ministerio de Desarrollo Económico
MDMP	Ministerio de Minas y Petróleos
ICT	Instituto de Crédito Territorial
IIT	Instituto de Investigaciones Tecnológicas
ICONTEC	Instituto Colombiano de Normas Técnicas
SCI	Sociedad Colombiana de Ingenieros
ACIC	Asociación Colombiana de Ingenieros Contratistas
SCA	Sociedad Colombiana de Arquitectos
FNCV	Fondo Nacional de Caminos Vecinales
SOPD	Secretaría de Obras Públicas Departamentales
CAMACOL	Cámara Colombiana de la Construcción
INSFOPAL	Instituto de Fomento Municipal
ICCE	Instituto Colombiano de Construcciones Escolares
ICEL	Instituto Colombiano de Energía Eléctrica
CINVA	Centro Interamericano de Vivienda y Planeamiento
EAAB	Empresa de Acueducto y Alcantarillado de Bogotá D. E.
INCORA	Instituto Colombiano de la Reforma Agraria
BCH	Banco Central Hipotecario
ADL	Arthur D. Little Inc. Cambridge, Mass.

PROGRAMA DE TRABAJO

ACTIVIDADES \ SEMANAS	FEBRERO					MARZO				ABRIL				MAYO					JUNIO		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
PRIMERA FASE (Colombia)																					
Términos de Referencia																					
Recolección de Datos																					
Informes Preliminares																					
SEGUNDA FASE (Boston, USA)																					
Análisis de los datos																					
Revisión de Informes																					
Simulación del Seminario																					
TERCERA FASE (Bogotá)																					
Organización del Seminario																					
Desarrollo del Seminario																					
CUARTA FASE (Bogotá)																					
Revisión de Informes																					
Informe Final																					

Cuadro 5-1

PARTICIPACION DE LAS ENTIDADES EN LAS DISTINTAS AREAS DEL ESTUDIO

	DNP	MOP	MDD	ICT	IIT	ICONT	SCI	AGIC	SCA	FNCV	SOP	CAMACOL	INSFOPAL	ICCE	ICEL	CINVA	EAAB	INCORA	BCH	ADL	MDM
3.1	R																				
3.1.1	X		X																		
3.1.2	X																				X
3.1.3	X											X								X	
3.1.4	X				X	X														X	
3.1.5	X																			X	
3.2	R																			X	
3.2.1	X				X															X	
3.2.2	X				X	X														X	
3.2.3	X		X																	X	
3.2.4	X					X														X	
3.2.5	X		X																	X	
3.2.6	X		X																	X	
3.2.7	X		X		X															X	
3.3	R																			X	
3.3.1																				X	
3.3.1.1	X	X					X	X		X	X	X						X		X	
3.3.1.2	X	X					X	X		X	X	X						X		X	
3.3.1.3	X	X					X	X		X	X	X								X	
3.3.1.4	X	X	X				X	X		X	X							X		X	
3.3.2																				X	
3.3.2.1	X	X					X	X		X								X		X	
3.3.2.2	X	X					X	X										X		X	
3.3.2.3	X	X																X		X	
3.3.2.4	X	X					X	X		X										X	
3.3.2.5	X	X								X								X		X	
3.4.				R																X	
3.4.1	X			X					X							X			X	X	
3.4.2	X			X		X			X			X		X		X			X	X	
3.4.3	X			X		X			X			X		X		X			X	X	
3.4.4	X			X								X				X			X	X	
3.5	R																			X	
3.5.1	X	X		X																X	
3.5.2	X	X		X									X		X		X			X	
3.5.3	X	X		X																X	
3.5.4	X			X									X		X		X			X	
3.5.5	X	X		X																X	

APPENDIX A

SUMMARY OF THE DEVELOPMENT PLAN.

The principal feature of the Plan is that the general process of development is associated for the first time with an irreversible urbanization of the country, and, because of this the critical sector is to be construction within a framework of an urban development of social well being. The Plan hesitates not to anticipate that the migration of rural people to the cities will continue to increase, and that the country should be prepared to assimilate, rapidly and productively , these continuous additions to the urban work force. On the other hand, the tendency toward increasing agricultural productivity should be absorbed within systems that reform the ownership of the land such that its fruits directly benefit the rural population who will remain permanently on the land, and whose existence today is a marginal one.

In the former goals of development, the dynamics rested on achieving a designed rate of growth in the gross national product. This was supported by the dubious axiom that definite and predictable causal relations exist between importation and the formation of capital, between the formation of capital and the product, and between the product and employment.

Consequently, achieving investment for the formation of capital - i.e. achieving deliberately set goals of importation - was

formed upon former plans. This necessitated incurring foreign debts, and it was expected that with such formation of capital, employment would be generated from the increase of the product. Experience has demostrated that this has not been so, and we have begun to discover that development itself cannot be identified with economic growth.

The New Goals

Economic growth is an important element in the new Plan, but it is not the only one. Equal emphasis is placed on the quantity growth produces, on what it produces, and for whom it produces. It defines development as the condition achieved by many countries which have gained material abundance, but also where this abundance has been largely equally divided where the growth resulted in self-stimulation of growth where natural resources have been conserved where there is no dependence on continued foreign aid, and where the rate of growth of population has fallen to a level where development is able to continue unabated. Accordingly, achieving development is not the same as achieving well-being, although development is an important element of well-being. Thus, just as the abolition of poverty is essential although not a sufficient condition for development, development is essential although by itself not a sufficient condition for achieving well-being, the ultimate objective of society and the individuals that comprise it.

The Plan not only proposes goals more adequate than those of former plans - i.e. those of achieving development and well-being- but also identifies the difficulties to be overcome. Hence, the identification of which of these difficulties are to be diagnosed tells us the strategies which will serve to overcome them. An extended and a sustained courage is needed to penetrate the twin vicious circles of poverty. First, there is the low purchasing power of the masses, the small markets, the low investments, the low productivity, and the poverty which results from all this. Then, there are the high rates of population growth and the low levels of income and education. The conditions which create poverty rein - force these same conditions and release more poverty. The glowing statisfics reporting specific comprehensive, or partial, results of economic activity, publicized year after year, do not serve to penetrate the twin vicious circles of poverty. To the shame of these glowing statisfics, the country is enabled to remain in the category of undeveloped.

The Great Waste

In Colombia, the great waste is the squandering of its human resources. Only with ending this waste will we be able to penetrate the whirlpool of the vicious circles of poverty, i.e. by offering remunerative work to the underutilized labor force of the country to produce the things which the country needs. But, for what rea-

sons are men underutilized ? The plan, then, takes an original view. If distinguishes between possible limitations on growth and on the mobility of the factors involved in growth from the practical limitations on growth, i.e. it formulates strategies.

The plan identifies how limitations act on those sectors - agriculture or industry, for example- not at their capacity for production but rather at the effective demand. We have an historical example, coffee, whose production would thrive with the world demand, and growth was not the limited by capital, foreign currency, land, manpower, technology, or other factors. Many agricultural or industrial goods are in the same position as coffee, in looking for opportunities to market for the effective demand. All development plans that begin by increasing productive capacity by means of importing equipment and technology, -or as one may say by "investment promotion", place the cart before the ox.

It is for Colombia alone to aim at creating more production with more remunerative work, which is the base for increasing the consumption capacity of the country. Monetary expansion -by itself alone- results in inflation.

Areas for Employment Generation .

How to use our resources better ? The Plan considers that there are fields in which hundred of thousands of new jobs can be created without immediately saturating the markets. Which

are the fields ? The Plan emphasizes that these fields are those which interface with public services, in housing, and in exports . Why these specific fields ? Precisely because of the enormous increase in urban population and the consequent almost insatiable demand for more housing and services; and also precisely because of those prospects, except for coffee, where the increment of supply from Colombia to the world supply is week and there is no scope to influence a fall in world prices.

If the trend recorded between 1951-64 continues in the urban process, cities of more than 100,000 people will as a whole increase by 1980 to 16 million people, an increase of 6 million in ten years . This represents an enormous potential market.

Urban development and exportation are the strategic sectors in the sense that they permit the expansion of all other sectors agriculture and industry. Therefore, the Plan makes a distinction between the strategic sectors, i.e. those which give an initial impulse to development, and those which are important because of other considerations, such as primary education.

The Four Strategies.

Construction and exportation can be considered the two prime priority, or strategic ,programs,. The other two strategic programs are : an increase in the productivity of agriculture; and a better distribution of income together with a decrease in the differences in the

levels of consumption.

Without the development of the two prime sectors, a high level of productivity in agriculture would be conducive to a rapid saturation of the markets, and a deterioration of the income of the rural people.

On the other hand, with growing opportunities for employment and an upward mobility for labor, the beneficial effects of high productivity would practically have no limits. This tells the argument for the third strategy -the level of agricultural productivity depends on the degree of success obtained in the two primary sectors.

Finally, the Plan argues that great abundance ought not to be the goal as the expense of major inequality. On the contrary , the Plan emphasizes and demonstrates that it is possible to pursue a decrease in the differences in levels of consumption , education, and opportunities, without decreasing savings or the incentives to work by making innovations and improvements . Experience in developing countries has proven that with the imposition of effective provision for progressive taxation on the one side, and of social legislation on the other, it is possible to decrease social differences without destroying incentives for production and improvement.

The More Controversial Strategy

The more controversial strategy is, probably, that which refers to distribution. Our country, throughout the years, has established a progressive system of taxation yet at the same time a large part is nullified by the creation of a series of tax-exemp - tions and by a system deficient in fiscal control and in tax collec tion. We have created also an advanced system of social security. But this favors only a few, and has left the large remainder of the population with small protection. We may say that we have replaced the real situation by its shadow.

In synthesis, the three primary strategies seek a great abundance; and the fourth, a large participation of the population in the abundance. The four strategies are appropriately coordinated and move with the times, just the four wheels of an automobile move together.

The Allocation of Resources.

The budget for public investment by the National Government was approved before the goals of the Plan were formulated. The detailed appropriations are contained in the Public Investment Plan in Part Four of the Plan, and are the result of studies by the respective branches of the Government with the Budget Coordination Unit of the Departamento Nacional de Planeación. The implementation of many of the programs in the investment plan should continue

since they agree with the goals and priorities of the Plan. On the other hand, various projects are now under consideration by the Congress, whose formal approval determines the allocation of the resources the programs require. There are other projects, concerned with the mobility and channeling of savings for the priority programs of the Plan which already have been studied, and which the Government should propose at the opportune time.

A large part of the quantitative goals by sectors are taken up in the respective sectorial documents of Part Three of the Plan. Nevertheless, in the strategic guides of the General Plan, it was deliberately decided to concentrate attention on the basic principles and on the strategies, before calling for policy formulations and for specific measures or for quantifying the sources and the requirements for the different projects in each program.

APPENDIX B

ROAD AND HIGHWAY CONSTRUCTION

CONTENTS

1. SUMMARY OF INVESTIGATIONS

1.1 Institutional Aspects

1.2 Road Construction Specifications and Design Standards

1.3 Construction Equipment

1.4 Use of Materials

2. RECENT PROGRESS IN MODELING ROAD AND HIGHWAY CONSTRUCTION ACTIVITIES

2.1 Highway Cost Model (HCM)

2.2 Capital Labor Model (CLM)

1. SUMMARY OF INVESTIGATIONS

Four aspects, each of which seems to have potential for improving the use of resources directed toward road construction and maintenance, were studied in the work and are explained below. It should be understood that with respect to the problem of reducing costs in this sector, the approach taken in the four studies was not integrated. Consequently, the studies are reported separately and no systematic relationship should be apparent.

The four aspects and the organization of the information developed during the investigations are as follows:

1.1 Institutional Aspects

- 1.11 Framework
- 1.12 Ministry of Works Bidding and Contracting Procedures
- 1.13 Problems Leading to Overcosts

1.2 Road Construction and Design Standards

1.3 Construction Equipment

- 1.31 Problems in the Pattern of Utilization
- 1.32 Methodology for Improvement

1.4 Use of Materials

- 1.41 Cement-Concrete vs. Asphalt Pavements
- 1.42 Asphalt vs. Coal-Tar Pavements
- 1.43 Gabions

The non-integrated approach represented by the results of the investigation can identify opportunities to reduce costs which could be implemented immediately. To identify opportunities that may lead to more significant cost reductions a more systematic integrated approach is needed. The analytical tools for achieving such an approach are described in Section 2, Recent Progress in Modeling Road and Highway Construction Activities.

1.1 Institutional Aspects*

1.11 Framework

The organizations listed below are involved in the construction of roads and highways and their maintenance:

Ministry of Public Works (MOP) This Ministry studies, proposes, and plans national road and highway construction; and also maintains the existing national road and highway network. The Fondo Vial Nacional (National Road Fund) which was created by legislation in December 1966 reports to this Ministry. The aims of the Fund were fixed as the improvement and extension of the national road network and the assurance that the investments in road projects are effective. The legislation granted to the Road Fund decision-taking powers, a specified level of autonomy, and its own source of funds. In turn, it requires the Fund to provide the expenses involved in the study, construction and maintenance of the national road network.

The Fondo Nacional de Caminos Vecinales (National Rural Road Fund) was created by decree in 1960. It also reports in the Ministry of Public Works, and functions as a public establishment. It is provided with decision-taking powers, a degree of administrative autonomy,

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* A comprehensive report covering the operations and recommended reorganization of the Ministry of Public Works was submitted to them in May 1968, by a consortium of Cia. Mexicana de Consultores en Ingenieria, S. A. and Frederic R. Harris Engineering Corporation (Comec-Harris).

and its own source of funds. The aim of this Fund is to promote in the country the construction of the rural roads or roads of regional character. The Fund administration cooperates with Departments, Intendencies, Commissariats, and Municipalities; and with other official, semi-official, or private agencies.

Secretariats of Public Works in the Departments. These are the offices in charge of planning, constructing, and maintaining roads at the departmental level. These projects originate either in the Assembly or in the Government, or the respective Department, and are accomplished with local technical personnel, resources, and equipment. Depending on the administrative structure of the Department, there may or may not be a planning office responsible for making preliminary construction studies within its boundaries.

Municipalities. The Municipalities as a general rule are involved in the construction and maintenance of streets and avenues within their urban boundaries. On some occasions, however, in order to satisfy local needs they may undertake the construction of roads or low specifications according to the plans of the Municipal Council or of the Mayor's office.

Others. Other public agencies invest in roads with the specific objective of solving transport problems in their individual development programs. Examples are the Regional Corporations, the Federacion Nacional de Cafeteros, and the Armed Forces. Finally, private roads are constructed by mining companies, oil companies, sugar refineries, cement factories, and owners of rural farms searching for a better exploitation of their lands.

1.12 Ministry of Works Bidding and Contracting Procedures

Both national and international bids are opened for new projects considered in the annual budget of the Fondo Vial Nacional. No notice of opening dates of bidding is given in advance of the fiscal

year. In practice, the bidding procedure begins once the necessary requirements such as the preparation of studies, plans and designs, estimated quantities of work, and specifications are fulfilled. This work is undertaken on a project-by-project basis. The usual practice for developing bids and contracts is the following:

Preparation of Documents. Following the issuance of instructions from the General Direction of Construction, the Programs and Contracting Division proceeds to prepare bid documents, based on the information supplied by the following divisions of the Ministry:

- Division of Studies and Designs: for plans and designs, for quantities of work, and for special construction specifications and particular information for the project.

- Division of Engineering and Materials: for geological and soil studies, for designs of the mixes of materials and for sources of materials.

For projects which are foreign financed, the data above are prepared by consulting firms. In such cases, they are reviewed for acceptance by the appropriate technical divisions of the Ministry. When the consulting firm also prepares bid documents from the data the Programs and Contracting Division reviews and revises them, if such is necessary, before the announcement of the invitation to bid.

Official Budget for the Work. For the bidding of projects that have been studied and designed by the Ministry of Public Works, the Programs and Contracting Division establishes the budget, which is then submitted for the approval of the General Direction of Construction of the Ministry. When documents are prepared by consultants, they then also establish the budget, after which it is reviewed by the Programs and Contracting Division, and finally approved by the General Direction of Construction. The approved budget is published officially.

Invitation to Bid. The Programs and Contracting Division prepares the Bid Notice, which is submitted for the approval of the General Direction of Construction. The Programs and Contracting Division is in charge of the sale of the bid documents.

Qualifications of Bidders. Every construction firm, national or foreign, who wishes to propose for contracts financed by the Fondo Vial Nacional, should have qualified itself previously to the Programs and Contracting Division of the Ministry of Public Works. The qualifications should be renewed every six months, or when important changes occur in the enterprise.

There is no classification of firms into categories based on their qualifications. Therefore, all the firms qualified may in principle respond to all the bids; but in practice; this possibility is limited by the specific conditions for the construction project that are fixed in each bid document, especially with respect to equipment.

For projects financed with foreign credit from the World Bank, a prequalification of firms is made according to the procedure established in the respective loan agreement. The prequalification result is based on verifying the reputation of the firm, its experience in the construction of works with characteristics and magnitude similar to those in the work to be bid, the adequacy of its personnel and equipment, and its capacity to finance the operations.

Bid Opening. The opening of the offers is made publicly on the day and hour specified in the bidding notice. The Programs and Contracting Division analyzes the offers presented. The financial study of the participating firms is made by the Ministry's Finance Division. When dealing with internationally financed work, a copy of the proposals is sent to the consulting firm involved in the project. Its analysis of the offers and its opinion are then submitted to the Ministry.

Award of Contract. The analysis of the offers is discussed in an internal meeting of the Ministry in which the Secretary General, General Directors, Chief of the Legal Office, and Fiscal Auditor are usually represented. The Chief of the Programs and Contracting Division acts as the secretary of this meeting. Other officials of the Ministry, whose presence is considered necessary, may also be represented. Written minutes of these meetings are produced describing the concepts established and the reasons on which the contract award is based. The selection for a contract award is generally oriented toward the lowest offer of a prequalified firm.

Preparation of the Contract. The Legal Office is in charge of all the proceedings necessary for the formulation and the legalization of the final contract. The proceedings are completed within 15 to 30 days. The documents that the contractor should supply for the preparation of the final contract are specified in the bid document.

Contract and Sub-contract Terms. All construction contracts granted by the Ministry of Public Works (Fondo Vial Nacional) are based on a fixed price and term. In practice, amendments to the terms up to 50% of the initial value may be authorized when there is incomplete justification. The contractors may not transfer the contract during the period it is effective, or sub-contract its total or partial execution, without the expressed consent of the Fondo Vial Nacional. The terms of the main contract that are understood to be the exclusive responsibility of the contractor may not be transferred to any sub-contract.

Method of Payment. The Fondo Vial grants advancements of up to 20% of the contract's total value but a monthly interest rate of 1.25% is charged for the amount that corresponds to uncompleted work. As the work advances, the contractor receives monthly payments, corresponding to newly completed work, which first have been reviewed and approved by the supervisor. This payment can be delayed should there be a lack of funds in the National Treasury. The unit prices stated in the contract

are reviewed periodically according to readjustment formulas suggested by ACIC and established by the Ministry of Public Works. It is thought that the formulas favor the contractor, though this has not been proven.

Modifications to the Original Contract. Every modification of the project during its construction, that alters locations, design specifications, quantities of work, prices, etc., or that causes variations of the contract's value or of its term, is agreed to by the contract supervisor and the contractor; and then executed by means of a contract change within the limits permitted by the original contract. For each contract change, a re-estimate is made of the original or current quantities of the work affected by the change. In the accompanying documents, the contract supervisor records the new quantity estimates and defines the final design, or the additional specifications. In the case that the change includes new prices, the basis on which they were determined is indicated. When the total value of the contract changes surpasses the limits established in the contract, the surplus is the subject of an additional contract. The unit prices of the additional contract are the same as specified in the original contract. The value of the additional contract may not exceed 50% of the value of the original contract.

1.13 Problems Leading to Overcost.

There are serious deficiencies of coordination of activities among the official agencies that put into effect the planning, construction and maintenance of the roads in the country (i.e. the MOP, the Fondo Nacional de Caminos Vecinales, the Public Works Secretariats of the Departments, and the Municipalities). The Ministry of Public Works builds and maintains the national road network. The Departments and Municipalities do the same with their local network, although because of lack of resources the National Government on several occasions contributes its own funds to its construction, while the Ministry of Public Works maintains some of these roads. Of the Departments visited during the investigations, only Antioquia, Valle and Cundinamarca are developing new road construction projects; the rest are restricted by

their limited budget resources to a poor maintenance of their road network. Occasionally, they accomplish national road projects through transfer of Ministry of Public Works resources.

The Fondo Nacional de Caminos Vecinales builds area penetration roads with tripartite finance through equal contributions from this Fund, from the particular Department involved, and from local governmental units. Once the rural road is built, it is administered and maintained by the Department. Since Department treasuries generally lack sufficient resources to maintain their basic road network, and since the length in the network of the roads to be maintained is constantly increasing*, in several cases there has been almost total loss of the roads constructed by the Fondo Nacional de Caminos Vecinales. Since 1971 the Fondo Nacional has been testing a new policy of contributions to the Department for road maintenance in order to relieve the departmental budget of maintenance costs and to achieve a better maintenance of the roads already constructed.

Thus, there seems to be room for improvement in the level of coordination of construction and maintenance programs among the numerous agencies connected with road investments. Inadequate coordination added to inadequate basic technical information leads to shortcomings in the planning for complementing the national road network with the individual Departmental road networks. It is clear that these shortcomings are the cause of a major increase in cost of the road construction projects in the country's road network when it is considered as a whole. Although the cost increases that result from lack of coordination in the planning for maintenance have not been quantified, these factors may be identified leading to significant overcosts, since their ultimate result is the periodical reconstruction of the roads owing to lack of adequate maintenance.

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*For example, the road constructed by other agencies (the Army and INCORA in particular) are added to the departmental network.

Another problem that can lead to overcosts is the non-uniform system of bidding and contracting which exists not only between the different agencies charged with executing road projects, but also within the agencies themselves. For example, the MOP usually rewrites contract documents instead of establishing a standard document for all road projects, or at least standard portions for the contract documents. This lack of standardization can lead to confusion or to misinterpretation on the part of the consultant or the contractor.

The Division of Project Design and Supervision of the Ministry of Public Works lacks coordination and control over the studies that are made before and during the construction of a road. Three observations can be made about the operations of this office.

- First, there is no collaboration among the several offices that study the design of the road. For example, the Division of Engineering Studies does not consult the Division of Construction Supervision or the Maintenance Branch when accepting a road design from a consultant.

- Second, only four aspects of design are considered: earth movement; surface drainage; bridges; and pavement. The corresponding studies for these aspects are done mostly in the field, with no communication with the offices in the Ministry. In many cases, these studies are not handed to the contractor as a package, but one-by-one as they are completed so that he may be able to begin the work immediately. This procedure makes effective planning to the requirements difficult, if not impossible.

- Third, the lack of exact specifications to which a contractor should conform makes the supervision and evaluation of his work difficult for the MOP to achieve effectively.

As a general observation much of the mediocre performance of the Ministry of Public Works with respect to costs and road performance can be attributed to an insufficiency of personnel to handle the work load.

A problem involves the MOP's contract practice in which the official budget is published simultaneously with the invitation to bid. The influenceof this information on the budgets presented by the contractors is probably large since obviously they try to adjust their estimates to agree with the official budget. If the official budget has not been carefully established, the contractor could have considerable overcost, or conversely he could obtain exaggerated benefits.

In accepting a portion of a completed road project, the Ministry of Public Works does not assure itself that the portion can be fully utilized. Therefore, some maintenance costs are incurred before the total project is completed and accepted.

Finally, the Ministry of Public Works does not effectively collect the penalties which are called for in the contract for departures from the contract, or for non-performance.

1.2 Road Construction Specifications and Design Standards

Standardization of road construction specifications and design has been identified as one of the possibilities of reducing costs in road construction. The present situation with respect to standardization may be summarized as follows:

- As already mentioned, several agencies that construct roads exist in the country. Each agency may fix its own standards on road construction and design.

- The coordination between these agencies is poor, or non-existent, in matters of standardization. There is no agency in the country

solely responsible for regulating road construction specifications and design.

- The standards which are generally followed are transferred from foreign organizations which have investigated and published results reflecting construction conditions in their own country.

- The Ministry of Public Works has adopted and published standards related to:

a) Road construction
b) Works of art
c) Geometric design
d) Pavement design
e) Road signs
f) Testing of materials

Of these standards only those relative to road signs have been applied nationally; and their use is obligatory to all road construction agencies. For a period of over ten years, the Ministry of Public Works has been applying these standards to projects they construct or to those contracted from them by the Departments.

The Secretariats of Public Works in the Department use different standards.

Standardization of design and specifications can produce a reduction of construction costs in a number of ways:

- Engineering and administration costs are reduced, if the designers can refer to a manual of standards.

- With a predictable and consistent system of design and construction, investment budgets could be estimated more accurately.

- Quality control in road construction could be facilitated if there were a higher level of consistency in the specifications.

Cost reduction that can be attributed to standardization cannot be quantified, but authorities involved in road construction agree that the establishment and the regulation of construction and design standards and specifications would be advantageous.

1.3 Construction Equipment

The services of construction equipment are a fundamental input to the construction of roads and highways and other infrastructure, and consideration of its pattern of use could offer possibility of identifying opportunities to reduce construction costs. The use of equipment represents between 30 and 60% of the total costs in heavy infractructure construction depending on the type of work*. With a few exceptions the machinery used for such construction is imported. The annual cost of acquisition of new equipment and replacement of old equipment represents a major expenditure of foreign exchange.

One of the major components in the national investment budget is the investment in the construction infrastructure (see Table No. B-1). By law, certain resources must be allocated to support the investment in infrastructure. Examples are the gasoline tax and certain requirements in the development of electricity supply. Past loan agreements with international financing organizations have specified resources from the national investment budget to be pre-empted in order to provide the local counterpart funds for the construction projects financed with foreign credit. The investments already made in infrastructure require the allocation of future resources for maintenance in order that the construction resulting from these investments will give maximum service during its useful life.

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* Readjustment Formulas A.C.I.C.

The maintenance activities require the use of heavy construction equipment.

Opportune and adequate supplies of replacement parts and the physical maintenance of the equipment itself largely determines the pattern of equipment use and as a result the cost of its utilization. The formulation of tariff policies, import procedures, and the allocation of foreign exchange adequate to the needs of acquiring replacement parts and as well the determination of the size and potential of the market for the local industry to supply replacements and spare parts for construction equipment, require complete information on size and composition of the inventory of construction equipment now in the country.

An interesting aspect with respect to the import of spare parts is the system "in bond" which has been approved by the Government, but which has not yet been put into operation. Under this system the distributors of the parts would be authorized to import replacements which in turn would be stored in special warehouses for this purpose. When a specific spare part is required, it could be obtained immediately under a guarantee that the tariff would be paid when the import license is authorized. The approval of the "in-bond" system emphasizes the importance of heavy construction equipment in the nation's economy.

Nevertheless, there is no reliable information on the size and composition of the nation's inventory of heavy construction equipment nor do sources exist which could permit this type of data to be established eventually. If a data collection program could be devised to achieve such an inventory as an immediate objective, the existence of such information could serve as a fundamental basis for the development of policies in the medium term that could lead to significant cost reductions in construction arising out of a more effective utilization of heavy construction equipment.

The immediate aims of the data collection program would be:

- to know the size, the composition and the distribution of the inventory of heavy construction equipment existing in the country;

- to determine the present state of the existing machinery, and its pattern of use;

- to know the situation with respect to the procurement and the distribution of replacement and spare parts;

- to quantify the amount of investment already made in construction machinery;

- to have information on the number of private enterprises that own equipment, their legal nature, and the nature of their activities; and

- to define the procedure for establishing and organizing a permanent register of equipment that should include the periodical updating of the data initially obtained.

The medium-term aims would be to use the data collected in order

- to forecast the need to acquire new equipment and to replace old equipment reflecting to the construction capacity of the equipment in the inventory and the capacity required to support the construction of infractructure projects, that have been programmed.

- to establish the basis for an import and machinery-financing policy, reflecting the experiences and the needs of the country and the diversity of the different brands and models registered in the inventory; and

- to promote a national rather than a regional pattern of use of the equipment in the inventory using the knowledge of the geographical distribution, the current use pattern, and the technical characteristics of the equipment.

The scope of work to achieve the short-term objective of establishing the construction equipment inventory would be:

- to identify the equipment owned by official organizations and by private enterprises as of the date of the census;

- to investigate the types of equipment by priority such as are shown in Tables B2A and B2B, to include the data also shown in the Tables. The equipment in the list concerns those in major and frequent use in heavy construction.

Initially an inventory will be made to serve as a basis on which the National Register of Equipment can be established. This register should be organized in a way which guarantees that it will be updated periodically. The work of compiling the inventory can be divided into the following stages:

Directory (Guide) of Information Sources. To establish the information sources, a guide of enterprises and organizations that use heavey construction equipment will be prepared.

Collection. The inventory will be established by means of direct interviews with companies and organizations who own or control units of equipment. These may be formed by one or several groups. For collecting information, a form (Table B-3, also Tables B-2A and B-2B) will be used by a corps of field interviewers who will have been previously trained for this purpose. The form will be accompanied by a manual of instructions containing the definitions and the explanations for each one of the items for which information is desired.

Evaluation and Codification of the Data. Once the information is collected, the data will be reviewed to detect and correct possible errors. Simultaneously,

Equipos con Prioridad A	Marca	Modelo	Peso	Capacidad	Potencia	Serie	Ano	# llantas	Dim. de llantas	Dimensio-nes	Longitud d.la pluma	Aditamen-tos	Ancho	Tipo
Aplanadoras Tandem	x	x	x	x	x	x	x							
Cargadoras sobre oruga	x	x		x	x	x	x							
Aplanadores de 3 ruedas	x	x	x	x	x	x	x							
Central de Mezclas de Homrigon	x	x		x	x	x	x							
Cargadores sobre llantas	x	x		x	x	x	x							
Compactadores de llantas	x	x	x	x		x	x	x	x		x			
Compactadores Vibratorios	x	x		x	x	x	x			x				
Compresores	x	x		x		x	x							
Irrigadores de Asfalto	x	x				x							x	
Mezcladoras sobre camion	x	x		x	x		x							
Motoniveladoras	x	x			x	x	x							
Mototraillas	x	x		x	x	x	x	x						
Palas sobre orugas	x	x		x		x	x				x	x		
Palas sobre llantas	x	x		x		x	x				x	x		
Plantas de asfalto	x	x		x		x	x							
Plantas de trituracion	x	x		x		x	x							x
Terminadoras asfalticas	x	x		x		x	x						x	
Tractomulas	x	x			x	x	x							
Tractores sobre llantas	x	x			x	x	x		x					
Tractores sobre orugas	x	x			x	x	x							
Traillas	x	x		x		x	x	x	x					
Trituradoras Primarias	x	x		x		x	x							
Trituradoras Secundarias	x	x		x		x	x							
Volquetas	x	x		x	x	x	x							

TABLE B-2A

TYPES OF EQUIPMENT AND DATA TO BE COLLECTED - PRIORITY A

PRIORITY -B Equipos Con Prioridad B.										
Compactadores Pata de Cabra	x x	x x	x x			x x	x x		x	x
Compactadores Rejilla	x	x	x			x	x			
Compresores pequenos	x	x				x	x		x	
Escobas mechanicas	x	x		x		x	x			
Irrigadores de agua	x	x		x		x	x			
Mezcladoras Esparcidores de suelo	x	x		x		x	x			x
Cemento	x	x				x	x	x		
Mezcladoras de Cemento portatiles	x	x				x				
Motobombas	x	x				x		x		
Plantas de asfalto	x	x				x				

TABLE B-2

TYPES OF EQUIPMENT AND DATA TO BE COLLECTED

a codification of the same will be made for data processing. This stage requires the preparation of a manual for evaluation and codification.

Program Preparation. The preparation of a computer program for the processing of information obtained will be carried out simultaneously with the work of the previous stages.

Data Processing and Card-Punching. Once the previous stages of effort are complemented, the data that have been collected will be processed and analyzed.

Publication of Results. The tabulated information and the analysis of the data on the heavy construction equipment inventory will be published in a report to serve as the basis for achieving the medium-term objectives already described.

One major need in order to produce the inventory is to secure the cooperation of companies and organizations who own equipment to supplying information. In order to stimulate such cooperation it is necessary to establish a series of measures that publicize the utility of the inventory and the benefits of cooperation. The following measures are suggested to obtain such cooperation.

- Establish a policy of financing the purchase of new and used equipment according to the country's needs, using such organizations as the Fondo de Contratistas or their mechanisms already established by the Government for this purpose.

- Permit the import of replacement and spare parts for construction machinery through the "IN BOND" system only for properly registered equipment.

TABLE B-3

Register of Heavy Construction Machinery

Form for Firms and Organizations

_____ City_____ _____ Register Number
Day Month Year

1. Identification of the Firm or Organization

_____ Social Reason or Name_____

_____Department_____Municipality_____

Address_____Telephone No._____

_____Has sectionals_____Branches_____Affiliates_____

2. Data Referring to the Firm or Organization

_____Official Organization_____Private_____Mixed_____

_____Natural Person_____Limited Society_____

Silent Partnership Society_____Anonymous Society_____

Collective Society_____Cooperative Society_____

_____Social Object or Main Activity_____

_____

_____Gross Assets on December 31, 1971 $_____

- Require that the equipment usage offered by the proposers for construction contracts to be awarded by public organizations involve only registered equipment.

As already noted, the equipment inventory will be the basis to establish the National Register of Equipment. To maintain the usefulness of such a Register, a process should be defined to assure that the information in the inventory will be periodically brought up to date. The agency to take charge of its management is identified. The process of updating of the data consists of accounting for four types of events:

Equipment going out of service permanently.
Purchases and sales of equipment already existing in the country.
Import of new or used equipment.
Acquisition of new equipment produced within the country.

Just as is needed for the success of the initial inventory, a series of measures that encourage the cooperation of the equipment owners to provide information of change is necessary for the Register to continue to function correctly. The same measures should achieve such a purpose. In addition, securing the cooperation of the organizations to regulate imports to the country is needed so that information of import transactions for construction machinery can be used to help update the Register.

1.4 Use of Materials

Cement-Concrete vs. Asphalt Pavements. Cement-concrete pavements have been used in Colombia primarily along the Atlantic Coast. One stretch of such pavement in good condition exists on the road between Bogotá and Villavicencio in the vicinity of the latter. The reasons why suddenly the construction changes from asphalt to concrete on this road for the same traffic pattern were not determined. But, its existence raises the prospect that the global cost of one pavement versus the other could be comparable. This prospect in turn raises the possibility that

Government purchases of cement to a preagreed price formula could be used to help support an expansion of the cement-manufacturing industry in the fact of foreseeable but unpredictable growth of demand.

Asphalt vs. Coal-Tar Pavements. The use of pitch or tar from coke-oven coal carbonization (such as is practiced at Acerias Paz del Rio) in road pavements has always been an alternative to asphalt residues from petroleum distillation. In fact, coal tar was the original material used for this purpose. Asphalt replaced coal tar as it became more available because of the latter's technical advantage of rapidly changing its viscosity with changes in temperature, in other words the poor stability of tar to temperature. The effect is present; too fluid a tar in hot weather, and too brittle a tar in cold. However, such a magnitude of temperature change does, for practical purposes, not exist in the country.

Acerias Paz del Rio now produces 900 tons per month of tar, and this quantity could increase to as much as 2700 tons per month by about 1980, when the planned increase in production capacity has been achieved. Acerias has used their coal tar as the road paving material within their plant limits, and have found the material to perform quite satisfactorily. There has also been some use by the Ministry of Public Works in the area. If coal-tar is used extensively to replace asphalt as the supply increases, the asphalt thus freed from use in the geographical area of the steel plant would become available for export, either as asphalt or as a component in residual low-sulfur fuel oil.

Gabions. The use of gabions in another area that was investigated as a possible means of reducing costs in road construction, especially because gabion utilization is more labor intensive than other means of construction that accomplish the same results. It was found that the Ministry of Public Works already has imported a machine to produce acceptable wire-mesh boxes for the gabion construction, and that a Colombian firm was manufacturing suitable galvanized wire for use by the M.O.P. The Ministry is using gabions intensively and experiencing good results. Thus, nothing need be considered further in this area.

2. RECENT PROGRESS IN MODELING ROAD AND HIGHWAY CONSTRUCTION ACTIVITIES

Two recent developments seem now to make feasible a quantitative analysis of the set of activities involved in road and highway construction and maintenance. The activities start at the time the decision is taken to construct a new road or highway between two locations, continue through the time of commissioning the road and through its lifetime of maintenance. The developments can convert the analysis from a series of inadequately coordinated efforts which lead to cost and performance results usually far from the optimum for local conditions, to a set of efforts which are highly coordinated within a system, or process, in which the set of activities are elements. As the result, relatively quick analysis of alternatives ultimately become practical in order to select the cost and performance of road and highway construction projects that will be close to the optimum in terms of national goals and policies.

The developments are the Highway Cost Model (HCM) and the Labor and Capital Cost Model (CLM). The development of the HCM began with World Bank sponsorship of work by a group from MIT (CLM Systems, Inc*) It was completed by the Department of Civil Engineering of MIT for the U.S. Department of Transportation. The Labor and Capital Cost Model (CLM) has been developed by the World Bank.

2.1 HCM

The HCM is designed to estimate the costs of alternative strategies for investment in roads and highways. The model is composed basically of three parts which are submodels covering the costs of construction, the costs of maintenance, and the costs of operating vehicles. The objectives

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* Charles L. Miller Systems, Inc.

are to determine that combination of design standards, maintenance standards, and traffic volume and distribution which results in the least total social cost.

The construction submodel has as inputs the environment, the technology, the pavement standards, and geometric standards. It then estimates the quantity survey; and from data for productivity and unit costs, it estimates the costs for each operation in the construction of the road.

The maintenance submodel essentially has the same inputs, plus data on traffic usage. Through simulation, this submodel evaluates the deterioration of the road, and from unit cost data, the total cost of maintaining it.

The vehicle operating cost submodel demands data on traffic volumes and types of road surface condition, vehicle maintenance costs, and road geometrics; and its outputs is vehicle operating costs.

The maintenance submodel performs the important function of linking construction standards (and costs), road maintenance standards (and costs) and vehicle operating costs through the road deterioration relationships. Road deterioration is a function of the original pavement design standards, material types, the volume and axle load configuation of the traffic, and climate. Road maintenance costs are then derived from the deterioration experienced and the maintenance standards adopted. The road deterioration relations are thus control for estimating both maintenance costs and vehicle operating costs and relating both to pavement design standards.

The HCM permits analyzing the sensitivity of the total social cost produced for a set of input conditions to the uncertainty that may exist in the forecast of traffic volumes and types over the useful life of the road project. In a reverse manner, since the actual future increase

in traffic will depend on the condition of the road surface, the model permits considering a specific future physical condition of the road and from this predicting the increase in the traffic in accordance with the costs to the user of the road under the physical condition specified.

Another capability of the model of potential interest is its ability to analyze a staged system of road construction. Such a system consists in designing the road to accommodate a volume of traffic less than the expectations for the long term, with the purpose of making improvements as soon as the increase in demand justifies. These improvements can include changes such as using a different wearing surface, realignment, and widening the road.

2.11 Required Data

The input data or information that the model requires can be classified in two types:

2.111 Information over which there is no control of change. Illustrations of this type of data are:

2.1111 Unit prices of the resources (labor, equipment, and materials).

2.1112 Physical conditions of the environment (topography, climate, geology, availability of materials).

2.1113 Current demand for transport (initial traffic, and its sensitivity to change in transporter's cost for using the road).

2.1114 Opportunity costs of capital (rate of discount).

2.112 Data that can change or are variable in some form, and which are amenable to alteration in order to find a better solution. Illustrations of this type of data are:

2.1121 Engineering decisions (alignments, profiles, pavement specifications, transverse sections, construction alternatives of the stages, useful life).

2.1122 Decisions on maintenance policy (use of motorized graders,patching, sealing, repavement, etc.)

2.1123 Traffic composition including the rate of increase for each type of vehicle.

2.113 As soon as these data are available as input, the HCM simulates the construction of the road, its maintenance, and its operation in order to determine the total costs. The engineer can then act to improve his design by means of considering changes in input data, particularly of the second type.

2.12 Results

The model produces several kinds of results, such as detailed quantities of work for construction and for maintenance, the costs of the work, the corresponding costs and the quantities of the resources consumed, and vehicle operating costs. Costs can be presented in discounted form for the years of useful life of the project, or they can be presented not discounted. Costs can be allocated among labor, materials, transport, and equipment; as well as an allocation to show the import components of each one of the items. Social costs limited of markets costs can be obtained if opportunity costs are used for resources instead of market costs.

2.13 Possibilities of Analysis

Although the model is relatively simple, it is possible to accomplish a series of analyses of great value. The effects of variations such as in the rate of discount, in the technologies and practices used in construction and maintenance, and in programing by stages, can be readily explored.

Given such analytical possibilities, it becomes practical to study different alternative standards and specifications such as for materials of construction and for thickness of pavement, and to foresee the implications of each in the total cost of a road construction project and in the vehicle operating costs. Equally, the model permits comparing, in principle, alternative policies for balancing first costs for construction with deferred costs for maintenance and vehicle operation.

2.14 Present Status

The final report describing the HCM is now officially available from the U.S. Department of Transportation. The development work has been a continuation of an investigation begun in 1969 by the World Bank. The Bank, assisted by the Road Research Laboratory of England, is currently undertaking a series of studies in Africa, the principle objective of which is the empirical estimation of some of more important hypotheses (and subsequent mathematical relations) used to develop the HCM. This investigation is oriented also to the collection of complete and reliable information of the cost of operation of vehicles under conditions typical of developing countries. The results to be obtained from this effort will be useful to refine, or eventually to amend, the hypotheses and relationships within the HCM.

In addition, direct practical application of the HCM is now being seriously considered in Brazil, Argentina and Venezuela. In Brazil, the HCM will be used after present planning work is completed, to establish guide lines and policy to control a data collection program being undertaken by a French consultant for the Brazilian government. Brazil currently is spending US $1 - billion on roads and highways, and is interested that the data collected be sufficiently disaggregated and internally coherent.

In Argentina, ten consultants have established for the government separate studies of 500 km. sections of road construction representing both penetration roads and elements of the national road network. The model is actually being used to evaluate alternatives for preliminary planning and design in terms of costs of construction costs of maintenance, and vehicle operating costs. One other function will be to rationalize differences among the consultants with respect to the adequacy of the assumptions made in their studies.

In Venezuela, the HCM application is focussing on maintenance of the existing road network. The HCM will establish the resources needed for maintenance and policies for reconstruction and resurfacing. An important element will be an evaluation of the labor-intensive practices currently employed in maintenance work.

2.2 CLM

The World Bank has become interested in recent years with evaluating the magnitude of the problem of the appropriate use of labor resources in construction work in economies where underemployment is prevalent, and with developing analytical tools which could be used by the Bank and in the countries where the problem of labor utilization is of a large magnitude. With this objective in mind, the Bank has conducted data collection programs in connection with a number of firms* to collect experience, to analyse the background on the labor-utilization problem, and to set up a basis for developing a methodology to analyse the problem. Currently, as part of the work, the Bank is using information assembled in India in a mathematical model which they have already developed.

2.21 The Basic Principles

The general idea is to explore the technical possibilities of substituting labor for capital (i.e. machinery) in the construction of

*Namely: Scott Wilson Kirkpatrick and Partners, Ltd; Bureau Centrale d'Etudes pour los Equipement Economique et Social; and the Economist Intelligence Unit, Ltd.

roads and to determine the economic feasibility of substitution. In theory, considering that capital and labor are consumptions in a process whose final product is a kilometer of road, a series of alternative ways (i.e., technologies) to combine these two consumptions is possible, each of which will produce that kilometer of road. The universe of such possibilities might be plotted as shown in Figure B-1.

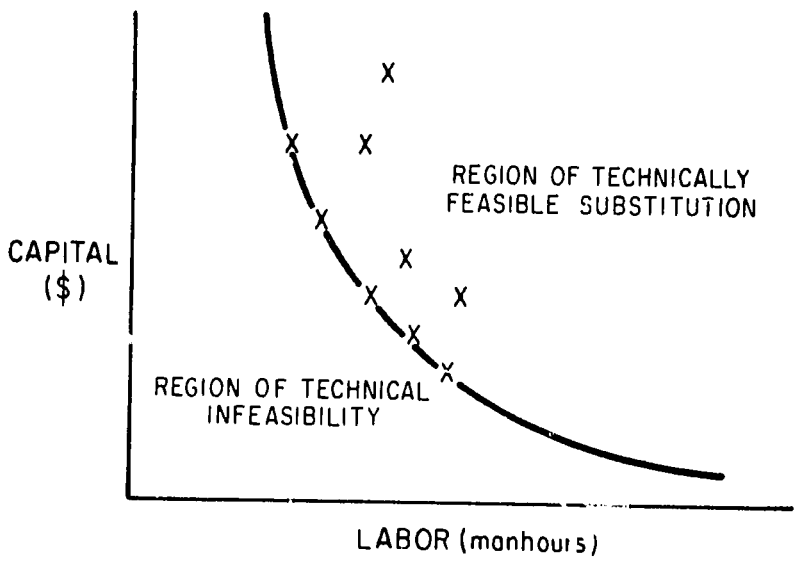

FIGURE B-1

If such a universe is evaluated to identify criteria for substitutions, a limit could be established up to which it is not technically feasible to substitute the capital-labor factors, i.e., no technologies exist for these labor-capital combinations that can produce the one kilometer of road. Beyond such a limit all technologies for combining labor and capital are feasible, but only when they fall on the limit are the technologies efficient, that is to say, they require less total quantities of labor and capital than the feasible technologies that do not fall on the limit.

The World Bank has had as the objective of its work to develop a methodology which can identify such a limit function, i.e., the boundary between feasible and non-feasible labor/capital substitution technologies. Such a limit function is the production function and it is the basis for proceeding later to economic evaluation.

Depending on the conditions of a road construction project, there are different ways to substitute the labor/capital factors. The parameters having a major influence on the rate of productivity of labor and capital and therefore those which define the forms and the locations of the production functions are:

- The physical environment (geology, climate, vegetation, the distance of earth moving).
- The size or scale of the project and the time available for its execution.
- The quality standards (specifications) of the project.
- The social and institutional environment.

It has been found that variations in these parameters can lead to radically different conclusions concerning labor-capital substitution. Since these parameters do vary for each road project, it becomes obvious that it will not be possible to produce detailed recommendations for labor-capital substitution that will be valid at a national level. Rather,

it would be necessary to analyze each road project on its own merits. Accordingly the need then becomes one of having a simple but adequate tool for such analyses.

Other findings from the World Bank work are:

- It is technically feasible to substitute labor for equipment for up to 80-90% of the total direct construction cost of a road project.
- The feasibility of using an intermediate technology, one involving using a mixture of modern machinery with hand methods, appears very promising.
- The potential to create employment by means of applying a vigorous government policy to construct roads by labor-intensive methods is large. Still this potential for additional employment will constitute only a small fraction of the total desired. In one special case analyzed in the World Bank Work (Morocco) it was estimated that the maximum generation of employment in the construction of roads would constitute scarcely 3% of the employment necessary for simply keeping the actual rate of unemployment constant.
- Nevertheless, the results and the methodology of analysis of labor-intensiveness in road construction could be applicable to other civil construction, especially in building construction, and this could offer additional opportunities for employment.

2.22 Description of the Methodology

Basically, the methodology reduces itself to identifying the technologically feasible alternatives for substitution, to choosing those that are the most efficient, and to evaluating the economic attractiveness of the selection. Accordingly, the necessary work to build a road has been disaggregated into tasks, activities and sub-activities,

the last of which disaggregated to a level which could be realized by machinery alone or by labor alone.

For the purpose of simple illustration, the taks of "moving earth" could be disaggregated into the activities: excavation; loading; transporting; unloading; and spreading. In turn, each activity could be accomplished by different methods or subactivities. For example, transporting could be done by a road scraper, a tilt-cart, a wagon, an ox-cart, baskets carried by laborers, or in wheelbarrows. Then, a comparison can be made of all possible alternatives to substituting a capital-intensive method by a labor-intensive method in the task of "moving earth".

We can suppose, to continue the illustration, that one task consists of three basic activities which can be realized exclusively by equipment or by labor with the following assumptions:

Activity	Equipment $	Labor Man-days	Daily Equivalent $ man-day
1	5,000	50	100
2	10,000	50	200
3	5,000	100	50
	20,000	200	100

Mathematically, if there are "n" basic activities in an operation each of which can be achieved in one of two ways, the number of combinations possible is two elevated to the power "n". In case of the example proposed, it is 2^3, that is 8 These possibilities are presented graphically, Figure B-2, and numerically, Table B-4.

TABLE B-4

POSSIBLE LABOR/CAPITAL COMBINATIONS

Combination	Equipment		Labor	
	Activity	Cost	Activity	Man-Days
a	1-2-3	20,000	-	-
b	2-3	15,000	1	50
c	1-3	10,000	2	50
d	1-2	15,000	3	100
e	3	5,000	1-2	100
f	2	10,000	1-3	150
g	1	5,000	2-3	150
h	-	-	1-2-3	200

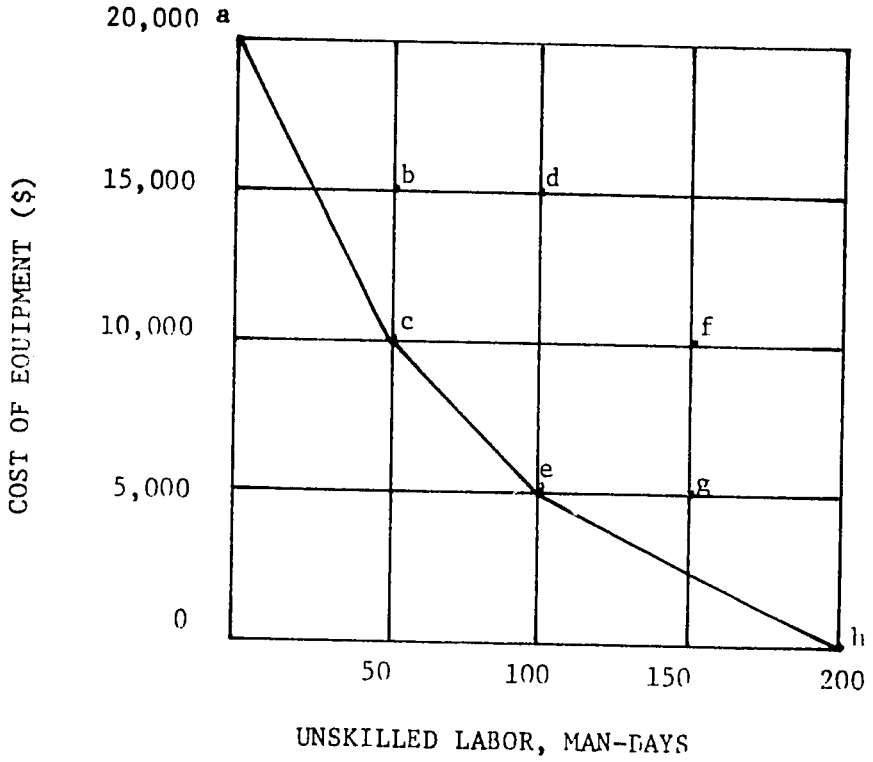
20,000
a
15,000
b
d
10,000
c
f
5,000
e
g
0
h
50
100
150
200
COST OF EQUIPMENT ($)
UNSKILLED LABOR, MAN-DAYS

FIGURE B-2

From Figure B-2, it can be seen that only the activities, a, c, e, and h, represent technologies that are efficient. The other combinations of the three basic activities to accomplish the task require more resources. In this way, it is possible to obtain isoquants, the function in Figure B-2, for each activity in the road construction project and then to define intermediate technologies for example, c and e. The linear characteristics of the functions then permit the use of mathematical programming methods for "optimization" in order to select the appropriate technologies.

The form of the production functions, and hence of the isoquants, is obviously determined by the productivity of the labor and equipment factors. These vary with the physical and social environment. The results in terms of selecting the "efficient technologies" and consequently their economic feasibility can also vary, and these even radically.

Expanding the above illustration, a complete group of tasks in the production function for constructing roads would be the following. The tasks listed are both sequential and interdependent.

1. Moving soft earth: excavation, loading, transporting (for various distances), unloading, and spreading.
2. Moving in rock: excavating, loading, transporting (for various distances), and unloading.
3. Excavation of rock in a stone quarry (for crushing): excavacation, loading, transporting, and unloading.
4. Gravel sub-base: excavation in the hard material, loading, transporting, unloading, and spreading.
5. Gravel base: excavation in the hard material, loading, transporting, unloading, and spreading.
6. Macadam base (from the crusher to the site): loading, transporting, unloading and spreading.

7. Crushed-stone base: loading, transporting, unloading and spreading.

8. Water distribution: loading, transporting, unloading, and spreading.

9. Fine gravel for spreading asphalt (from the crusher to the site): loading, transporting, unloading and spreading.

10. Distribution of asphalt: loading, transporting, unloading, and spreading (including the process of heating).

Ultimately, each one of these activities could be accomplished by different methods (technologies). A non-exhaustive list of possible technologies in moving soft earth (Task No. 1) would be as shown in Table B.5.

Defining the activities one way in this form, it is possible (supposing that there exists adequate information for the different productivities of the labor/capital factors for each activity) to obtain the production function for each technology specified. The slopes of the straight-line segments forming this function (e.g., the function in Figure B-2) determines the limit of wages below which it is convenient to substitute labor for machinery, from a cost point of view.

Other considerations should also be taken into account. For example, loading one tilt-cart by hand means that this equipment will remain idle for some time. Equally, there are machines that can accomplish several basic operations simultaneously. Because of the similar nature of the different tasks in a road project, the activities involved in one task may not be independent of similar activities involved in another task. Thus, the technology selected for one task influences the selection of technologies for the other tasks. Definitely, a process of suboptimization task by task will not lead to the optimization of the global system.

TABLE B-5

POSSIBLE TECHNOLOGIES IN THE TASK OF MOVING SOFT EARTH

Technology or Method of Operation	- ACTIVITY -				
	Excavation	Loading	Transport	Unloading	Spreading
A	Road-Scraper	Road-Scraper	Road-Scraper	Road-Scraper	Road-Scraper
B	D8 Bulldozer	Shovel into tilt-cart	Tilt-cart	Dump tilt-cart	Grader
C	D8 Bulldozer	Shovel into tilt-cart	Tilt-cart	Dump tilt-cart	Labor
D	D8 Bulldozer	Shovel into trailer	Tractor and trailer	Dump trailer	Grader
E	D8 Bulldozer	Labor into trailer	Tractor and trailer	Dump trailer	Labor
F	Labor	Labor into basket	Basket	Dump basket	Labor
G	Labor	Labor into wheelbarrow	Wheelbarrow	Dump wheel-barrow	Labor
H	Labor	Labor into wheelbarrow	Wheelbarrow	Dump wheel-barrow	Grader
I	Labor	Labor into oxcart	Oxcart	Labor	Labor
J	Labor	Labor into trailer	Tractor and trailer	Dump trailer	Grader
K	Labor	Labor into trailer	Tractor and trailer	Dump trailer	Grader
L	Labor	Labor into tilt-cart	Tilt-cart	Dump tilt-cart	Labor
M	Labor	Labor into tilt-cart	Tilt-cart	Dump tilt-cart	Grader

Therefore, it has been necessary in the development of the mathematical model to build in capability to consider all these restrictions together. Such a model would receive as basic information, the definition of the project (possibly as quantities of work) together with a diagram showing the diverse items of work, their sequence, and their disaggregation as basic sequential activities.

Other required information could be the definition of the environmental conditions (and their seasonal variations), the objective to be achieved (for example, minimizing costs), and the external restrictions (for example, finance or the period of construction) together with cost information. The model would use "standard" data for productivity, and would adjust them in the light of the conditions of the environment.*

We have seen that the fundamental variable determining the economic feasibility of substituting labor and capital is the productivity of each of these factors. Labor productivity varies enormously. In general, one could consider that the productive capacity of labor will depend on factors such as the physical environment, cultural patterns, nutrition, etc; factors which could change only in the long-term.

On the other hand, the work accomplished by labor could be much less than the capability. The actual difference between capability and actual work output depends on typical administrative factors (incentives, organization, facilities, etc.). The fact that experience in the analysis of such differences is very scarce and that engineers are not trained in this discipline, could make the degree of managing this aspect crucial to the success of a program of promoting intensive utilization of labor.

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* Obviously, those standard data, as well as the implications of the environment, would result in an investigation and a statistical collection accomplished in Colombia, with which to calibrate the model.

2.23 A Brief Description of the Model

The objective of the model is to select a method of construction in accord with the local conditions of labor and capital availability. The selection of the method depends on two main variables:

- the nature and size (scale) of the project; and
- the kinds of resources and their availability in the country, or in the region.

The resources are defined in a very general way. They include equipment, personnel, foreign currency, and other items consumed. Any element which may be considered as a resource, and whose availability affects the selection of specific technologies, could be considered in the model.

The development of a model is desirable, since the number of alternatives to be examined for a road construction project is of a combinatorial nature, and the result can be a very large number of alternatives. These large numbers of options must be analyzed in an expeditious manner to identify the combination that minimizes the objective function, usually cost. Mathematical programming techniques are available which permit such analyses. The problem does not consist in the development of a programming technique, but rather in the mathematical formulation of the same.

2.231 Assumptions

In order to develop the model, it was necessary to establish a series of assumptions about the activities. The methods of utilizing the equipment, with their associated requirement for resources and their availability for specific tasks of production, should be defined explicitly, and this definition could involve the simulation of the road construction project. The terminology and the assumptions in the model are summarized as follows.

2.232 Tasks

The model is based on defining quantitatively a group of tasks in the project, which in general have been identified using typical design classifications. To illustrate, one task, with its quantity of work, could be defined as the movement of earth (m^3), clearing and cleaning (m^2), compaction (m^2), etc. These tasks could be subdivided to the level of detail desired. For example, the task to move earth could be subdivided in accordance with the type of material and the distance of transport. Generally, the tasks include various activities, such as excavation, loading, transporting, and unloading.

2.233 Methods

A method is the manner (or the technology) for accomplishing a task. The task is accomplished using a specific combination of labor, equipment, and consumable resources. The possible methods to accomplish a task can vary from only labor (no equipment) to practically only equipment with very little labor. Intermediate methods can exist which use different quantities and sizes of equipment.

Each method requires, therefore, a specific mix of resources, which determines the production function for that method. In turn, each task takes in a group of associated methods, and each one of these has its requirement of resources, or its particular production function.

2.234 Phases

The tasks to be achieved in the project can be allocated to groups which represent periods of time, or phases. In this manner, the time sequence for the tasks can be considered without the detail normally required in PERT-type analyses.

2.235 Installation

The model permits the efforts to mobilize equipment and people and bring them to the construction site to be considered.

2.236 Linear Relationships

The technique of mathematical programming used in the model is linear programming, which requires that all the mathematical relationships be linear. This requires that there are no economies of scale among the number of tasks involved in a specific road construction project, and that the number of tasks does not change regardless of whether large or small quantities of personnel or equipment are required. Nevertheless, in order to consider the different "methods" where scale is significant, different sizes of equipment with their associated productivities can be programmed, so that the parameter of scale can be taken into account for analysis in the evaluation of a method.

2.237 Foreign Exchange

The model has been formulated to include the impact of availability of foreign exchange for a road project. When required, foreign exchange can be considered with its opportunity cost in place of the financial cost in the objective function.

2.238 Availability

In each period of time or phase, each one of the resources has a certain number of hours of availability. If more hours are required to accomplish the task of the phase, other units of this resource must be brought into this phase. The availability must include the climatic conditions, the general efficiency of the resource, and, in the case of equipment, the time for repair and maintenance.

With such assumptions and definitions, the problem is formulated mathematically in the usual manner of linear programming. The optimum solution is the minimum cost of the construction project, and the solution specifies the corresponding construction methods and the quantities of the resources necessary to obtain the cost. In other words, the combination of resources and associated methods of all the available alternatives presented, is determined which minimizes the cost of the project. The objective function can consider the economic costs of certain resources in place of their financial costs.

The linear programming calculations, at the appropriate time, permit a series of analyses of much interest to be accomplished. Among these, the most important are:

- Permissible variations in the costs (prices) of the resources. The model can calculate the range of values for the coefficient of the objective function (i.e., the prices of the resources) for which the same solution is valid. If a specific resource is involved in the solution, it calculates how much the price of this resource can be raised before it becomes more advantageous to use another resource in its place. Also, it is possible to obtain the amount one must lower the price of a certain resource in order to make it advantageous to use it more intensively. If a resource is not involved in the solution, it calculates the amount the price of this resource must be lowered so that it will become desirable to use it.
- Incompletely consumed resources. The model yields the available quantity of resources which have not been consumed in order to obtain the optimum solution.
- Estimation of shadow prices. These prices reflect the costs associated with the limitations (restrictions) in the number of available resources. For a method or resource that is not involved

in the solution, shadow price represents the price needed to use such a method or resource in the tasks, in place of the method or resources selected in the solution.

2.24 Illustration of the Type of Information Required

In Table B-6, production functions are presented for 13 technologies or methods (A through M) for accomplishing the specific task of "moving 1000 m^3 of soft earth a transport distance of 200 meters." For example, the method "H" requires the following resources:

Grader	0.5	hours
Unskilled labor	4109	hours
Operators	0.5	hours
Fuels	22	liters
Oils	0.25	liters
Small carts	6000	hours

This method consists of accomplishing the excavation, loading, transport, and unloading with labor, with spreading by a grader, to move 1000 m^3 of material.

The possible methods and their corresponding production functions must then be defined for each task. The model will consider the project as a whole, analyze all the possible combinations of technologies, and select those offering the minimum project cost.

2.25 Evaluation of the Model

The model (or in a wider sense the methodology developed to analyze the labor/capital problem) has the following characteristics:

TABLE B-6

PRODUCTION FUNCTION vs. TECHNOLOGY

(Movement of 1000 cu. meters of soft earth
a transport distance of 200 meters)

Resources (Hours)	METHODS*												
	A	B	C	D	E	F	G	H	I	J	K	L	M
Trailer	10.6												
Tilt-cart		35.77	35.77									92.77	92.77
D-8	5.0	7.0	7.0	7.0	7.0								
Back-hoe		18.0	18.0	18.0	18.0								
Grader		1.0		1.0				0.5			1.0		1.0
Ox-cart									57.05				
Unskilled labor			160	13.3	173.3	14629	4199	4109	1035	913.3	783.3	930	770
Operator	15.6	26.0	25.0	26.0	25.0			0.5			1.0		1.0
Tilt-cart driver		35.77	35.77									92.77	92.77
Tractor operator				25.0	25.0					25.0	25.0		
Fuel (lts)	734	1099	1057	1154	1132			22		475	497	420	442
Oil (lts)	12.5	13.0	12.8	16.6	16.4			0.25		6.25	6.5	2.7	2.9
Wheelbarrow							6000	6000					
Trailer				56.3	56.3					188.3	188.3		
Tractor				25.0	25.0					25.0	25.0		
Ox and driver									233				
Assistant operators	5	8	7	8	7			.5			1		1

*See description of each one of the methods in Table B-5.

- It takes in the entire process of construction for the project.
- It takes in the entire set of existing technological alternatives.
- It considers the economic, social, and institutional restrictions (that is to say, it leads to a realistic solution).
- It permits defining the objective function in accordance with different scales of values (economic costs, financial costs).
- It permits making detailed analyses of the sensitivity of the solution found as different parameters vary.

These characteristics make the methodology proposed an important tool for the analysis of the methods in use for the construction of roads and for the identification of costs that can be incurred if these methods are not the most appropriate. As a result, relevant policies that should be followed can be identified and implemented.

Thus, the model so far described has a scope so vast that in order to apply its potential adequately an extensive statistical base is needed which reflects the reality of local conditions. Therefore, the collection of information could be comprehensive and hence, costly.

On the other hand, the model is enormously flexible because it permits the tasks and the number of technologies studied to be disaggregated entirely as the user wishes. It is possible, therefore, to reduce considerably the need for reliable data and information simply by reducing the scope of the model.

New practical experience in addition to the development studies so far accomplished show that a good opportunity to substitute labor for capital is presented in earth-moving activities since the percentage of the total cost of the construction work attributable to earth-moving is on the order of 50%. For other activities substitution is possible, but the

acceptability of the results of substitution is subject to achieving the desired quality in the completed construction. Thus, if the scope is reduced to analyzing only earth-moving operations, the cost of collecting reliable information and data could be reduced considerably. The extent to which the scope of the analysis should be reduced depends only on determining when the reductions in the cost of data collection begin to diminish marginally.

Furthermore, the model as so far described, can consider a very large group of alternative technologies to accomplish each task. A reduction of the number of technologies to be considered in a manner that focuses attention only on those that are responsive to local conditions, equally can reduce the cost of collecting information. Furthermore, this can significantly reduce the complexity of the analysis.

On such a basis, by considering an analysis of a more limited scope totally adapted to Colombian conditions, and by exhaustively evaluating the realistic possibilities for labor/capital substitution existing in the country, the proposed methodology could be of great utility. Besides representing an already-developed analytical tool, the collection of data, productivities, and results would be compatible with the results of studies already made in other countries. This compatibility would permit making a series of comparisons of great utility in respect to testing possible new technologies that do not yet exist in this country.

2.3 Application to Colombia

It should now be clear that the HCM and CLM can complement each other if they are applied to analyze the activities in the road and highway sector with respect to both construction and maintenance. The method for application could be described below. Regardless of the method chosen, however, basic input data will be required for both models and these data

should be sufficiently comprehensive and representative of local conditions so that realistic results are obtained when the ultimate purpose of the application is achieved.

The method can be based on accomplishing a set of consecutive steps; as each step is accomplished, confidence in the validity of the results increases; and in the final step introducing the use of the HCM/CLM combination as an analytical tool for day-by-day management and control of the design and institutional practices involved in road and highway construction and maintenance. A practical set of steps is:

2.31 Sampling of Projects

Select a sample of current and recent projects for which design and cost data are at least extensive if not complete. Apply the HCM to determine the quantity surveys independently, using the same inputs of topographical and geometrical conditions. Compare the computer results with the designer results, and evaluate the differences in terms of the reasons that explain them. Aim for conclusions regarding the merits of adopting the HCM as a basic procedure for computing quantity surveys for future projects, such as by parallel off-line computer-manual procedures, and finally by on-line computer procedures alone. The ultimate result will be an improvement in the accuracy of the quantity survey data on which construction contracts are based.

2.32 Focus on Pick and Shovel

Select a sample of "pick and shovel" projects and apply the CLM to the experiences to determine the effectiveness of the labor utilization so far, and the opportunities to improve labor utilization through changes in the construction technologies employed. In addition, aim for conclusions regarding the merits of applying the CLM for identifying the appropriate technologies to be adopted as general practices in the road and highway sector, and perhaps to other civil construction, e.g., housing.

2.33 Relate HCM with CLM by Cost Factors

Use the CLM technique to establish cost factors based on the most appropriate use of construction technologies in terms of labor employment, foreign exchange demand, and financial cost; and apply these costs to the quantity surveys computed by the HCM for the sample of road and highway construction projects. Compute the total field cost for each project and from the records compare with the total project cost. Analyze the difference between each total project cost and total field cost in terms of its components, namely: the differences between actual quantity survey experienced, the designed quantity survey in the contract, and the computer (HCM) result; the differences between actual unit costs experienced, unit costs in the contract and the computer (CLM) result; and the inefficiencies in the construction progress that may have arisen from delays experienced in progress payments. Aim to identify from the results the probable contractor's home office overhead and profit. The ultimate result will be the ability to establish potential cost-reduction opportunities quantitatively to serve as the incentive to make the institutional changes that are appropriate for realizing these opportunities.

2.34 Use of HCM/CLM Combination

Use the HCM and CLM in combination to determine construction standards and specifications that are appropriate to Colombian economic, traffic, and environmental conditions. Use the combination to revise these as conditions change. Establish the justification to change institutional practices in a way that appropriate standards and specifications can be effectively employed in road and highway construction projects. Evaluate appropriate policies for allocating the global cost of road and highway construction projects between the initial cost of construction and the deferred cost of maintenance.

APPENDIX C

URBAN MULTIFAMILY HOUSING CONSTRUCTION

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1. INTRODUCTION

The investigations concerned with the technological and cost aspects of vertical multi-unit housing were undertaken by the Division of Urban and Housing Development with the assistance of the firm of consultants, Londofio y Velásquez of Bototá. The work results are now in the final stages of assembly and reporting, and will be available in the near future as a report of the Division. The purpose in this Appendix is to abstract the findings in a manner that will support the formulation of an action plan for the reduction of costs of urban housing construction. It is to be understood here that the full report of the Division should be consulted for details, data, and further explanation.

2. SCOPE OF THE INVESTIGATION

The investigation was based on the data for construction costs and on the experiences of the consultants in recent years in the construction of urban housing in the country. A number of specific evaluations were completed based on these data and experiences.

a. Analysis of Building Costs

A sample was selected of twelve urban housing buildings of varying sizes constructed within the past five years in the major cities of the country. Twenty-one categories of components of the construction cost were isolated; nineteen of which represent actual physical components of the construction, one the costs of plans and fees, and the last the costs of permits, taxes, and insurance. The sample was organized into six classifications depending basically on the heights. Allocations of the costs were made by category for the six classifications of buildings as percentages of the total cost. The range of variation of cost per unit area arising out of the building classifications is given for each category. The classifications encompass single-family dwelling through 30-story multi-dwelling buildings. Complete definititions of the scope of the efforts included in each cost category are presented.

The data for construction cost for each classification of building are also reported as the cost per unit area for each cost category and as a total unit area cost for the classification. The specifications in each classification are summarized. Labor cost data are reported as percentages; one set of data representing the percentage of a cost category that is the cost of labor, and another set translating these percentages as percentages of the labor cost of each category in the total cost of labor in the construction.

A table is included which indicates the interrelationships among the cost categories in terms of the sensitivity of the remaining categories to a change in one category. Other data are presented that allocate the total sales prices of the buildings in the sample among the costs of urbanized land, construction cost, and sales and capital costs.

Finally, using the results of the cost analysis as a basis, each cost category was separately considered and given an assessment of the possibility to reduce its costs as part of the entire cost of the construction, and for each category the areas of concentration of efforts such as reduction of specifications, better study of designs, and better quality of labor are indicated. The analysis reached the stage where the twenty-one cost categories could be collected in a preliminary manner into three separate groups, which were then ranked in the order of the priority of attention that should be given them for finding opportunities to reduce costs.

b. Analysis of Costs of Construction Alternatives

For selected categories of the cost components, the costs of a number of alternative constructions were analysed and the results compared. Specifically, the following comparisons were made:

- Masonry Walls. Four alternative constructions were selected, namely: hollow burned-clay tile; solid burned-clay brick; portland cement-concrete block; and a commercial brand of bituminous block.

Alternative designs were selected for each type of wall construction, and costs of erection were estimated under the condition prevailing in Bogotá, excluding the costs of ornamental finishes. Excluded also were differences in costs arising from differences in the efforts needed to accommodate electrical and plumbing fixtures in the walls and from differences in loadings on the foundation that result.

- Type of Steel Reinforcement. Two alternative constructions for placing steel reinforcement in the structural concrete were considered: one a shop-fabricated wire mesh, and the other field-fabricated assemblies of reinforcing roads. Five different reinforcement applications were considered.

- Construction of Floor Slabs. Five alternative systems for constructing floor slabs that reduce dead loading were considered; involving both generally-available weight-reducing shapes and proprietary designs. In addition, the costs of nine different constructions for finishing floors were compared including ordinary or white cement finish, wood, clay tiles, cement tiles, pvc plastic tiles, and ornamental stone.

c. Fees and Charges

This item is one of the categories of cost components in the construction cost analysis mentioned above. The investigation included compiling data for the fees charged for such services as architectural design and supervision, structural design, estimation of costs, scheduling and control. These data were compiled for the building classifications considered in the construction cost analysis described above.

d. Others

The investigation drew on the experiences of the consultant to identify and quantify costs of numerous operations associated with building construction,

such as the handling of materials at the building site and the application of ornamental finishes.

3. SCOPE OF RESULTS

The results of the individual investigations are presented in graphical and/or tabular form, and represent a body of data on a rather limited sample of recent urban housing construction activities in several major cities of the country. The utility of the results lie more in the beginning they represent toward the compilation of comprehensive data covering a more extensive sample of urban housing construction activities, rather than in their potential to enable formulation of conclusions of specific opportunities for reducing costs.

Nevertheless, it was possible to obtain some preliminary conclusions from the results. The choice of height of buildings as determined by the value of land was explored, and the optimum height for the sample of constructions determined. Observations were made of the effects on total construction cost for different productivities of labor and alternative scales of wages. "Trade-offs" were explored between different approaches to cost reduction such as elimination of cost of specific finishes in terms of increased density of construction such that a net effect of zero on the total project cost is produced.

Thus, it becomes apparent that a continuation of the effort is justified. A series of coordinated actions should be planned to the extent that the results lead to the identification of cost reduction opportunities that are practical to implement.

4. PROBLEM AREAS

Another result of the investigation is based on the experiences and the industry contacts of the consultants, and is the identification of a number of problem areas, solutions to which are needed if productivity in

the housing sector is to be increased. The following is a representative summary, arranged by the nature of the problems.

a. Institutional

The channels of communication among the many organizations engaged in the building construction sector are ineffective. Either they do not exist, or if they do are ineffectively used. If the volume of construction activity increases markedly, bottlenecks can develop which could delay schedules, increase costs, and in general decrease the productivity of investment significantly. For example, there is at present no way to foresee needs for skilled construction labor and to anticipate needs through effective training programs. There is no effective way to know whether the construction industry has the capacity to undertake the volume of construction activities that may result because of new financial policies for savings and loans. New lower-cost construction materials, e.g. non-portland masonry cements, would be difficult to introduce.

Past efforts to achieve a coordination have not been successful for clear reasons. CINVA has international objectives and could not readily involve itself in local institutional problems. Centro Colombiano de la Construcción (Bouwcentrum) has specific private objectives and could not readily accommodate itself to governmental viewpoints. Other efforts have similarly been ineffective, but the experiences are valuable and relevant.

A new opportunity exists to achieve the desirable level of coordination of the individual efforts and activities of the building construction sector. This is the creation of FAVI with a legal power to set standards under which they will grant loans. Definition is needed of specific measures which FAVI can consider to implement their authority in a way that leads to greater productivity from the loans they grant.

b. Labor

The construction industry finds itself with respect to labor as training institution for labor. Unskilled people finding jobs in the construction industry eventually achieve levels of skills that are attractive to manufacturing industry and the service sector. They leave their position, and the construction sector then must train new people. The reason no doubt lies in the greater stability and better conditions of work outside of the construction sector.

The solution to this problem lies outside the scope of the Ad-Hoc project. Obviously, from the point of view of the economy, the training function of the construction sector may produce benefits overall that justify the increased costs that are incurred for construction. On the other hand, from the point of view of the construction sector, training on a continual basis leads to reduced efficiency, reduced productivity, and hence increased costs. Policy and actions to alleviate this condition should be established with a point of view far broader than is represented by the Ad-Hoc project.

c. Materials

Although the quantities of materials available for construction so far have been adequate, the variations in the qualities of the materials lead to construction inefficiencies because of increased use of labor to accommodate the materials to the installations. For example, dimensional standards for brick shapes and for lumber products either do not exist, or where they do enforcement may be ineffective. This requires greater attention by construction labor to maintain the required final dimensions of the installation. In addition designers are not sufficiently observant of the need to specify dimensions of finished installations that reflect the sizes and dimensions of the materials available in the country; nor do they pay sufficient attention to the usual variations in the quality (strength and appearance, for example) when preparing final designs.

The materials manufacturing industry does not adequately publicize the specifications of the products they produce. If they do, there is no assurance that the materials actually shipped to a construction site conform to published information.

The remedy seems to lie in the combination of the power of FAVI to enforce standards for construction of housing financed through them and the activities of ICONTEC to set standards for the country. ICONTEC has no powers to enforce any official standards or to encourage their widespread use. Such a combination should include interchange and coordination of activities by both organizations such that the country, and the construction industry in particular, will have consistent control and knowledge of the quality of the output of materials of construction. The cooperation of other government and private organizations, such as the ICT and the BCH, should be enlisted to insure universal acceptance and the identification of standards appropriate to Colombian construction conditions.

d. Equipment

Construction firms partially qualify themselves for bidding on major building construction projects financed by the large groups such as BCH, by the extent of direct ownership of construction equipment. The differences in this respect among the bidders for a specific project is a determining factor in the award of the contract. This leads to an ineffective and inefficient use of construction equipment in the country, because construction firms in order to protect the strength of their bidding position would rather keep equipment (usually imported) than sell to other firms. In addition, the usual difficulties to obtain imported spare parts or replacements, help to keep equipment idle.

The remedy seems to lie in extending to the building construction sector the interest typified by the Ministry of Public Works in establishing a "Bolsa de Equipo" for heavy road-construction equipment, in which the members

would interchange the usage of their individually-owned equipment to the changing demand patterns. At the same time, contracting procedures should be changed, so that construction firms can qualify by membership in a Bolsa as well as by direct ownership of a total lot of equipment. The encouragement of the development of equipmental rental services is an alternative.

Another problem in the equipment area is in the poor design of hand tools in relationship to body movements which tends to generate fatigue in the worker and a reduction of productivity. An effort should be undertaken to determine how improvements in hand tools already made in other countries, as well as locally, could be transferred to Colombia. A start already has been made by CINVA.

e. Technology

Much of the technology, particularly for the construction of large structures, is imported. This represents the use of methods especially suited to the conditions in the country of origin of the technology. Thus, the opportunities for labor employment or for a reduction of imports are not necessarily present because the technology may not be appropriate to local conditions. Also, reliance on use of imported technology tends to discourage any local initiative to develop technological practices better suited to local resources. Although some technological practices must be imported because of their level of sophistication, nevertheless there probably exist numerous opportunities to rely more on local initiative and creativity to develop appropriate methods. Some opportunity to reduce costs exists.

The remedy appears to lie in a further application to the building construction industry of the analytical and quantitative approach adopted and developed by the World Bank for road and highway construction. The experiences expected from the application of this approach to Colombian road or highway construction should be applied to a similar analysis of the operations in the building construction sectors.

APPENDIX D

MATERIALS OF CONSTRUCTION

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1. THE DEMAND FOR CEMENT

a. Alternative I

Projections Based on Historical Consumption. For this purpose, the internal consumption of cement in the year 1971 is taken as the base consumption and an annual rate of 10% is assumed as the average increase of the 1971 consumption. This national consumption is regionalized in accordance with the distribution of sales of cement in the country and it is collated as the regional consumption calculated for the year 1972. In this way, future increases in the consumption of cement with respect to the year 1972 can be projected.

The resulting figures are developed as follows:

- consumption of cement in the base year of 1971; 2,677,355 tons
- projection based on average historical increase.

Year	Consumption (thousands of tons)
1972	2,944
1973	3,238
1974	3,561
1975	3,917

- Regional consumption: with the object of projecting regional consumptions, the sales of cement for national consumption in each region was studied. As it is observed in the following table, the participation of sales by region has become stable in the last three years (this is the basic assumption for each alternative I, II, and III).

National Sales of Cement

	1969	1970	1971	Approximate Average
	%	%	%	%
Atlantic Coast	16.0	16.5	19.0	17.0
Northwest	18.0	18.5	18.8	19.0
Southwest	24.0	25.0	24.7	22.0
Central	35.0	35.2	34.9	35.0
Northeast	7.0	7.8	7.6	7.0

Using the average percentages calculated in the table above, the increases in regional consumption with respect to 1972 in the table on the following page can be calculated.

- Projections of regional consumption in thousands of tons. The figures in parentheses represent regional participation in sales.

To be able to calculate the regional deficits, the increases in consumption calculated above are compared with the increases in installed capacity which are projected for the year 1973. The expansions for new production are detailed as follows:

Region	Expansion Tons	Date of Completion
Atlantic Coast	270,000	March 1973
Northwest	150,000	December 1972
Southwest	275,000	March 1973
Central	175,000	December 1972

Region	Year	Consumption	Consumption in 1972	Difference
Atlantic Coast (17%)	1973	550	500	50
	1974	605	500	105
	1975	665	500	165
Northwest (19%)	1973	615	559	56
	1974	676	559	117
	1975	744	559	185
Southwest (22%)	1973	712	648	64
	1974	783	648	135
	1975	861	648	213
Central (35%)	1973	1,133	1,030	103
	1974	1,246	1,030	216
	1975	1,370	1,030	340
Northeast (7%)	1973	226	206	20
	1974	249	206	43
	1975	274	206	68
TOTAL	1973	3,238		294
	1974	3,561		617
	1975	3,917		973

If it is assumed that the increases in consumption above the level of 1972 are totally supplied by the planned expansions, the regional deficits in Alternative I will be the following:

Region	Year	Consumption	Capacity	Deficit
Atlantic Coast	1973	50	170	-
	1974	105	270	-
	1975	165	270	-
Northwest	1973	56	150	-
	1974	117	150	-
	1975	185	150	35
Southwest	1973	64	275	-
	1974	135	275	-
	1975	213	275	-
Central	1973	103	175	-
	1974	216	175	41
	1975	340	175	165
Northeast	1973	20	-	20
	1974	43	-	43
	1975	68	-	68
TOTAL (National)	1973			20
	1974			84
	1975			268

b. Alternative II

(1) Projection of Investments

This alternative proposes the following goals for investment in construction.

(a) Investment in Buildings. According to the Unit of Global Programming, the additional annual investment in buildings can easily reach the following levels:

(Millions of 1968 Pesos)

Year	Increase in Investment	Increase over Actual Investment (1972)
1973	1,250	1,250
1974	1,250	2,500
1975	1,250	3,750

(b) Investment in Infrastructure. The following are estimates of annual increase of investment in the sectors of water systems and public works, and the energy sector.

(Millions of 1968 Pesos)

Year	Additional Annual Increase	Increase above Actual Investment (1972)
1973	769	769
1974	833	1,602
1975	895	2,497

(2) Participation of Cement in the Investments

(a) Buildings. The following estimates are available of the average direct participation of cement in the value of buildings.

a. Camacol - 6.18%

b. Planeacion (UPG) - 7.5%

For the purpose of the projections, a coefficient of 7.5% is adopted.

(b) Works of Infrastructure. The Unit of Global Programming of Planeacion estimates that the participation of cement in the total value of investment and infrastructure can be on the average of 5%. For the purpose of the projections this is the coefficient used.

(3) Projections of the Consumption of Cement

Two methodologies are proposed for the purpose of calculating the consumption of cement.

(a) Make use of the estimate of direct and indirect consumption of cement in the economy resulting from increasing investment in construction.

(b) Make use of the historical data of the participation of cement in the investment in buildings and infrastructure.

- to project the direct and indirect consumption of cement resulting from the additional investment (to which reference is made in Section 1 of Alternative II), use has been made of the input-output table prepared by the Unit of Global Programming of Planeacion. The results obtained are the following:

Year	Thousands of Tons*
1973	550
1974	1,040
1975	1,650

*Increase in the consumption of cement in relation to actual levels, that is to say, in the year 1975 a demand for cement would be 1.65 million tons above the demand for 1972.

- The direct consumption of cement can be calculated making use of the percentages discussed in the section (2) above, adjusted by an index that reflects that the changes in the cost of living relative to the price of cement since 1968. This index has been calculated as 1.11. The investment in 1968 pesos are converted to 1971 pesos using a general index of cost of living (1.35). Then, this figure of investment is translated to demand for cement using the coefficient for buildings of 8.25 (equal 7.5% x 1.11), and for infrastructure of 5.55 (equals 5% x 1.11). This demand will be in 1971 pesos, and it is converted to tons of demand dividing by the average price of cement to the consumer (450 pesos per ton in 1971). The calculations are the following:

INVESTMENT IN BUILDINGS

YEAR	(1)	(2) = (1) x 1.35	(3)	(4) = (3) x 7.5%
1973	1,250	1,675	1,675	123
1974	1,250	1,675	3,350	246
1975	1,250	1,675	5,025	369

INVESTMENT IN INFRASTRUCTURE

YEAR	(1)	(2)	(3)	(4)
1973	769	1,040	1,040	52
1974	833	1,125	2,165	104
1975	895	1,209	3,364	156

NOTES

(1) Additional investment in millions of 1968 pesos.

(2) Additional investment in millions of 1971 pesos.

(3) Additional investment above the level of 1972 in millions of 1971 pesos.

(4) Value of the additional demand for cement in relation to 1972, in millions of 1971 pesos.

Multiplying the values in column (4) by 1.11, and dividing these by 450 pesos, the following additional demands for cement are found:

Year	Additional Demand Above The 1972 Level Thousands of Tons
1973	430
1974	863
1975	1,300

For the purpose of projection, it is considered that the direct and indirect demands should be taken into account; for this purpose the figures resulting from the methodology (3a) above are utilized.

(4) Deficits Foreseen for The Country

(a) Expansions

Four firms are achieving expansions in their capacity according to details as follows:

	Expansion Tons	Date of Completion
1. Atlantic Coast	270,000	March 1973
2. Northwest	150,000	December 1972
3. Southwest	275,000	March 1972
4. Central	175,000	December 1972
TOTAL	870,000	

This is to say that the country can count on 870,000 tons of capacity additional in the production of cement before June 1973, which would be used to support the demand in 1973.

For 1974 the deficit can easily be foreseen since the 1,040,000 tons of additional demand in that year will have only 870,000 tons offered.

TOTAL DEFICITS IN THE COUNTRY
(Thousands of tons per year)

Year	Increase in Demand	Increase in Supply	Deficit
1973	550	870	-
1974	1,040	870	170
1975	1,650	870	780

(b) Regional Demands

The sales of cement by regions indicate the following percentages with respect to the total sales of the country:

Region	
1. Atlantic Coast	17%
2. Northwest	19%
3. Southwest	22%
4. Central	35%
5. Northeast	7%
TOTAL	100%

These percentages are utilized to estimate what will be the additional consumption of cement by regions. The results are the following:

Region	Year	Additional Consumption	Additional Capacity	Deficit
Atlantic Coast (17%)	1973	94	270	-
	1974	177	270	-
	1975	280	270	10
Northwest (19%)	1973	104	150	-
	1974	197	150	47
	1975	313	150	163
Southwest (22%)	1973	121	275	-
	1974	228	275	-
	1975	363	275	88
Central (35%)	1973	192	175	17
	1974	364	175	189
	1975	577	175	402
Northeast (7%)	1973	38	-	38
	1974	72	-	72
	1975	115	-	115

c. Alternative III

(1) Projection of Investment

(a) Investment in Building. Alternative III proposes goals much higher in investment than were considered in Alternative II. In the year 1973 the investment in dwellings will increase 1,825 millions of pesos (of value constant for 1968) above the level reached in the year 1972. The increase for 1974 would be 1,825 millions above the level for 1973, and for 1975 it would be 2,500 millions of pesos above the level of the former year. These goals represent accumulated increase in investment in building in the following order:

Year	Accumulated Increase in Investment in Buildings above the Level of 1972
1973	1,825
1974	3,650
1975	6,150

(b) Investment in Infrastructure. For the Alternative III it is assumed that the level of investment in infrastructure would reach the same limits proposed for Alternative III. These are the following:

(Millions of 1968 pesos)

Year	Increase in Investment	Accumulated Increase in Investment above The Level of 1972
1973	769	769
1974	833	1,602
1975	895	2,497

(2) Projection of Cement Consumption

Following the methodology for calculating the direct consumption of cement explained in Alternative II, it is calculated that the participation of cement in buildings and infrastructure for Alternative III would reach the following amounts:

(Millions of pesos of 1971)

Year	Additional Investment in Cement for Building	Additional Investment in Cement for Infrastructure	Total
1973	185	52	237
1974	185	56	241
1975	253	60	313

These amounts after accumulating and correcting for an index of variation of relative prices, can be translated to tons of cement using an average price of 450 pesos per ton. These calculations indicate that the consumption in the country would increase thus:

Year	Increase*
1973	584
1974	1,177
1975	1,951

*Thousands of tons of additional cement above the consumption of cement in 1972.

(3) Regional Deficits

The following table summarizes the situation of supply and demand for each region of the country.

	Year	Consumption	Capacity	Deficit
Atlantic Coast (17%)	1973	100	270	-
	1974	200	270	-
	1975	331	270	61
Northwest (19%)	1973	110	150	-
	1974	223	150	73
	1975	370	150	220
Southwest (22%)	1973	128	275	-
	1974	258	275	-
	1975	429	275	154
Central (35%)	1973	204	175	29
	1974	412	175	237
	1975	682	175	507
Northeast (7%)	1973			70
	1974			392
	1975			1,117

2. THE CEMENT INDUSTRY, PRESENT SITUATION

All data in this section are based on the results of investigations made by UEIA from February to May, 1972.

a. Installed Capacity, and Production and Capacity Utilization

(1) The total installed capacity at the end of 1971 was 3,245,000 tons. The total production, including exports, was 2,876,679 tons. The utilization of installed capacity at national level was 89% (See Table No. D-1).

(2) By regions, the utilization of installed capacity was as follows (See Table D-1).

Region	Utilization of Capacity
Atlantic Coast	84%
Northwest (Antioquia and Surroundings)	95
Southwest (Valle, Antiguo, Caldas, Nariño)	84
Central (Cundinamarca, Boyacá, Tolima, Huila)	92
Northeast (Santanderes and Surroundings)	93

(3) The data above show that the quantity of additional cement that may be produced with the present installed capacity is very small.

b. Expansions in Progress

(1) Four firms are undergoing expansion in capacity at the present. These firms are located in four of the five main cement markets (See Table D-2).

TABLE D-1

INSTALLED CAPACITY AND CEMENT PRODUCTION

Year 1971

FIRM		Installed Capacity Tons/year	Production Tons	Utilization of Capacity %
	ATLANTIC COAST			
1.	Cementos del Caribe	545,000	519,560	95
2.	Tolcementos	240,000	139,000	58
	SUB-TOTAL	795,000	658,560	84
	NORTHWEST			
3.	Cementos El Cairo	345,000	350,879(2)	100
4.	Cementos Argos (1)			
5.	Cementos del Nare	168,000	135,498 (3)	81
	SUB-TOTAL	513,000	486,377	95
	SOUTHWEST			
6.	Cementos Boyacá	580,000	498,249	86
7.	Cementos Caldas	203,000	163,476	80
	SUB-TOTAL	783,000	661,725	84
	CENTRAL			
8.	Cementos Boyacá	350,000	317,943	91
9.	Cementos Samper	370,000	340,343	92
10.	Cementos Diamante (Apulo)	140,000	118,800	85
11.	Cementos Diamante (Bs. Aires)	100,000	103,055 (4)	100
	SUB-TOTAL	960,000	880,141	92
	NORTHEAST			
12.	Cementos Hércules	36,000	35,482(5)	98
13.	Cementos Diamante (B/Manga)	122,000	109,185	89
14.	Cementos del Norte	46,500	45,209	97
	SUB-TOTAL	204,500	189,876	93
	TOTAL	3,245,500	2,876,679	89

Notes, Table No. D-1

(1) Argos grinds the clinker produced by Cairo.
(2) Includes clinker ground by Argos after purchases from Nare.
(3) Excludes clinker sold to Cairo (23,000 tons).
(4) Worked for a number of days above the average.
(5) Includes special and Type V cement.

TABLE D-2

Data are missing because of loss of the original English version copy in an international air-freight shipment. The Spanish-version original being prepared by Planeacion should contain the data for this table which the reader can insert, if and when convenient.

The total installed capacity of the country, after the expansions are completed will rise to 4,115,500 tons, 27% greater than the present level of productive capacity.

(2) Production from these four expansion projects will become available before March 1973.

(3) Percentagewise, the major expansions are being made in the Atlantic Coast (additional 34%), in the Northwest (additional 29%), and in the Southwest (additional 35%). Part of the new production in the Atlantic Coast will serve export markets.

(4) The expansion in the center of the country represents one of the minor regional increases (additional 18%). This contrasts with the fact that this zone (especially Bogotá) has been subjected to frequent cement shortages in former years.

(5) In the Northeast region (Santanderes), no capacity increase is in progress, and there is no evidence of cement shortages in this zone in the past. However, the plants that produce for this region serve two important intermediate-size cities of potential rapid growth (Cúcuta and Bucaramanga).

c. Exports

(1) Four firms are capable of exporting cement. They are shown in Table D-3.

(2) Of these, only Caribe exports portland cement at the present. Small exports from Tolcementos are being made through Caribe. The total

TABLE D-3

Data are missing because of loss of the original English version copy in an international air-freight shipment. The Spanish-version original being prepared by Planeacion should contain the data for this table which the reader can insert, if and when convenient.

exported by this firm in 1971 was 189,337 tons, equivalent to more than U.S. $3-million.

(3) Nare exports white cement but in 1971 only 689 tons were exported. The export market demand is much larger, but the productive capacity of the white-cement plant is used primarily for the domestic market.

d. Inputs

(1) Limestone: This material is abundant in each one of the five regions considered, and does not constitute a limitation for the further development of the industry.

(2) Others

Gypsum: Also exists in several regions of the country. The majority of the plants obtain today from Los Santos (Santander). The supply does not limit the future development of the industry.

Electric Energy: Also does not constitute a serious limitation. In some regions the present supply is deficient, but it is clear that the improvements being introduced into the national electrical interconnection network will resolve limitations of supply satisfactorily. It may be assumed that further expansion will be based primarily on the purchase of energy from the national system.

Fuels: Fuel oil, gas and coal are used depending on the location of the plant. Fuel oil is exportable. With respect to natural gas, the extent of the reserves are unknown. Consequently,

the future developments of the industry should be based mainly on coal.

e. Transportation

(1) Railway: Only Nare uses the railroad to transport cement. Boyacá, Diamante (Buenos Aires), and Valle could use it. In general, the use of the railroad is not intensive. According to the plant managements, this is due to deficiencies in the service rendered by the railway.

(2) River: This is the least expensive form of exportation in in the country. Nare uses the Magdalena River to distribute part of its production. This river represents an excellent route to transport cement destined for export from a plant on the river shore to the Coast, such as in the case for Nare.

(3) Road: Almost the entire volume of cement is transported within the country by this means.

f. Commercial Practices

(1) Every firm, except Nare, Caldas, Diamante (Buenos Aires), and Hércules, sell strictly on cash payment. In Bogotá, cases of waiting lines of up to three months after cash payment exists. It may be observed, therefore, that currently no cases of limitation of production because of scarcity of working capital should be found.

(2) Only five plants have distributors, or agencies. These are: Tolcementos, Cairo, Caldas, Diamante (Buenos Aires), and Hércules. All the rest sell at the plant gate.

(3) In general, the price of cement, sacked and delivered at the plant, varies from 302 pesos to 416 pesos per ton. The average would be around 380 pesos.

(4) Even though currently the major part of the cement is sold in sacks, the proportion of cement sold in bulk grows daily.

g. Profitability

(1) An analysis of the balance sheets and Profit and Loss Statements permits the calculation of the rate of return of capital after taxes (see Table No. D-4). In 1970, this varied from 6.4% to 24.8%, with an arithmetic average of 14.9%.

(2) The arithmetic average for rate of return of capital for the ten firms shown in Table D-4 has risen in the following manner from 1967-1970:

1967	11.0
1968	11.0
1969	11.8
1970	14.9

h. Distribution of Ownership

(1) From an analysis of the ownership of stock two groups which have common interests are distinguished, separated in general by the geographic barrier of the Central Mountain Range (Cordillera Central).

TABLE D-4

Data are missing because of loss of the original English version copy in an international air-freight shipment. The Spanish-version original being prepared by Planeacion should contain the data for this table which the reader can insert, if and when convenient.

Caribbean Coast-West	Center Northeast
Caribe	Samper
Argos	Boyacá
Cairo	Diamante
Caldas	Hércules
Nare	Norte

(2) Tolcementos is independent from these groups. However, its production is marketed by the "Distribuidora de Cemento" in which Cementos del Caribe is a stockholder. Nevertheless, Tolcementos pays this firm a fee to permit it to penetrate its own natural market area, namely the area of the Caribbean Coast from Cartagena toward the southwest.

3. THE CEMENT INDUSTRY: DEVELOPMENT ALTERNATIVES

a. Introduction

(1) The implementation of the General Development Plan should mean a growth rate of cement consumption above the historical rates on which the industry estimates of 10% annual growth in the near future are based. The industry programs its investment accordingly. Consequently, it seems correct to suppose that the current expansions that have resulted will not be sufficient after the medium term (2-3 years). In conclusion then, the study of new expansions should be undertaken at the appropriate time.

(2) This section will discuss the alternatives that appear to be the most attractive at this time for the realization of production expansions.

Attention will focus on:

- the size that may be considered efficient for the expansions of existing plants and for investments in new plants.
- alternatives for industrial location.
- alternatives of industrial ownership.

b. Efficient Plant Sizes

(1) The most important consideration for choosing the size of the expansion (or of a new plant) is the size of the market. The following enter into consideration:

- the quantity of the production that can absorb the high capital costs and permit production at reasonable prices;
- the efficiency in the use of fuel (for a larger unit capacity - less cost of fuel per ton);
- the efficiency in the utilization of manpower; and
- the proportion of the "fixed" expenses in the cost per ton.

(2) For the expansion of an existing plant, given an adequate size of market, a size of 700 tons/day in one kiln (230,000 tons/year) may be considered an economic minimum for the local conditions.

(3) For a new plant, the minimum size should be around 1,500 tons/day in one kiln (495,000 tons/year).

(4) The selection of a maximum size for the expansion of an existing plant, besides being subject to market expectations, depends on the difficulties presented by the location where the construction will occur with respect to equipment transport. Thus:

- in the interior of the country it will be difficult to install a kiln of more than 800 tons/day in the wet process, or 900 tons/day in the dry process;

- on the coast, or on the banks of the Magdalena, this problem is not present; however, through other considerations such as local experience with large kilns, the maximum size per kiln should not exceed 2,000 tons/day.

c. Alternatives of Location

(1) The location of new plants, or expansions to existing plants, should be guided by criteria relative to:

- the existence of raw materials, especially limestone;
- a continuous supply of fuels at reasonable prices, especially coal;
- a sufficient supply of electric energy;
- and advantageous position respecting market in terms of size; and
- efficient and reasonably priced transportation.

(2) Two major alternatives are evident for the expansion of cement production in Colombia in the medium term (2-3 years)

- to install a central plant at Nare of large capacity (2,000 to 4,000 tons/day) that should supply cement to the entire country and for export.

- to expand some of the existing plants, with relatively smaller capacity, so that each one continues to serve a limited regional market.

(3) First Alternative, Nare (Central)

- Location: near the outlet of Rio Nare on the Magdalena, some 50 kilometers up river from Puerto Berrio.

- Size: the maximum initial production could be 2,000 tons/day (660,000 tons/year) in one kiln. Moreover, the plant could be designed to foresee a rational process of successive expansions, with kilns of the same size, or even larger.

- Markets: It can serve all the regional markets of the country. Besides, it has the possibility of exporting its production surpluses to the Antilles, Central America, or Florida.

- Transportation: regarding the main cities, the plant would be situated approximately at the following distances (straight line):

City	Distance, Km.
Bogotá	190
Medellin	109
Cali	370
Barranquilla	535
Manizales	165
Bucaramanga	190
Average	260

If distribution to all these centers is required, it is necessary to consider specialized transportation for cement in bulk by train using the national railway system which at present is under-utilized.

For export, the Magdalena River provides an inexpensive means of transportation. It should be noted that the present plant at Nare, even though it has a small size and deficient transportation, can compete in many of the regional markets of the country. Thus, it may be expected that a large plant with rationalized transportation could do so even more advantageously.

- Inputs. The richest reserves of limestone in the country of magnificent quality are there. Natural gas, fuel oil or coal may be obtained in adequate quantities, at low or reasonable prices. The required electric energy may be obtained from the national interconnection system.

- Summarizing. This location offers major advantages of potential economy of scale and low cost of inputs.

Together with the possibility of choosing the most appropriate manufacturing technology it assures efficient production and low cost. The specialized railway transportation of large quantities of cement in bulk could make the output of this plant reach even the most distant markets. The possibility of exporting surplus will allow a high and continuous level of utilization of the installed capacity, even in the case that the domestic market does not grow as fast as present expectations. This partly decreases the investment risk.

(4) Second Alternative, Multiple Expansions

Locating an expansion (or a new plant) in each one of the five regional markets of the country: namely Cúcuta, Cartagena, Nare, Sogamoso and Cali.

- Size: These would be expansions of some 700 tons/day on the average. The total sum would be 3,500 tons/day, added to the present productive capacity. The minimum economic size in chosen for the expansion. Two new plants are provided for (Cúcuta and Cartagena) which could have a larger unit size kiln.

- Markets: Each plant supplies one regional market:

Plant	Market
Cúcuta	Northeast
Cartagena	Caribbean Coast

Plant	Market
Nare	North West
Sogamoso	Central
Cali	South West

It would only be possible to export from Cartagena and Nare.

- Transportation may be done by train or road, without modifying the present railway system. The distances are relatively small compared to Central Nare.

- Inputs: each one of these plants can count on sufficient limestone reserves, the supply of a reasonably priced basic fuel, and the supply of electric energy from the national or municipal system.

- Summarizing, the investments in this alternative can count on inputs at reasonable prices or costs, and relatively near locations to the markets they serve. However, the plant sizes used do not permit as efficient an operation as at Nare. Notwithstanding these small sizes, the total sum of the additional capacity is above that achieved in the first alternative (Nare-Central), but the danger of operating at low capacity is more probable which could lead to higher production costs.

(5) Evaluation

In favor of Nare, are the low production costs and the possibility of a major utilization of capacity, and also successive expansions of high efficiency. The cement transportation system to the markets and the resulting prices should be studied in detail.

Favoring the second alternative is the nearness of the markets; against it, possibility of a lower utilization of capacity and higher production costs. The investment risk seems greater than in the first alternative.

d. Alternatives of Ownership

For the new investments (especially the first) there are several ways in which it is possible to combine the capital arising from the State, from foreign investors, and from domestic investors. The following alternatives may be considered in the particular case of Nare-Central

- exclusive participation of private domestic capital.
- exclusive participation of the Government.
- major participation of the Government.
- minor participation of the Government.
- exclusive minor or major participation of foreign capital with the Government.

According to the concept adopted for Nare-Central as an example, a greater degree of competition could be introduced into all the regional markets that could contribute to the stability of cement prices.

4. TRANSPORT OF CEMENT IN BULK BY RAILROAD

Although cement is transported in bulk by railway in numerous instances throughout the world, the experience in Great Britain over the past ten years is unique in that the technology seems readily transferable to Colombia with minimum problems, and the impact of the technology on the Colombian cement industry can be significant to relieve industry pressure on Government to raise prices. Furthermore, an ideal opportunity to transfer this technology initially on a pilot basis exists in the use of the present under-utilized railway line from Benecito to Bogotá for transport of cement in bulk to Bogotá from the Cementos Boyacá plant at Nobsa. The only new trackage involved is a 3 km. spur from the railway line at Sogamoso to the loading silos in the cement factory. The right-of-way is already developed except for the construction of three minor river crossings. Investment would be involved in the adaptation of cement loading and discharging facilities at the terminals, and in the acquisition of suitable rolling stock by conversion of already available railway cars. The value of the total investment seems sensitive to the capacity chosen for a single unit train, and some careful study is warranted here.

In June 1972, Arthur D. Little, Inc. explored the British experience by interviewing personnel in the Freight Marketing Department of British Rails in London. The characteristics of the British experiences were

developed in the interview, and these are reported below.

a. Literature References

British publications have described the experiences recently in :

- "Northfleet Merry-Go-Round Circuit Handles Three Commodities" from the Railway Gazette; August 7, 1970; pages 572-574.

- "Bulk Cement Movements in the British Isles" - A review of 1966-1972, Peter N. Grimshaw, from Cement, Lime and Gravel; May 1972, pages 112, 113.

- "The Changing Pattern of Bulk Cement Movement in the UK", Peter N. Grimshaw, from Cement, Lime and Gravel; 1968; Vol. 43, No. 7; pages 21 et seq.

b. History and Characteristics

Company Train-Load Operation (the name given bulk transport) for cement is about 10 years old. The system now extends through England and Scotland, and in Eire, and moves about 3-million tons of cement annually. The Associated Portland Cement firm ships this way throughout the entire country. Tunnel Cement ships to selected areas, as does Rugby Cement. Four smaller firms, each having only one works, ship this way but for distances less than 100 miles.

The newer rail wagons use low-pressure pneumatic and gravity means for unloading and loading wagons. The older wagons rely entirely on air pressure. Trains are kept as a unit with no intention to separate

wagons while in normal operation, rather only when maintenance is required.

The cement companies have private rail sidings. Except for the North-fleet "Merry-Go-Round", the railway normally leaves the wagons for unloading without the engine, for the plant locomotive to haul. The wagons then are returned empty to the same location for pickup for the return journey usually by the same locomotive that brought them. In the interim, the railway's locomotive can be refueled, inspected, parked for the crew mealtimes, and possibly for other reasons. The reverse situation can occur at the loading terminal.

c. Commercial Practices

The ownership of the railway rolling stock is divided between British Rails and the individual cement company. The railway charge for transport reflects the ownership of the wagons. The larger 100-ton gross weight (76-77 ton payload) wagons are mainly privately owned. The smaller wagons are 45-ton gross weight (32-33 ton payload). The maintenance of the private wagons is usually done under contract, and the railways will bid for these contracts because it is in their own interest to secure the main lines against breakdowns.

Haulage charges are negotiated privately between the managements of cement companies and the railways and, although the railways are nationalized, the charges are not necessarily published. Nor need the averaged ton-mile charges have consistency. The British Government gives the railways management freedom in this respect. Therefore, the

railways can act to meet their competition of highway transport and of easy transport by coastal waterway. The railway charges reflect their actions in this respect.

Overall, the experience over the past ten years in the railways' view is that railway initiative of offering attractive charges has encouraged a reduction in the number of production plants in the country and increased the unit capacity of the production units in the remainder. Thus, currently there are 42 cement works in the United Kingdom whereas six years ago there were 53 works. In the same period production rose to about 18 million tons annually, up 6 percent.

d. Colombian-British Comparison

Distribution from Nare. A requirement is that a large central plant at this location, based on unit-train bulk cement distribution, should be able to vary the transport routing to meet unanticipated demands in the different market centers of Colombia. Such a capability would not be practical in England because the rails are also used intensively for high-speed passenger transport. Unit-trains therefore must travel perhaps 800-100 Kms. per hour to avoid interfering with passenger train schedules. Accordingly, train crews must be specialized in thoroughly knowing specific routes which travel through densely populated areas, which have sophisticated signalling systems, and in which high-speed freight trains are operated. If the routes were continually shifted, this would introduce a difficult and costly scheduling and availability problem for the specialized crews. However, the conditions in these respects in Colombia are quite different and could be non-restricting.

Reverse Haulage, Coal/Cement. On balance, the elimination of empty haulage in the return direction by finding another commodity moving opposite may not be as attractive as it sounds. Quantities and availability may not match train schedules, and the same equipment cannot be used for both commodities. Savings arising from the lesser demand for engines can soon be overcome by the cost of idle equipment or commodity storage charges.

e. Further Data

It is possible that a formal approach to British Rails could produce disguised data on charges they make for the haulage service in about the following form:

- a standard ton-mile range of charges for some standard distance and quantity of haulage.
- how this charge varies should distances be smaller or larger.
- how this charge varies should quantities be larger or smaller.
- how the standard charge allocates among labor (manhours applicable to the service), fixed charges, fuel, and maintenance. Such an allocation would enable the total cost to be translated to reflect Colombian conditions.

Finally, it should be possible to obtain from British Rails data on British Rails Engineering, Ltd. (Sheldon Works), who built much of the rolling stock used for company train load operation.

f. Relevant Experience

Unit-train transport in bulk in the United States has been focused primarily on the movement of coal. On the other hand, the experience that has been accumulated since about 1960 is impressive in terms of the tonnage handled and the distance traveled. The application of the technology, which began when the unit-train shuttle concept was forced on the USA railroad industry in 1958 by the success of the coal-slurry pipeline pilot program in Ohio, has been expanding. The extent of application at the present is perhaps best illustrated by a recent announcement in the magazine "Traffic World" that the Burlington Northern Railway will haul 42.5 million tons of coal from Wyoming to Texas beginning in 1976.

The railroad will operate three unit trains of 110 cars weekly between an Amax Coal Company mine near Gillette (Wyoming) and a plant which Southwestern Electric Power Company is building at Avinger (Texas). Each train will carry 11,000 tons. The 1483 mile (2400 km) run will be longer than any other unit-train haul in the United States, according to the management of the railway company.

5. THE BRICK INDUSTRY IN COLOMBIA-PRESENT SITUATION

a. Introduction

(1) The following zones were investigated:

- Bogotá
- Medellin

- Cali
- Manizales-Pereira-Armenia-Cartago (MPAC).

These represented 78.3% of the total built-up area in 1970 in the country.

(2) The following types of enterprises were studied within each zone:

- Large: production over 2 million "toletes" per month.
- Medium: production from 800,000 to 2 million "toletes" per month.
- Small: production from 100,000 to 800,000 "toletes" per month.
- Chircales: production up to 100,000 "toletes" per month.

(3) A total of 692 establishments producing fired clay bricks have been estimated for the country (1). Of these, UEIA studied 513; in other words, 74.1% of the total, distributed in this way:

Zone	Establishments Studied
Bogotá	324
Medellin	35
Cali	45
MPAC	109
Total	513

(1) According to the DANE-ANDI Industrial Register, 1969.

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According to their size, the establishments studied are catalogued as follows:

Size of the Establishment	No. of Plants	% of the Sample
Large (1)	1	0.2
Medium	12	2.3
Small	82	16.1
Chircales	418	81.4

b. Market

(1) The brick industry supplies regional markets. Each market is protected from the competition from others by the high transportation costs due to:

- the low unit value compared to weight.
- the loss by breakage or imperfection, resulting from handling the material.

(2) The main brick markets have their center in the large and intermediate cities of the country.

(3) The isolation of the markets, their geographical and climatic differences, and the degree of urban development contribute to the different characteristics presented by the product especially in the size, shape and quality.

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(1) There is only one firm of this size in the country.

(4) Notwithstanding the above, the use made of the product is generally the same. It is used:

- as a structural element in buildings of one or two stories.
- as an element to separate the spaces in the entire building.
- as an ornamental element in houses, buildings, etc.

c. Technology Used and Industrial Structure

(1) The technology used is basically the same in the whole country. However, for purposes of analysis, it is useful to study it from the point of view of the capital intensity, the mechanization of production, and its administrative element. Thus, an "industrialized" sector of the industry can be referred to that shows the above characteristics to a high degree, and an artisan sector that possesses them to a lower degree.

(2) In general, as the mechanization increases, the quality of the product and the uniformity in its production improves. Also, the advantage of continuity of supply is obtained.

(3) In some regions (for example, Bogotá) the industrialized sector has penetrated the major portion of the market. In others, because of recent investments, it is penetrating the market (Cali, for example). Finally, there are centers where the production is fundamentally of an artisan or semi-artisan type (MPAC).

(4) The industry is very competitive in practically every region, because of the large number of producing firms.

d. Distribution and Commercial Practices

(1) The marketing aspect is especially important in this industry. The modern sector that reaches the market easily has well-established distribution channels, and can count on a stable number of large buyers. The artisan sector finds it difficult to sell its product. Sales are made to small buyers, and consequently, the demand is unstable.

(2) The following selling conditions prevail:

- payment on delivery
- payment on order
- deferred payment (30 to 90 days)

These conditions vary greatly from region to region and also vary through the year according to the level of the building activity.

(3) The large majority of the sales are made at the plant gate. However, there also exists the system of delivery to the work site. Until now there have been no distributors or wholesalers authorized by the enterprises. Unauthorized wholesalers appear in periods of scarcity of the product, securing small inventories, but selling at prices much higher than those to be found at the plants.

(4) Because of the differences of the product from region to region and the variable market conditions, there is no uniformity of prices at a national level, nor among the firms that supply each region.

This last point is especially true in periods of scarcity. The weighted prices for each one of the zones studied follows:

Zone	Prices per thousand units*
Bogotá	620 pesos
Medellin	600
Cali	650
Pereira-Armenia-Manizales-Cartago	758
National Average	625

The price is weighted according to production quantities. The uniformity indicated by the figures is only apparent, since difference among products in one area is large.

e. Production Factors

Inputs

(1) The fundamental prime material is clay, which is abundant in the entire national territory.

(2) The fuels used are:

- Industrial sector: fuel oil and coal
- Artisan sector: coal and coffee shells MPAC

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* The price refers to the typical product Bogotá: tolete
Medellin: bocadillo
Cali : tolete
MPAC : bocadillo

Employment

(3) Only mechanized enterprises require a certain degree of skill in the labor. In the rest, the training is rudimentary.

(4) According to data from DANE (1969), the generation of employment by this industry in proportion to the generation in the non-metalic minerals sector was 17%. In the total manufacturing industry it was 1.5%. In the zones visited by the UEIA, the 513 establishments provide more than 4600 (direct) jobs, the employment per establishment depending on the degree of mechanization and the size of the firm.

(5) It is possible to estimate (1) that the capital/employment ratio is on average some 85,000 pesos for small and medium plants. In the chircales, this relation fluctuates between 2,500 and 10,000 pesos.

(6) Piece-work and fixed-term contracts are frequent for specific labors within the plant. As the mechanization increases, the contracting systems tend to be modified to offer more stable employment.

(7) Salaries increase with the mechanization in the sector. They may fluctuate between 12 and 25 pesos per day in the chircales, not counting the family enterprises. In the industrialized sector, the variation found was from 35 to 50 pesos on average (not including benefits).

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(1) Joint estimate of UEIA and IIT.

(8) It is possible to estimate[2] that the capital/product ratio for a medium size firm is 1.4 and for a large firm 1.7[3].

f. Production, Installed Capacity and Expansions in Process

(1) Table D-5 shows an estimate of the production, installed capacity and use of capacity in the zones visited. The use is higher in Bogotá (92%) followed by Medellin 78% and Cali (75%). The average of the use in the four zones is 84%.

(2) Table No. D-6 shows the increases planned in the industry.

g. Demand for Brick

As a result of the study of the Unidad de Programacion Global, the additional annual investment in building construction can be set in the order of 1,250 million pesos for the next three years, in 1968 pesos. Now, if the additional investment is taken over the level of 1972 but in millions of 1971 pesos, the following results are obtained:

Year	Total Additional Investment	Bogotá	Medellin	Cali	MPAC	Remainder
1973	1,675	675	241,2	239,95	103,8	415,4
1974	3,350	1,350	482,4	479,0	207,7	830,8
1975	5,025	2,025	723,6	718,6	311,6	1,246,2

The distribution of the investments by regions is based on the trends of the past 13 years, according to the figures which were obtained in the investigation, namely the following percentages:

(2) UEIA estimate

(3) Calculated as the total initial investment divided by the output during the year.

Bogotá	40.3
Medellin	14.4
Cali	14.3
MPAC	6.2
Remainder	24.8

Investments in Brick

As a result of studies by the Division of Urban and Housing Development, the participation of brick in the cost of building construction is estimated at 10%. Thus:

(Millions of Pesos of 1971)

Year	Total	Bogota	Medellin	Cali	MPAC	Remainder
1973	167,5	67,5	24,1	23,9	10,4	41,5
1974	335,0	135,0	48,2	47,9	20,8	83,1
1975	502,5	202,5	72,4	71,8	31,2	124,6

Volume of Brick Required

To calculate the units required for the next three years, the figures for investment in brick are translated into volume in accordance with the price per thousand bricks which were found in this investigation:

Bogotá	620 pesos
Medellin	600 pesos
Cali	650
MPAC	758
National Average	625

TABLE D-5

UTILIZATION OF CAPACITY IN THE BRICK INDUSTRY

BY ZONE VISITED*

Zone	Thousands of toletes per month. Present Production	Installed Capacity	% of Utilization of Capacity
BOGOTA			
Factories	23,398	25,737	90
Chircales	3,125	3,125	100
Subtotal	26,523	28,862	92
MEDELLIN			
Factories	12,740	16,271	78
Chircales	100	100	100
Subtotal	12,840	16,371	78
CALI			
Factories	5,330	7,230	74
Chircales	480	480	100
Subtotal	5,810	7,710	75
MPAC			
Factories	1,320	2,387	55
Chircales	912	980	93
Subtotal	2,232	3,367	66
TOTAL	47,405	56,310	84

* The data correspond to an estimation of the total production and of the installed capacity of the zone visited.

SOURCE: UEIA Inquiry.

TABLE No. D-6

EXPANSIONS IN THE ZONE VISITED*

(Thousand of Toletes per month)

Zone	Present Installed Capacity	Increase	Installed Capacity End of 1972	Percentage of Increase
Bogota	28,862	7,200	36,062	25
Medellin	16,371	3,711	20,082	23
Cali	7,710	250	7,960	3
MPAC	3,367	2,000	5,367	59

* Refers both to expansions and new plants of the industrialized sector

The expansion for chircales are not know.

(Thousands of Bricks)

Year	Total	Bogotá	Medellin	Cali	MPAC	Remainder
1973	268,000	108,871	40,167	36,769	13,769	66,400
1974	536,000	217,742	80,334	73,692	27,441	132,960
1975	804,000	326,613	120,667	110,462	41,160	199,360

i. Available Annual Brick Capacity at the End of 1972

To estimate these quantities, further account was taken of the percentage of under-utilization of actual capacity installed and the expansion projected in the brick sector at the end of 1972.

(Thousands of Bricks per Year)

Zone	Best Utilization of Installed Capacity	Expansions	Total
Bogotá	28,068	86,400	114,468
Medellin	42,373	44,532	86,904
Cali	22,800	3,000	25,800
MPAC	13,620	24,000	37,620
Remainder	-	-	-

j. Regional Shortages of Brick

Here a comparison is established between the additional demand for the next three years and the supply calculated at the end of 1972, assuming that there are no new investments in brick manufacture in the next three years. See Tables D-7 and D-8. Deficits are also expressed

TABLE D-7

COMPARISON OF BRICK DEMAND AND SUPPLY

(Thousands of Bricks/Year, 1973-1975)

Zone	Year	Additional Demand	Additional Supply	Deficit
Bogotá	1973	108,871	114,468	-
	1974	217,742	114,468	103,274
	1975	326,613	114,468	212,145
Medellin	1973	40,167	86,904	-
	1974	80,334	86,904	-
	1975	120,667	86,904	33,763
Cali	1973	36,769	25,800	10,969
	1974	73,692	25,800	47,892
	1975	110,462	25,800	84,662
MPAC	1973	13,720	37,620	-
	1974	27,441	37,620	-
	1975	41,160	37,620	3,540
Remainder of Country	1973	66,400	-	
	1974	132,960	-	
	1975	199,360	-	

NOTE: The additional supply at the end of 1972 is not known.

TABLE D-8

SUBSTITUTION OF BRICK DEFICITS BY CONCRETE BLOCK

(Thousands of Blocks per year, 1973-1975)

Zone	Year	Deficit of Blocks
Bogotá	1973	-
	1974	23,906
	1975	49,107
Medellin	1973	-
	1974	-
	1975	7,815
Cali	1973	2,540
	1974	11,086
	1975	19,598
MPAC	1973	-
	1974	-
	1975	820

in terms of the numbers of cement block that would be required to substitute for the brick.

k. Additional Supply of Concrete Blocks at the End of 1972

(Thousands of Blocks of 10 x 20 x 40 cms)

Zone	Best Utilization Of Installed Capacity	Expansions	Total
Bogotá	2,986	-	2,986
Medellin	7,810	2,664	10,474
Cali	3,744	-	3,744
Barranquilla	3,456	5,080	8,536

In Table D-9 a comparison is presented between the additional supply of concrete blocks and the deficit of bricks expressed as equivalent units of blocks.

TABLE D-9

COMPARISON OF DEMAND AND SUPPLY OF CONCRETE

BLOCKS TO MEET BRICK SHORTAGES BY

SUBSTITUTION

(Thousands of Blocks of 10 x 20 x 40 cm. 1973-1975)

Zone	Year	Deficit	Additional Supply	New Manufacturing Investment
Bogotá	1973	-	2,986	
	1974	23,906	2,986	20,920
	1975	49,107	2,986	46,121
Medellin	1973	-	10,474	
	1974	-	10,474	
	1975	7,815	10,474	
Cali	1973	2,540	3,744	
	1974	11,086	3,744	7,342
	1975	19,598	3,744	15,854
MPAC	1973	-		
	1974	-		
	1975	820		
Barranquilla	1973		8,536	