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REPORT OF

GEOTECHNICAL AND MATERIALS ENGINEER

SHORT TERM CONSULTANCY

FEBRUARY 11 - APRIL 2, 1992

AFGHAN CONSTRUCTION AND LOGISTICS UNIT

CONSTRUCTION CONTROL SERVICES CORPORATION

PESHAWAR

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CONSULTING ENGINEER

EXECUTIVE SUMMARY

A consultant was retained by CCSC to initiate a quality control system for ACLU. Forty-five work days were allocated.

The consultant was able to utilize the lesson plans, field manual and other materials developed on a similar project which required one year in another country.

The consultant did the following:

1. Set up a workable basic soil testing laboratory using apparatus purchased before his arrival, in an available building. The laboratory is a beginning level facility for soil, aggregate and concrete testing only and requires sustained development.

2. Conducted a 2 week hands-on school for 10 engineers in the laboratory. The group was highly motivated, attentive and apparently grasped the material rather well. They need a lot of experience and practice.

3. Gave 2 days of classroom lectures on basic, low-technology soil mechanics which can be used by Afghan engineers without a large investment for the kinds of work currently done. The class was 18 engineers.

4. Presented 3 general lectures to an audience of 35 or more engineers on: Geotechnical and Materials Engineering Concepts; Quality Control/Assurance Concepts and Construction Inspection in General. Each lecture was about 3 hours in length with questions from the audience.

5. Attempted to teach the most basic rudiments of subsurface soil exploration. This could not be done because we were unable to locate a Pakistani driller working in the field to demonstrate the equipment. Rain and the Ramazan schedule interfered.

Quality control/assurance is seen as an integral part of all highway department operations involving planning, design, construction, operations and maintenance. About ½ of quality assurance work requires materials testing which is a function of the Geotechnical and Materials Engineering Staff Unit (G & ME). Quality assurance can not be a separate function. It must involve all functions of the organization and should not develop either faster or slower than the remainder of the program.

Equipping ACLU for subsurface exploration would cost about US $ 224,000 initially and to be practicable would require an assured annual budget of about US $10,000 for expendable supplies, and sufficient workload to keep the equipment active. An expatriate equipment operator/trainer is required as well. Purchase of drilling equipment is not recommended if any reasonable alternative, such as a Pakistani contractor, is available.

Equipping ACLU Construction Units for construction quality control testing is estimated to cost about US $64,000 for the present four construction units with an additional annual requirement of US $12,000 to US $15,000 for additional units and expansion of the central laboratory capability. Locally made lab apparatus is of poor quality so European or American imports might be necessary, at an additional cost for freight.

Three or more Afghan Engineers or Senior Technicians should be sent to the U.S. for training. One man each in Geotechnical Engineering or Engineering Geology, Materials Engineering, and Soil/Materials Testing Technology are recommended initially. The professionals would enroll for a Masters Degree program, the technician would work in a State or Federal Highway Laboratory for a year.

The employment of expatriates specializing in subsurface investigation field work (drilling and sampling already mentioned), as well as laboratory testing technology and Materials/Quality Engineering would be desirable, for about one year each.

In passing, it is suggested that ACLU consider developing a master plan for the organization of an Afghanistan Highway Department, together with the development of design criteria and construction specifications consistent with the skills of available design personnel and the capability of construction forces.

The Afghan nationals with whom the consultant dealt are to be complimented for their attentiveness, interest and diligence in performing the work required in the training sessions.

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1. INTRODUCTION:

This report describes the activities of a short term consultant employed by Construction Control Services Corporation (CCSC) during the period of February 11 to April 4, 1992, a total of 45 work days. The purpose of the consultancy was to initiate a quality control system for the Afghan Construction and Logistic Unit (ACLU).

Within that the following were required:

1. To set up a Materials Testing Laboratory suitable for the start of a quality control program for the present operations of the ACLU.

2. To train several men as materials testing Engineers and technicians.

3. To conduct training in subsurface investigation technique for ACLU roads and bridges.

4. To conduct introductory training in basic soil mechanics appropriate to ACLU works.

These requirements were very ambitions for the time allocated and would have been impossible to accomplish had the consultant not done similar project in another country. He was able to use previously prepared lesson plans for the laboratory tester training and the time saved was then available for the other training efforts. In the normal case about six to eight weeks would have been required to develop the lesson plans and manual before conducting the laboratory classes. It may be noted that the Consultant's previous similar project was a full time assignment for one year.

It is impossible in such a short consultancy as this to make more than the smallest beginning at a comprehensive Quality Control capability, and that was done. It remains now for ACLU with the assistance of CCSC and possible further Consultants, to build on this beginning. It cannot be done instantly.

This report will discuss the broad concepts of a Quality Control/Assurance System, its place in a highway department, and the qualifications of some of the major staff members.

Then the accomplishments of this Consultancy will be discussed as they fit into the concepts, and recommendations for further developments will be presented.

The Consultant's daily calendar is included in Appendix 1 of this report.

2. THE QUALITY ASSURANCE SYSTEM:

2.1 Definitions:

2.1.1 Quality: Quality is defined as ...."a degree or standard of excellence." Another definition might be.... what is needed to fulfill the objectives of a project.

2.1.2 Quality Control: Quality Control (QC) or process control can be considered to be synonymous and may be defined as the control of a building process or the control of the relative quality of a product. In the west, process control is considered to be the responsibility of the road builder or contractor.

2.1.3 Quality Assurance: Quality assurance (QA) is the means by which the buyer or owner assures himself that the product conforms with the quality defined in his specifications. It is the buyer's responsibility.

2.1.4 System: A system is a group of interrelated, interdependent, or interacting elements forming a collective entity.

It is obvious that when construction is carried out by in-house forces, there is very little difference between quality control and quality assurance as defined above. However, even now within ACLU the pressures exerted on construction forces are said to be beginning to reveal some of the same factors which exist in contract construction. In addition ACLU is to encourage development of the private contracting sector, so it's forces should make every effort to be competitive in cost and quality with whatever contractors may become interested in Afghan work.

2.2 Quality Assurance System Elements:

On the basis of the foregoing definitions, a QA system for a road project consists of the following basic elements.

2.2.1 Project Objectives: Among other things these include: start and end points; geometric standards; kind and volume of traffic; commodities, people and places served; anticipated service life; and salvage value at the end of that life.

These objectives or criteria are usually derived by the highway planning staff unit and assigned a priority within the overall national or regional plan.

2.2.2 *Define Available Materials: Since a road is built using earth materials, soil and rock, in either their natural or processed states the Geotechnical and Materials Engineering (G&ME) staff unit must explore the selected routes and find out what materials are available and how these may be used most efficiently.*

2.2.3 *Define the Required Quality: The design staff unit then prepares the project plans, specifications and other documents. In effect, these state the quality which is required to meet the objectives of the project and convey this statement to the builder or contractor. Ideally, any quality less than that stated will cause some sort of failure of the project, usually experienced in terms of excessive maintenance or shortened service life. Any quality greater than stated will be desirable but probably more expensive than necessary.*

2.2.4 *Verify Quality: Construction inspection, or quality control/assurance, contains many elements which involve materials testing and many which do not. The materials testing activity falls within the scope of the G&ME unit. In some cases it is performed by testing specialists, in others it is done by site inspectors who are trained to do certain tests within their overall scope.*

2.2.5 *Feedback: There should be continuous feedback to planning and design to alert them to designs which are not practicable to construct or which might be too difficult to maintain so that the design will be changed in future projects.*

Likewise, the maintenance unit needs to know how a road element was built, and what is underground so that they can maintain it properly.

2.2.6 *Documentation: There must be full documentation at all times in order to certify payments, account for engineering and other decisions and provide the feedback mentioned above.*

It is obvious that an effective QC/QA system involves every person and every function of a highway department. Materials testing before, during and even after construction is a major segment of the overall system. It is perhaps the most visible part of the system and is the focus of this consultancy.

2.3 Geotechnical and Materials Engineering:

These are disciplines which have emerged within the last thirty or so years and so do not yet have the recognition usually accorded to the more traditional disciplines such as surveying or bridge engineering. If fact there is a great amount of overlapping among disciplines since, for example, a highway engineer must know a lot about materials, etc.

2.3.1 Geotechnical Engineering:

This discipline is often referred to as Soil Mechanics and/or Rock Mechanics It is concerned with soil and rock, as they occur in place in nature, or only slightly modified, as structural materials. In contrast with steel or concrete whose properties can be controlled in the manufacturing process, soil and rock properties must be determined on a site specific basis and then utilized.

The Geotechnical Engineer can be either an Engineer with strong appropriate training in Geology, or an Engineering Geologist with strong training in Highway Engineering. Field surface and subsurface investigations, and laboratory testing are major tools. Major inputs occur in the design process, but emergencies such as the occurrence of landslides require geotechnical involvement in the construction and maintenance sectors as well.

2.3.2 Materials Engineering:

This discipline deals with earth materials, soil and rock, usually in some processed form, such a compacted earth embankments or crushed aggregates for various uses. In addition it deals with aggregate road surfaces, bituminous or portland cement concrete, pavement structures and manufactured materials such as asphalt, cement, steel, etc.

Field investigations and laboratory testing are major tools and those use some of the same techniques and apparatus as in Geotechnical Engineering but with a different focus, as well as some different techniques and apparatus. Major inputs occur in the design, construction and maintenance phases of a project, and materials testing is an important part of the construction quality control/assurance effort.

2.3.3 *Organization: It is obvious that there is strong overlap between Geotechnical and Materials Engineering as disciplines and in small organizations they are often combined in one person with a supporting staff operating across both areas. In larger organizations the two disciplines may be separated but share supporting staff, field and laboratory test equipment, etc.*

The G&ME functions cross all of the other operations of a highway department such as planning, design, construction, structures and maintenance, etc. Therefore, coordination and communication should be facilitated, and staffing and budget problems eased if GME is accorded equal rank and status with the other principal staff divisions.

In some American State Highway Departments Geotechnical Engineering is located in a preconstruction unit such as Design while Materials Engineering is located in the Construction Division. This arrangement seems to work well enough but American agencies are very informal with respect to inter-departmental communication and coordination. Formalities might cause problems in other cultural contexts.

3 CONSTRAINTS:

The road system in Afghanistan was severely damaged during the war and the following period. Any equipment has disappeared and the staff was scattered. Many of the staff have been forced to work at other occupations and have lost much of their skills.

ACLU has begun to rebuild some roads in Afghanistan and for the present is fulfilling some of the functions of a highway department. It could evolve into the nucleus of a restored Afghanistan Highway Department (AHD). Alternatively, it could as easily evolve into a private sector turnkey (Engineering and Construction) organization. This is a unique project because, since the war has lasted so long, there is no foundation on which to build.

The Consultant has based his work on the following perceptions.

1. *Most of the roads in Afghanistan are one or two lanes in width and gravel on earth surfaced.*

2. *Bituminous pavements probably will not be built within the next few years. Therefore, there will be time for additional training on these later, before the need arises.*

3. Most structures will be bridges or large culverts having spans generally 20 meters of less in length. There may be multiple spans. Some bridges may be rebuilt an existing foundations.

4. The country is generally mountainous, semiarid and temperate. Therefore, problems associated with extensive deposits of deep low strength soils such as are found in coastal areas or old lake beds, will be uncommon.

5. Most of the work to be undertaken will be rehabilitation with only a limited amount of new construction. New construction will probably be segments within rehabilitations.

CCSC and ACLU have recognized that some subsurface exploration for bridges and quality controls for the construction processes are essential to the success of their program. However, in view of budget constraints this program must concentrate on starting with some minimum capability and later building systematically toward the long term goal either of a fully functional highway department or a major design/construction company. Since the CCSC project will expire at the end of 1992, there is no time for CCSC to develop the full, long term objectives.

In addition, the 45 days allocated for this consultant severely limited both the amount of work which was feasible and the number of students which could be accommodated.

4 CONSULTANT'S APPROACH:

Section 2 preceding broadly outlines the Consultant's viewpoint of Quality Control/Assurance as a broad responsibility which must be shared by every unit and staff member of a highway organization. A major fraction, say between $\frac{1}{2}$ and $^2/_3$ of the QC/QA effort, utilizes technology which may be housed within the Geotechnical and Materials Engineering staff unit.

In this section the approaches to the specific ACLU situation taken by the Consultant are discussed as they fit within the framework described in Section 2 and the constraints listed in Section 3 of this report.

4.1 Subsurface Investigation:

For the present, subsurface investigation is limited to consideration of test boring and soil sampling by means of the Standard Penetration Test (SPT, ASTM Method D-1586 and related procedures) and thin walled tube sampling of soils (ASTM Practice D-1587). Other techniques and indirect methods cannot be considered now because of time and budget constraints.

can be done. In addition, the unit would require a truck about 8 tons capacity, a crew transport and an annual budget for tools and expendable supplies.

A very quick estimate of the initial cost of outfitting for test borings using the only available equipment catalogue, suggests the following approximate costs:

Medium capacity drilling machine.	US	$64000
Truck, 8 to 10 ton, diesel, 4WD		60000
Crew transport/tool truck, 1 ton 4WD		35000
Basic tools and supplies		25000
One year spare parts		10000
Contingency		15000
Freight U.S to Afghanistan		15000
Total for programming	US	$224000

An annual budget for expendable supplies of at least US$ 10000 can be anticipated. Present workload requirements probably will not provide economic justification for this outlay and it is questionable whether ACLU or the successor highway department will be able to keep the equipment in operation after donor support is withdrawn.

A small amount of apparatus (194000 Rs equal to US $7800) was bought and delivered. A few more small items are required and with these it would be possible, under unusually good conditions in clay soil, to drill and perform standard penetration tests to a depth of ten meters. This would meet the immediate need visualized. Unfortunately, soils in Afghanistan are not likely to provide the unusually good conditions.

Time available and rainy weather made any training on the equipment at hand impossible. One Pakistani tubewell driller claims to be able to do Standard Penetration Tests and says that he will do work in Afghanistan. It is assumed that there are others so inclined but time prevented searching for and evaluating any of these. Contract exploration under ACLU supervision, if of good quality, would be a highly viable alternative to purchase of the equipment and training of the men for an in-house capability.

Structures of the sort visualized for the next few years are sometimes designed without subsurface investigation on the basis of local area experience, judgement and conservative assumptions relative to the foundation type and bearing capacity. The construction contractor is then required to verify the assumptions before proceeding with construction.

This often results in an overdesigned foundation where the soil is found to be stronger than the assumptions used. Sometimes however, the reverse is the case and the contractor is required to [illegible]

subsurface investigation capability, it is a workable approach and can be utilized pending development of the ACLU capability.

4.2 Laboratory:

In December 1991, the Consultant prepared and sent to CCSC the minimum list of laboratory apparatus and reference books required. Some items were on hand, but most were ordered from a local supplier and delivered before the Consultant's arrival. The cost of the new purchases was approximately 360000 Rs or US$ 14600. The value of the items on hand is not known but is not large.

Immediately after arrival the Consultant and the Chief Quality Engineer developed a working layout of the available laboratory space and ordered some locally procured small tools, a work table, electrical and plumbing work, etc., and these were completed a day after the start of the laboratory training. The total value of the apparatus and building modifications is roughly 500000 Rs or US$ 20000.

The present laboratory space is one room of about 42 sq meters area with adjacent office and storage spaces. It is adequate for two or three technicians. There are one or sometimes two pieces of apparatus available for a few of the most basic tests to be performed on soils, aggregates and concrete. One of the functions of the G and ME unit is the coordination of purchase, distribution and maintenance of testing apparatus for field forces. At present, it is not ready to fulfill that function and a substantial future investment in apparatus will be required. This is discussed further in Section 5.2.

It should be noted in passing that the Pakistani manufactured apparatus purchased was of outstandingly bad quality. Unless a better manufacturer can be found, future purchases will require imports from Europe or North America with consequent higher costs and long lead times.

Time, complicated by the Ramazan period work schedule, apparatus and space limitations restricted the training session to two weeks, for ten men. Eight of the ten are assigned to the present QC staff. The others included one bridge engineer and one highway engineer. The Consultant hoped that these men would be selected for their potential to pass their training on to others. The class was attentive, energetic and is to be complimented on their response to the lessons which included both classroom work and hands-on practice in the basic procedures presented. A list of the test procedures covered is included in Appendix 2.

The Consultant will be satisfied if he accomplished the following:

1. Familiarization with materials testing concepts and apparatus.

2. Respect for standardized technique and written standards.

3. Respect for and proper handling of apparatus.

4. Importance of proper data keeping.

5. Some skill at manipulations.

The training done is only the most basic beginning of the QC/QA effort.

In addition, the Consultant edited and reprinted a Field Materials Manual prepared originally for another country. This manual presents about 28 test procedures in language both expanded and simplified from the basic American Society for Testing and Materials (ASTM) procedures together with examples of self checking data sheets and calculations.

The laboratory training, as the essential beginning of any QC/QA work, was the major effort of this consultancy and occupied approximately 2/3 of the time available in preparation and performance.

4.3 Geotechnical Lectures:

Though not originally a part of his scope, the Consultant was asked to present some basic geotechnical instruction to a class of about 18 Engineers. This class included several of the lab school students as well as other men and was performed on February 25 and 26 in the CCSC conference room.

Four lectures were presented on the following subjects:

1. Mountain soil formation and occurrence in general.

2. Foundations for bridges and large culverts using spread footings and piles.

3. Slope stability in general.

4. Overview of landslides.

With the exception of retaining walls which had previously been covered in a separate CCSC program, these four lectures were intended to cover in very general terms most of the common problems likely to be found by ACLC in the next few years. The basic premise is that there are available some

simple, low-technology means of handling most of the problems usually encountered in mountain road design and construction.

4.4 Other Lectures:

The Consultant prepared and presented two other lectures to ACLU audiences of about 35 men each, mostly drawn from the field construction units. The first of these, on February 29, presented the general concepts of G & ME as summarized in Section 2.3 of this report.

The second on April 1, discussed the QC/QA concepts summarized briefly in Sections 2.1 and 2.2 of this report and then discussed in more detail some basic factors in construction inspection.

The lecture outlines are included in Appendix 3 of this report.

4.5 Summary of Training:

The training just described attempted to present:

1. The basic concepts of a QC/QA program including the division of responsibility for various phases of it, and the qualifications of the major staff members.

2. Very basic introduction to subsurface investigation. This was curtailed by lack of time, apparatus, and a period of rainy weather.

3. Basic training in few of the most common materials testing techniques which form the most visible part of a QC/QA effort.

5 RECOMMENDATIONS:

As noted in Section 2.2, the QC/QA capability is highly involved with all other aspects of a highway department. Thus, in order to control quality, one must define it in the designs, plans and specifications. The equipment and technology required to produce the demands of the design must be available in the construction unit or contractor's organization. Therefore, the QC/QA capability must develop in harmony with the investigation, design and construction capabilities of ACLU.

It appears to this Consultant that there is a major requirement for the early development and implementation of design criteria and standards. Immediately following these, construction specifications appropriate to the skill level of both the design and construction units can be written. The QC/QA forces can then enforce the specifications.

There is however, plenty of work for the QC unit at this time. The bridge unit has made certain assumptions about the strength of concrete and reinforcing steel and field achievement of these must be verified. There is equipment available for concrete testing and the subject was covered in the recent training. Steel strength testing probably can be arranged at the University. Other field and laboratory testing should be done whether specifications exist or not as a means of gaining experience and accumulating data which might be useful in writing specifications.

If ACLU is to evolve into an Afghanistan Highway Department, it would appear desirable to prepare a long range master plan for its development. Such a plan would define the organization chart for several levels, write a charter for each office and could write major job descriptions. Policy and Procedures Manuals can be set up in outline form. This plan would systematically guide the development of the AHD. On the other hand, if ACLU is to become a private sector firm, planning can be more flexible. However certain guidelines still desirable.

It is recommended that ACLU and any successor organization adopt the Materials Specifications and Test Procedures of the American Society of Testing and Materials (ASTM), supplemented when necessary by those of the American Association of State Highway and Transportation Officials (AASHTO). Metric or SI units should be used.

ASTM Specifications, Test Methods, Procedures, and Practices are generally accepted world wide and most apparatus supply houses stock conforming items. ASTM publications are readily available (in English) and are reprinted in several countries. They are kept current by application of a systematic policy for review and update and are published in a convenient format.

There are small differences between ASTM and AASHTO methods in many cases. However, for most purposes the differences are insignificant.

To some extent the following recommendations are idealized because so much is unknown about the future direction of ACLU or its successors, workload and donor participation.

The Consultant's principal experiences are with U.S. public sector agencies. The fullest development of the QC/QA concepts presented herein occurs in these agencies which typically are concerned with all phases of planning, design, construction by either contract or in - house forces, operation and maintenance. A private sector engineering firm could be concerned with the design and/or QA functions and a construction firm might be only interested in the process or quality control aspects and these might be significantly different. In the interest of presenting a complete discussion, the remainder of this Section mostly is directed toward a public agencies.

5.1 Subsurface Investigation:

At some point, an AHD must have a subsurface investigation capability. However, in the Consultant's experiences with developing highway departments, this is an area which is seldom funded or staffed properly, perhaps because its product is not readily visible to those who control the budgets, and the substantial expense might be more visibly used in expanded construction.

A private sector firm could decide on the basis of business considerations whether it wants to get into the subsurface exploration business. Exploration capability is not essential to either a design engineering or a construction firm, though it can be highly useful and perhaps profitable.

Thus the Consultant is very reluctant to recommend an early investment of several hundred thousand US dollars if there is a reasonable alternative available in the form of Pakistani or other contractors, or by putting the exploration responsibility on construction, especially international, contractors. It is suggested that advertisements in several major cities might produce a list of interested Pakistani Engineers or drilling contractors who could then be evaluated and perhaps tried on a project or two before making a final decision.

For ACLU to undertake the development at this time, an assured budget and program for several years, and an assured workload to keep the equipment busy during most of each field season are required. Under these conditions an expatriate highly skilled in the hands-on operation of the equipment should be brought in. He would spend the first season mostly in the field operating and teaching the operation and maintenance of the machines. In subsequent field seasons he would monitor the operations on a decreasing basis for two or three seasons, until confident that the local men can handle the problems likely to occur and can do quality work. This long term approach is important because it will take some time for the drill crew to encounter a variety of geologic conditions and equipment problems with which they will need guidance.

5.2 Laboratories

In most highway departments a Central Laboratory at the headquarters level has the following missions:

1. Preconstruction exploration and design testing.

2. Qualification, standardization and verification of lower level laboratories.

3. Training.

4. Testing requiring apparatus or training which is too complex or rarely used to be done at lower level.

5. General peak workload support to lower levels.

6. Coordination of purchase, distribution and maintenance of apparatus.

7. Technical advice to all levels.

8. Planning, program, staffing, budget.

9. Applied technology, trials of new products or methods.

10. Others

In some organization some of these responsibilities are shared in scale with regional level organizations intermediate between the headquarters and the project. In a private organization several of the above missions would not be required.

The project level laboratory must have the space, manpower and apparatus appropriate to the project at hand. It can handle construction QC/QA testing and smaller design change testing requirements. It should be able to get help from higher levels for emergency situations, major design changes and peak workloads of short duration. This laboratory would be about the same for either a public or private agency.

As was indicated in Section 4.2, the present laboratory at Hayatabad is about the size and has the basic equipment necessary for a single project or construction unit doing earthwork and concrete construction. Making some allowances for duplicate apparatus, that laboratory would cost about 400,000 Rs or US$16,000 to duplicate at a construction site. A vehicle, electricity and running water are essential.

There are presently four construction units, so about 1,600,000 Rs or US$64,000, plus vehicles and possibly electric generators, are required for the present organization and workload.

If a future AHD begins using international construction contractors financed by the World Bank, etc. The contractors can be required to provide the field test apparatus for their project. This would be handed over to AHD at the end of the project and much of it would be salvageable for the inventory. However, these would be construction project laboratories only and would not replace the Central Laboratory nor would they do design testing.

In addition to the four field unit laboratories, the central laboratory, when moved to Kabul, should be programmed for a building space of about 200 sq meters in four or five rooms, running water, electricity, one or more vehicles, office space, etc.

The Consultant cannot estimate space and utility costs in Kabul. The central laboratory apparatus budget should be in the order of US $12000 to US $15000 annually for five or more

years with an additional $1000 annually earmarked for technical publications.

The employment of a full time expatriate testing technician for one year is recommended. This man would work in the laboratory doing hands - on training of local staff men as well as training for field testers and setting up and calibration/verification of field laboratories as needed.

A second expatriate, a Quality Engineer, should be brought in to organize the QC/QA program, write manuals and procedures, train local quality engineers, participate in writing AHD standard construction specifications, etc.

It is possible, though not highly likely, that the qualifications of both of these expatriates could be found in one man in which case an 18 month to two year consultancy could be feasible.

The rationale for recommending long term expatriates at the technician and drill operator level is simply that good technique can be introduced in a short school but not thoroughly assimilated by the testers. Good lab or equipment operation technique is learned only by repetition and practice, at first under close supervision and then under decreasing supervision. In addition, not all test procedures are done frequently and it takes some time to gain experience with wide variety of them. In the case of the driller, one of the most important elements of training is the response to special problems such as how to recover tools lost down a hole. One has to wait for a problem happen in order to teach the response to it. It will also take some time for the driller to experience a number if different soil and water conditions, hard and soft rock, etc, in which he will need advice and assistance.

The lab apparatus purchased to date is mostly dimensioned in U.S. customary units. Future acquisitions should be in metric or S.I units and the U.S. dimensioned equipment should be phased out to avoid errors resulting from mixing of apparatus having different dimensions.

5.3 Overseas Training:

Overseas training for two or more Afghan Engineers and Senior Technicians would be highly desirable. The basic objectives are indicated below, however there is no order of priority. All are equally desirable. The individuals selected should be required to pledge that they will remain with ACLU or a successor for a minimum of five years after their return. ACLU should be required to assure the donor agency that the men trained will work within that specialty for those five years without diversion to other fields as often happens in developing nations.

5.3.1 *Geotechnical Engineering/Eng.Geology: There appear to be a few Geologists among the Afghan residents of Pakistan but most of those seem to have specialized in classical geology or petroleum geology and none have worked in the field for many years. There is a serious need for at least one G.E. specialist within ACLU at this time and there will be greater needs after the return to Afghanistan and expansion to a full AHD. Several candidates should be considered for Master of Science program in Geotechnical Engineering or Engineering Geology at a U.S. University. Some sort of cooperative program involving alternative periods of campus study and practical work with a highway department, or a consultant would be highly desirable.*

5.3.2 *Materials Engineers: The same recommendation can be made with respect to the Materials Engineering specialty. This individual should be enrolled for a Master of Science in Highway Engineering and should specialize in Materials Technology, Pavement Design and Management and Quality Assurance Systems.*

Work experiences could be gained with a State Highway Department, the Federal Highway Adm., Direct Federal Construction Division in Denver, CO, or the U.S. Forest Service. Work in one of the intermountain western states such as Wyoming; Colorado, Utah or New Mexico probably would provide experiences most resembling Afghanistan so far as climate and terrain are concerned.

5.3.3 *Laboratory Technician: A senior laboratory technician could receive valuable hands - on training by arrangement with a state or FHWA materials testing laboratory in the U.S. A program whereby the trainee would work as a technician in an operating laboratory for nine months to a year, rotating systematically through all subdivisions of the lab in turn would be invaluable. The individual would become familiar with all aspects of testing as well as with the equipment and administration of the unit. The Federal Highway Administration, Office of Foreign Highway Cooperation can be contacted for assistance.*

Any program in the U.S. or Europe probably would train the students in technology which is beyond that available in Afghanistan. However, with no program in place it may be easier to introduce technology than it would be if there were an establishment to provide inertia.

6 ACKNOWLEDGEMENTS:

The Consultant is highly appreciative of the assistance extended by all members of the ACLU and CCSC staffs who were ready at all times to do whatever was necessary to facilitate the work.

The Consultant was particularly impressed with the eagerness to learn which was displayed by the Afghan Nationals. In particular, thanks are due to the head of the QC Department for his effective help in getting the laboratory set up and ready for the training session on very short notice.

APPENDIX I

CONSULTANT'S CALENDAR

Date	Activity/Remarks
Tu. 11/2/92	International Travel
W. 12/2/92	Arrived Peshawar
Th. 13/2/92	Briefing/Planning
F. 14/2/92	Day Off
Sa. 15/2/92	Work at Guest House
Su. 16/2/92	Holiday
M. 17/2/92	Laboratory (Hayatabad) Sorting Equipment
Tu. 18/2/92	Continue @ Lab, Mtgs., Equipment etc.
W. 19/2/92	Prepare Lesson Plans (L.P.) for Soil Mechan's Lesson/Lecture
Th. 20/2/92	Continue Prep. of L.P.
F. 21/2/92	Day Off
Sa. 22/2/92	Continue Prep. of L.P.
Su. 23/2/92	Continue Prep. of L.P.
M. 24/2/92	Continue Prep. of L.P.
Tu. 25/2/92	Soil Mechanics Lessons for 18 Engineers
W. 26/2/92	Soil Mechanics Lessons for 18 Engineers
Th. 27/2/92	Prepare Lesson Plan
F. 28/2/92	Day Off
Sa. 29/2/92	Lecture Geotech, & Mat'ls Engineering Concepts
Su. 01/3/92	Prepare L.P.
M. 02/3/92	Prepare L.P.

Date	Activity/Remarks
Tu. 03/3/92	Prepare Lesson Plan
W. 04/3/92	Prepare Lesson Plan
Th. 05/3/92	Prepare Lesson Plan
F. 06/3/92	Day Off
Sa. 07/3/92	Lab School (10 Engineers)
Su. 08/3/92	Lab School (10 Engineers)
M. 09/3/92	Lab School (10 Engineers)
Tu. 10/3/92	Lab School (10 Engineers)
W. 11/3/92	Lab School (10 Engineers)
Th. 12/3/92	Lab School (10 Engineers)
F. 13/3/92	Day Off
Sa. 14/3/92	Lab School (10 Engineers)
Su. 15/3/92	Lab School (10 Engineers)
M. 16/3/92	Lab School (10 Engineers)
Tu. 17/3 92	Lab School (10 Engineers)
W. 18/3 92	Lab School (10 Engineers)
Th. 19/3/92	Prepare Lesson Plan
F. 20/3/92	Day Off
Sa. 21/3/92	Prepare for Const./QC Lecture (30 to 35 Engr)
Su. 22/3/92	Prepare for Const./QC Lecture (30 to 35 Engr)
M. 23/3/92	Holiday Overview Lecture & Lab School
Tu. 24/3/92	Drilling Practical/Field Inst. Cancelled Rain

Date	Activity/Remarks
W. 25/3/92	Drilling Practical/Field Inst. Cancelled Rain
Th. 26/3/92	Final Report Preparation
F. 27/3/92	Day Off
Sa. 28/3/92	Final Report Preparation
Su. 29/3/92	Final Report Preparation
M. 30/3/92	Final Report Preparation
u. 31/3/92	Final Report and Lecture Preparation
W. 01/4/92	Construction QC/Inspection Lecture 30 to 35 Eng.
Th. 02/4/92	Final Report
F. 03/4/92	Day Off
Sa. 04/4/92	Travel Day
Su. 05/4/92	Travel Day

APPENDIX 2
TEST PROCEDURES COVERED IN LABORATORY TRAINING

SUBJECT	ASTM DESIGNATION	AASHTO DESIGNATION
SAMPLING AND SAMPLE REDUCTION:		
Sampling Aggregate Stockpile	D-75	T-2
Sampling of Soils	D-420	T-86
Sampling Portland Cement of Commercial Mineral Filler	C-183	T-27
Sampling of Fresh Concrete	C-172	T-141
Reduction Sample Size by use of Riffle Sample Splitter	C-702	T-248
Reducing Sample Size by the Quartering Method	C-702	T-248
SOIL AND AGGREGATE TESTING:		
Dry Preparation of Soils and Soil Aggregate Mixtures for Test	D-421	T-87
Sieve Analysis	C-117 C-136	T-11 T-27
Liquid Limit and Plasticity Index of Soils	D-4318	T89 T-90
Moisture-Density Relations of Soils using 2.49 kg Rammer and 305 mm drop	D-698	T-99
Family of Curves		
Field Density by the Sand Cone Method	D-1556	T-191
Determination of Moisture in Soils by means of a Calcium Carbide Gas Pressure Moisture Tester	D-4944	T-217
Clay Lumps and Friable Particles in Aggregate	C-142	T-112
Plastic Fines in Graded Aggregate and Soils by use of the Sand Equivalent Test	D-2419	T-176

Fractured Faces

CONCRETE TESTING:

Making, Curing, Capping, and Breaking Concrete Compression Test Specimens in the Field	C-39 C-192 D-617	T-22 T-23 T-231
Slump of Portland Cement Concrete	C-143	T-119
Yield, Weight Per Cubic Foot and Gravimetric Air Control of Concrete	C-138	T-121

APPENDIX 3

LECTURE OUTLINES

Geotechnical and Materials Engineering Concepts. February 29, 1992.

Quality Assurance Concepts and Construction Inspection Concepts. April 1, 1992.

Geotechnical and Materials Engineering Concepts

I. Introduction:

This is one of three talks on the general areas of Geotechnical and Materials Engineering Concepts, Quality Control Concepts, and Construction Inspection. The other two are scheduled late in March.

Today I want to present my viewpoint, based on more than 30 years experience in the area, of what these things are, the skills required to perform satisfactorily in the field, the place that these people should occupy in the total organization, and the interactions between G & ME and the other disciplines in a highway organization

II. Definitions:

A. Geotechnical Engineering deals with Soil and rock as it is in place or somewhat modified, as a structural material, formerly soil & rock mechanics.

B. Materials Engineering deals with soil and rock after some sort of processing, as structural materials or as raw materials for some manufactured product. Not to confused with metallurgy, etc.

III. Skills - Geotechnical Engineer:

A. Geologic Background

1. Basic understanding of nature of soil and rock.

   a. Formation and occurrence
   b. Mass properties
   c. Structural behavior

2. Ground water movement and properties.

B. Exploration technique

1. Remote Sensing

2. Drilling and Sampling, Subsurface Exploration

3. Laboratory Testing

4. Field instrumentation

C. Analytical Skills

D. Report

1. Design recommendations

2. Construction specifications

3. Technical Papers

E. Training

F. Supervision of supporting staff and Lab.

IV. Skills - Materials Engineer:

A. Geologic Background

1. Understand occurrence of soil rock and aggregates or special soils

B. Behavior of soil or rock materials as processed or mixed with others.

1. Excavation and compaction

2. Stabilized soil

a. Cement, lime, flyash
b. Bituminous materials
c. Blended soil
d. Chemicals
e. others

3. Concrete

4. Bituminous pavement

a. Structures
b. Mixtures

5. Maintenance Materials

6. Alternates to scarce materials.

C. Manufactured materials

D. Exploration technique - different emphasis

1. Remote sensing

2. Drilling and pit sampling

3. Laboratory testing

E. Analytical skills

1. Production of specification materials

2. Pavement structural designs

3. Quality Control recommendations

F. Reports

1. Design recommendations

2. Construction specifications

3. Professional papers

G. Training

H. Supervise support staff and laboratory testing

I. Trials new products or technology - applied research

V. Education - Geotechnical Engineer:

A. Either Highway Engineer or Engineering Geologist

1. Cross training in the opposite field.

a. Engineer MUST understand geologic principals.
b. Geologist MUST understand engineering needs.

B. Analytical skills similar.
EG may be a little less math oriented.
CE may be too theoretically oriented.
Highly individual.

VI. Education - Materials Engineer:

A. Highway Engineer with Engineering geology minor.

1. Pavement design specialty

2. Materials technology specialty

VII. Areas of Overlap:

A. Exploration

1. Same equipment and people
2. Different emphasis

B. Laboratory Testing

1. Same building space
2. Same personnel skills
3. Some of the same apparatus

C. Field Work

1. Crew can often perform both G & ME work in the same site visit.

VIII. G & ME Inputs to Pre Construction/Design:

A. Review proposed alternative corridors.

1. Slope stability, landslides
2. Excavation, Rock/Soil
3. Foundations for structures, general
4. Materials inventory & resources
5. Special problems

B. Cut and fill slope designs.

C. Site specific foundation recommendations; bridges, walls, large culverts.

D. Gravel Pit or quarry location and verification.

E. Specific landslide treatments

F. Pavement structure designs

G. Input to general and special specifications and drawings.

H. Special concrete mixtures & specs.

1. High Strength
2. Hot or cold weather placement.

I. Tunnels

L. Special problems

K. Recommendations on new technology or training

IX. **Inputs to Construction:**

A. Quality Assurance sampling and testing

B. Verification of outside tests

C. Training of Inspectors & testers

D. Advice and assistance to project staff

1. Routine

2. Emergency

E. Acceptance of manufactured materials (steel, asphalt, paint etc.)

F. Feedback to design

What is working
What should be changed next time

X. **Inputs to Operation and Maintenance:**

A. Maintenance materials

1. Corrosion protection for steel and pipes

2. Pavement repair materials & methods

3. New materials

Paint
Pavement & concrete repairs
Signs
etc.

B. Emergency problems

1. Landslides

2. Structural failure

3. etc.

C. Feedback to design & construction

D. Training

XIII. **G & ME Responsibility at National Level:**

A. Organizational Planning/Workload

1. Budget
2. Staffing
3. Procurement and distribution of equipment

B. Training: Inhouse and outside, Training needs

C. Library and publications distribution

D. Contributions to standard specifications

E. Dispatching of special equipment

1. Drilling
2. Pavement Evaluation
3. Other low demand items

F. Manuals and standards

G. Applied research

H. National and International meetings

I. Liaison with other divisions and lower levels - very important

J. Pavement inventory System

XIV. At Regional Level (Parallel with other divisions).

A. Organizational Planning/Workload

B. Training site staff, Training needs

C. Library

D. Site investigations & reports

E. Contributions to special specs

F. Coordinating requests for special equipment

G. Implementing applied research

I. Liaison with lower levels

XV. local level (Project):

A. Largely Quality Control and/or Assurance

Subject of another lecture later

XVI. Career ladder - for all disciplines:

A. Must have attractive job for qualified professionals and technicians

1. Good conditions
2. Systematic Training opportunities
3. Professional satisfaction

B. Visible opportunity for advancement

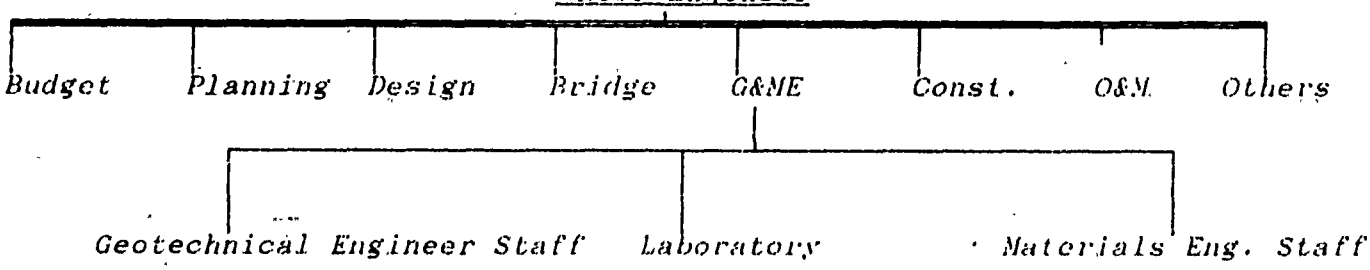
1. Salary
2. Responsibility
3. Status

C. Opportunity for advanced education

D. Chance to move into top management

From this it can seen that G & ME cuts completely across all of the operations of a highway department. It is concerned with planning, design, construction and O & M. Likewise it is involved with earthwork, structures, pavement and maintenance to different degrees in each case.

XI. Organization I:



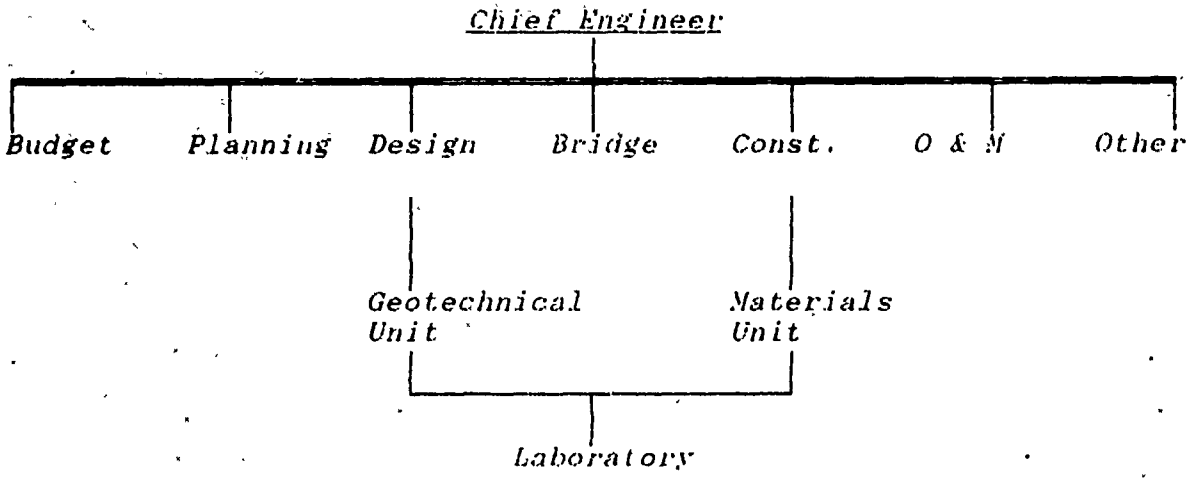
Advantages

1. Equal Status with other divisions
2. Career ladder for professionals
3. Equal accessibility to other divisions

Disadvantages

1. Competition with other divisions for budget and status.

XII. Organization II:



Advantages:

1. *Separates geologists from engineers*
2. *May simplify staffing and project assignment*
3. *Works in many states*
4. *Shelter within higher staff*

Disadvantages

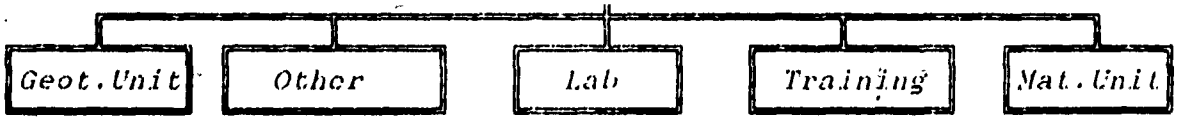
1. *Division crossing responsibilities*

Either system works well enough in practice. Org. I might be better suited to a smaller organization with Org. II better for a large one.

Likewise you might have one organization at the national level and another at the regional or division level.

Organization Within G&ME

Chief Geotech. & Mat'ls. Engineer



Conclusions

This is an overview of

1. *What is GE & ME*
2. *What skills are involved*
3. *What are the duties and responsibilities*
4. *Where should if fit into an organization*

Same of the concepts are too advanced for the present state of your organization. They will come along in the future.

Same G & ME functions are done by others who may not be as well qualified, i.e. Spec. writing often poorly done

Some G & ME functions simply are not done in many places, i.e. Pavement condition surveys (might also be in special pavement division in a big organization).

G & ME is a service to the other divisions and units. It must offer a useful service and it must be available to help when and where needed.

QUALITY ASSURANCE CONCEPTS

I. Introduction

A. Earlier lecture spoke of Geotechnical and Materials Engineering.

1. Q.C was one function of Materials Engineering.

B. This lecture will focus on Q.C or Q.A and then construction inspection as a part of QC.

C. Ideas are concepts only.

1. Need to be fitted to ACLU and later to Afghan DOR.
2. In-House construction different from contract construction.
3. Some of same pressures on in-house force.
   a. Economy.
   b. Time.

II **Definitions:**

A. Quality
A degree or standard of excellence
What is needed to fulfill but not exceed, a project objectives.

B. Design
A definition of the quality needed.
Plans and specifications.
Other documents.

1. Lesser quality will fail in some way to meet the objectives.

    a. Higher maintenance.
    b. Shorter service life.
    c. Very rarely catastrophic failure.

2. Greater quality is nice but uneconomic.

C. Process Control - The control of a process or method of doing something, for example, building a road.

D. Quality Control - Control of the relative quality of a product for example, a road, or the on going means by which a producer maintains control of a manufacturing process.

1. Responsibility is with the producer.
2. Owner can help, but not direct.

E. Quality assurance: The means by which the buyer assures himself that the stated quality (plans and specification) has been met.
Buyer's responsibility.

F. For ACLU there is not much difference between QC. and QA.

1. Differences will emerge in time.

III Elements of Quality Control/Assurance System:

A. Project Objectives.

1. Begin and end points
2. Level of service
3. Kind and volume of traffic
4. People and places served
5. Service life or economic analysis period
6. Salvage value or use at end of EAL

    a. Improve, rehabilitate
    b. Close
    c. Other.

B. ---Define available materials.

1. Preconstruction exploration and testing
2. Adjust alinement and grade
3. etc.

C. Prepare Design

1. Plans, specifications
2. State required quality

D. Limitations

1. Do not require more than is reasonably necessary
2. Do not write a specification that is unenforceable or that will not be enforced

    a. Builder will not respect
    b. Disrespect will spread to other items

E. Contract or Build Project

F. Verify that Quality is achieved

G. Feedback to design and maintenance

H. Documentation

1. Protects all parties
2. Basis for O&M
3. Feature design improvements

IV Principles:

A. Quality Control involves every member of a highway organization.

1. No single part of system can exist alone
2. Much of it does not involve materials testing

a. Construction inspection is about half-materials.
- Line, grade, cross section
- Quantities
- Environment
- Etc.

B. Required Quality must be clearly stated and enforced.

1. Project plans, etc.
2. Avoid pointless requirements

a. Unable to enforce
b. Unnecessary
c. Forces can't do for some reason

3. Be sure inspectors are trained

a. Support them when needed

C. Verify enforcement

1. Do not interfere with builder more than necessary.

D. Documentation and record essential.

1. Protects individuals
2. Facilitates investigation of failures
3. Maintenance planning and execution

Intermission.

CONSTRUCTION INSPECTION

I **Introduction:**

A. Review Previous

1. Quality must fit project objectives
   a. Neither too much nor too little

2. Must be clearly stated
   a. Plans, specifications, etc.

3. Must be within available technology

4. Must be enforceable and enforced.

5. Requirements can be less formal for in-house construction but must still be clearly understood by all parties.

II **Kinds of Specifications:**

A. Method
B. End Result
C. Mixed

III **Acceptance Criteria:**

A. Often not clearly stated

1. "Reasonably close Conformity"

   a. What is reasonably close?

2. "As Required by the Engineer"

   a. How far can he go?

B. Three situations for engineer

1. Clearly inside specifications
2. Clearly out of specifications
3. Not in specification but not harmful

IV **Reasonably Close Conformity:**

A. Always a statistical chance of

1. Rejecting satisfactory material
2. Accepting poor material

B. Inherent variability of material and tests.

C. Borderline results.

D. Judgement call by Engineer.

1. Must be defensible
   Contractor
   Superiors on own staff.

2. Excessive burden for Engineer
   May become overcautious.

V. **Marginal or out of Specification but Harmless:**

A. Very difficult for Engineer

B. Consider

1. Position of item in the work
2. Consequences of early failure
3. Can it be corrected?
4. Contractor relationship
5. Design safety factors

C. Price Adjustment usual in West
1. Reduction should reflect probable cost to owner

D. For in house construction, probably no action.

VI **Clearly out of Specifications:**

A. Correct at builders expense

1. remove and replace
2. Add additional materials

B. Builder will fight

1. May have later work on top of item

VII **Point of Acceptance:**

A. Must be defined in specifications

B. Should be the last place where item can be sampled

1. Just before final compaction
2. At concrete mixer
3. Etc.

VIII **Kinds of Samples/tests, materials or other:**

A. Convenience or Courtesy

1. Information only.
2. Results not binding or either side.
3. May be short cut procedure.
4. Helps Contractor or Engineer.
5. QC or Process Control.

B. Acceptance Testing.

1. Basic Quality Assurance.
2. Specified Frequency.
3. Random selection.
4. Data is binding.
5. Must be done strictly according to specified procedure.

C. Independent Assurance.

1. Verifies a group of acceptance tests.
2. Done by independent people, laboratories.
3. Must be very precise.

D. Special purpose testing.

IX **Testing Frequency:**

A. Should have a uniform policy

B. Varies with

1. Cost of item
2. Sensitivity of item
3. Cost or consequences of failure

C. Guide schedule of minimum frequency should be in the contract documents.

D. Sample schedule in field manual.

X **Sample Selection:**

A. Must be completely random.

1. Every sq.m one of the road must have an equal chance to be selected for testing.

2. Human selection always biased.

B. Should use random number selection.

1. Simple computer program.
2. Eliminates personal bias.
3. Protects inspector.

XI Data Interpretation (Refer to earlier section):

A. Old system left too much discretion to Project Engineer.

1. Different men - different actions
2. Subject to abuse
3. Caused a lot of legal problems
4. Engineer sometimes penalized unfairly for actions
5. Qualities of material represented by test not well defined

B. Development of Statistically based System.

1. Objectives

a. Eliminate bias
b. Protect personnel
c. Fair to all parties
d. Can be defined in contract documents

2. Gives direction on handling.

1. Exceeds specifications, bonus
2. Meets specifications
3. Marginal-cash penalty
4. Out of specification
5. Defines quantities concerned

C. Statistical System Complex

1. Sampling must be done on schedule
2. Staff must be well trained

D. Probably not appropriate for ACLU.

1. Some technique and concepts can be useful
2. Awareness of principals useful

XII Staffing:

A. Field must be controlled by Project Engineer.
B. All of inspection is not materials testing.

1. Site inspector should be present nearly all of the time.

C. Low frequency tests can be done by site inspector.

1. Earthwork compaction
2. Can sample and send to laboratory

D. High frequency testing may need materials technician.

1. Must be available when needed
2. Requires equipment and vehicle

XIII **Quality Control/Assurance Plan:**

A. Written Plans.

1. Project Engineer and Staff prepare
2. Before start of work
3. Negotiate with Contractor

B. Follow it through project.

C. Modify by change order or work order as needed.

D. Prevents problems.

XIV **Summary:**

A. Quality Assurance Concepts in general.

1. Definitions
2. Elements of a QC. System
3. Principles

a. Everybody is involved
b. Material testing is only a part of system
c. Documentation is essential

B. Construction Inspection in general.

1. Acceptance Criteria.
2. Engineers Problems.

a. How to deal with poor material.

3. Kinds of testing
4. Testing frequency
5. Sample selection
6. Data Interpretation
7. Staffing
8. QC. Plan