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Research and Development Program for Highway Construction Engineering Management

Executive Summary and Final Report
February 1990

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UR45

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16. Abstract

This report recommends a priority program of 16 research and development needs that, if carried out, could result in a significant reduction in the $1.2 billion annual cost of highway construction engineering. The methodology used to generate the needs statements, place them in priority order, and formulate the program is explained. The total list of 72 needs statements generated, a literature review, bibliography, research in progress, and comparison with a similar study conducted in 1979 are included.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The landmark Federal-aid highway act of 1956 mandated construction of the Interstate system that transformed the country. Today, 33 years and $120 billion later, the Interstate system is 98 percent complete.

The highway community is now looking to the future, trying to shape the highway program for the next generation. It is a national attempt to achieve a consensus on the future highway program. The Strategic Highway Research Program is another attempt to plan for the future. The success of this program will provide major advances in understanding how to build long-lasting pavements, how to keep them in shape through maintenance, and how to rehabilitate them for continued service.

After the shape of the future highway program has been decided, and the best techniques for building and rehabilitating highways and bridges have been determined, it is imperative that construction engineers assure that projects are constructed in accordance with plans and specifications.

Construction engineering is a vital topic today and for the future. The role of construction engineers has been changing since the last needs study of the subject was completed in 1979. This changing role is partly a result of the changing highway program. Today, the emphasis is on preserving our investment in the Interstate system and other roads and bridges. This emphasis is likely to remain a critical element of the national program for many years to come.

While the need for better construction engineering has been increasing, Federal and State agencies have been experiencing cutbacks in staff and resources, which have complicated the task of day-to-day construction engineering. The computer is revolutionizing many aspects of highway and bridge development, and although it is helping to relieve some of the burden caused by staff reductions, it cannot replace a competent construction engineer.

At the same time that these changes have been occurring, the cost of construction engineering has increased. This increased cost has become a problem as the program has changed to include a higher percentage of smaller projects that require proportionately as much engineering effort as the larger ones.

Good, cost-effective construction requires that these changes be approached through a comprehensive program that ensures that the performance of the final product is consistent with the resources invested in it. This report is an effort to identify the problems that we face and it recommends the steps that we can take to minimize or eliminate them.

The preceding synthesis of Federal Highway Administration (FHWA) Executive Director Richard D. Morgan's remarks from his keynote address "Preparing for the Future" (appendix E) delivered at the Asilomar Workshop in Pacific Grove, California, October 30-November 2, 1988, underscores the urgency of the problem. Morgan further states:

> Through construction monitoring, it is apparent that inadequate numbers or quality of staff contribute to highway quality problems in many States. We know how to build good roads and are continually learning how to do better, but if there is no staff to implement that knowledge, the job will not get done properly. It is therefore essential that greater numbers of well-

qualified people be recruited in both government and industry.

To improve the quality and quantity of engineering services, more and better training and certification programs must be considered.

The increasing number of contractor claims should be examined. We are wasting valuable resources defending ourselves, documenting our actions, and trying to avoid claims. Are construction engineers being kept abreast of current developments so that they can monitor new construction techniques properly?

The relationship between owners and contractors should encourage rather than stifle initiative, innovation, and quality. We need to know which incentives and penalties work, and which do not.

The staffing shortage puts a premium on cost-effective sampling and testing programs. A concerted effort must be made to develop programs that can rapidly and reliably predict the performance of the end product.

Contractors are continually improving their methods and equipment to increase production; testing and controlling must keep up. As agencies require more contractor process control testing, a better definition of agency acceptance is needed to ensure that only materials that meet specifications are accepted and that the use of available State personnel in the quality process is optimized.

Another effect of the shortage of experienced staff is the growing use of consultants for construction engineering and administration. These consultants can do a good job, however, assurance is needed that consultant personnel have the vital technical background required and that they have adequate knowledge of operating procedures and specifications.

A study similar to this one was conducted in 1979. That study defined 63 research and development needs and recommended a research program of the 17 highest-priority needs for funding.

In 1986 the American Association of State Highway and Transportation Officials (AASHTO) Highway Subcommittee on Construction determined that the status of research and development results for these 17 needs should be reviewed. The unpublished report of NCHRP 20-7, Task 26, contains an extensive listing of completed and ongoing research, various implementation activities, and personal contacts pertaining to these highest priority needs. Some of the major findings of the 1979 study are as follows:

1. A significant amount of research has been undertaken in most of the areas covered by the 17 high-priority needs. Ninety-two such projects were identified.

2. The FHWA was particularly effective in establishing research programs with Federal funds that were consistent with the 17 high-priority needs.

3. A continuing need exists to encourage highway operating agencies to implement results of construction engineering management research.

4. Because conditions and priorities have changed since 1979, a new study was recommended to determine current highway construction engineering management research needs.

5. The workshop approach to the conduct of the study was recommended as the best method of developing credibility.

The subcommittee passed a resolution to conduct a new study to update the research and development needs identified in the 1979 study. FHWA initiated the study under the sponsorship of 18 States. A steering committee consisting of representatives from the highway industry, State highway agencies, related Federal agencies, contractors, universities, and consultants was selected to direct the study. After considering various approaches for determining current research and development needs, workshops were selected.

To ensure a broad, all-encompassing discussion of research issues, it was considered essential to involve all segments of the transportation construction industry and a number of related areas in the workshops.

All disciplines and groups, public and private, worked together to identify the most critical problems that face the industry today. Of the 72 research and development needs identified, 16 were selected as being the most significant.

RECOMMENDATIONS

On the basis of its findings, the committee made the following recommendations:

1. The priority program of research and development produced by this study should be funded and completed as soon as possible.

2. The priority program should be immediately included as a funded category in a Federal program for research and development.

3. This research should also be conducted through Highway Planning & Research (HP&R), pooled-fund studies, NCHRP, SHRP, and the Federal highway research program.

4. In addition, all other sectors of the highway industry should become involved in the funding, accomplishment, and implementation of the program.

5. Planned research should focus on the 16 problems in the priority program in order to produce meaningful results.

6. The program should consist of both medium- and short-term research projects. Many will provide results that can be implemented in a short time frame.

7. Although the 16 priority problems constitute the recommended program of research and development, there are 56 other needs included in appendix A that should be considered by organizations funding research programs.

8. A well-funded, major, national program of research, development, and training will be required to satisfy the needs expressed in priority Statement 1: Performance-Based Specifications for Highway Construction; Statement 3: Development of More Effective Rapid Test Methods and Procedures; and Statement 7: Responsibility for Quality Management.

9. Given the relatively poor success rate in the past from trying to create new, rapid test methods through normal research contracts, a program of funding unsolicited proposals to foster innovative approaches to rapid test methods may prove to be more productive.

This multiyear priority program of research and development will cost $45 million. The annual cost of construction engineering for highways is more than $1.2 billion. A 1 percent saving over a period of 5 years would amount to $160 million, or almost four times the research and development costs. These facts support the urgency of the foregoing recommendations.

The 16 most important research and development needs shown below and summarized in table 1 comprise the recommended program.

Table 1. Highest priority research and development needs.

Priority	Problem	Problem Title	Cost	Time (man years)
1	QA-1	Performance-Based Specifications for Highway Construction	$27,000,000	180
2	C-1	Construction Claims and Their Resolution	450,000	3
3	QA-4	Development of More Effective Rapid Test Methods and Procedures	9,000,000	60
4	PC-12	Constructibility Review	450,000	3
5	C-16	Improving the Quality of Work on Highway Projects	450,000	3
6	PC-11	Alternate Methods to Facilitate Timely Reconstruction	600,000	4
7	QA-2	Responsibilities for Quality Management	3,300,000	22
8	OI-1	Effectiveness of the DBE Program	900,000	6
9	MN-6	Evaluating the Effects of Specifications and Other Contract Requirements on Staffing	450,000	3
10	MN-9	Retaining Quality Professional and Technical Personnel	300,000	2
11	ST-3	Constructibility and Operability of Pavement Drainage Systems	300,000	2
12	ET-2	Certification Programs for Construction Engineering Technicians	300,000	2
13	ST-2	Rut Resistant Asphalt Concrete Pavements and Overlays	450,000	3
14	ET-3	Management Skills for Construction Personnel	750,000	5
15	MN-1	Recruiting Qualified Highway Construction Engineering Personnel	300,000	2
16	PC-7	Optimizing the Use of Consultant Versus In-House Staff for the Design and Construction of Public Works.	225,000	1.5
		Total Cost Estimate	+ $45,225,000	

Cost and time estimates indicate general levels of effort deemed appropriate by the Steering Committee without benefit of detailed scope statements. Wide variations may result from more detailed evaluation of each problem.

Priority No. 1: Statement No. QA-1

TITLE

Performance-Based Specifications for Highway Construction

PROBLEM

Many sampling and testing procedures used in highway construction are rooted in tradition and may not be adequate to control the quality of materials and construction activities in relation to ultimate performance of the facility. Some materials may be under- or overtested with respect to the relationship between the tests and performance of the end product. Although significant research is currently being conducted in the area of performance-based specifications, substantial research and field experience continues to be needed to further develop these procedures and to encourage their acceptance and implementation.

OBJECTIVES

The objective of research in this problem area is to improve quality control of highway construction by developing and implementing performance-based specifications for aggregates, bases (bound and unbound), soils, structural materials, highway appurtenances, PCC pavement, paint and coatings, geosynthetics, traffic control devices, and asphalt mixtures. The research will involve the following:

1. Analysis and assessment of sampling and testing procedures currently used by State highway agencies for the acceptance or rejection of materials and construction activities with regard to influence on performance of the end product.

2. Further development of performance-based specifications.

3. Determination of cost effectiveness of performance-based specifications.

COST AND TIME ESTIMATE: $27,000,000 - 180 man years

COMMITTEE COMMENTS

The steering committee considered the amount of research currently under way or funded by National Cooperative Highway Research Program (NCHRP), Strategic Highway Research Program (SHRP), FHWA and so forth, and assigned the following Man Years and cost to individual segments of the required research:

Aggregates	- 1,500,000	-	10 man years
Bases bound and unbound	- 3,000,000	-	20 man years
Soils	- 3,000,000	-	20 man years
Structural materials	- 7,500,000	-	50 man years
Highway appurtenances	- 1,500,000	-	10 man years
PCC pavement	- 4,500,000	-	30 man years
Paint and coatings	- 1,500,000	-	10 man years

Geosynthetics	- 1,500,000	-	10 man years
Traffic control devices	- 1,500,000	-	10 man years
Asphalt mixtures	- 1,500,000	-	10 man years

The committee also considered that this problem was recognized in the 1979 study, and the voting system used in the current study ranked this proposed research project as the number one priority by a substantial margin. Substantial research in this problem area has been completed since 1979, and additional research is in progress; for example, consideration of current research in asphalt mixtures has resulted in a recommendation for a relatively small amount of research in the future.

The committee anticipates that this research will proceed as a large number of separate projects.

Priority No. 2: Statement No. C-1

TITLE

Construction Claims and Their Resolution

PROBLEM

The shift of emphasis from new construction to rehabilitation, especially in urban areas, has increased the numbers, resolution time, and costs of construction claims. In this setting, increased costs to the users, agencies, and contractors due to delays in the construction process can easily exceed the costs of the claims as the level of resolution is raised to higher echelons.

OBJECTIVES

1. Summarize previous research results and define the universe of construction claims in terms of their causes (e.g., inadequate plans, overly competitive contractors, personnel conflicts between contractors and agencies, lack of decision-making guidelines) and their ultimate costs.

2. Several avenues of claims resolution, such as in tunnelling work, minitrials, and other alternatives exist. These and other resolution methods need to be evaluated to determine optimal methods for the highway construction industry.

3. Develop guidelines for resolving claims to ensure project integrity while minimizing costs of project delay. Guidelines must include internal administration practices and procedures external to the contracting agency.

COST AND TIME ESTIMATE: $450,000 - 3 man years

COMMITTEE COMMENTS

Although a substantial amount of research has been undertaken in claims resolution, this project may require additional interviews to confirm or

complete the research. See NCHRP Project 20-7, Task 26, page 51 for list of completed research.

Priority 3: Statement No. QA-4

TITLE

Development of More Effective Rapid Test Methods and Procedures

PROBLEM

Modern high-production plants and equipment have outdistanced the ability to adequately test and control production. There is a need to provide quick, reliable field test results so that the contractor can modify the operation on a timely basis. Also, the highway agencies have a need to measure the quality of the end product rapidly, either on a real time basis or at the conclusion of the project.

OBJECTIVES

1. Develop new or modified rapid testing procedures for each of the various types of construction activities.

2. Develop innovative techniques to measure quality on a real-time basis during the construction.

Research should include but not be limited to the following:

- Bound and unbound pavement base courses.
- Aggregates.
- Soils.
- Structural materials.
- Highway appurtenances.
- PCC pavements.
- Paints and coatings.
- Geosynthetics.
- Traffic control devices.
- Asphaltic mixtures.

COST AND TIME ESTIMATE: $9,000,000 - 60 man years

COMMITTEE COMMENTS

The committee believed that it would be desirable to survey the available rapid test methods and determine their usefulness. The committee also recognized that a joint AASHTO/AGC/ARTBA (Associated General Contractors/American Road and Transportation Builders Association) task force is currently active in this field. It might be useful to identify the tests that have been implemented successfully. This step could provide a foundation and direction for the needed research.

As a final project, the study should deliver an implementation package that the users can readily employ. Therefore, the committee recognized that the research in structural materials would require a relatively high

level of effort because of the criticality and wide varieties of such materials, structural steel and weldments, prestressed concrete, post-tensioned concrete, bridge deck seals, and reinforcing materials.

Priority No. 4: Statement No. PC-12

TITLE

Constructibility Review

PROBLEM

A construction project is affected by contract plans and specifications that are inconsistent with normally accepted construction practice. Change orders, claims, and disputes are the result. During the preconstruction process, an independent constructibility review should identify inconsistencies that increase construction costs and delay the project.

OBJECTIVES

1. Review current procedures used by Federal, State and design firms for constructibility review.

2. Identify items and issues that affect constructibility.

3. Establish detailed guidelines for conducting an effective constructibility review.

4. Conduct field evaluations of recommended guidelines.

COST AND TIME ESTIMATE: $450,000 - 3 years

COMMITTEE COMMENTS

The steering committee suggests that early attention be given to this project. It is believed that much can be done to reduce construction costs by having construction professionals review design projects early in plan development. Such reviews should optimize a contractor's ability to economically build a project and satisfy the owner's intent.

Priority No. 5: Statement No: C-16

TITLE

Improving the Quality of Work on Highway Projects

PROBLEM

The quality of work performed on transportation projects has declined in recent years because of increased concern for legal and contractual protection by all parties. Emphasis on high quality construction will optimize cost effectiveness. With the future demand for increased transportation construction work and inadequate funding to support it, innovative methods

are needed to motivate owner and contractor personnel to produce a high quality product.

OBJECTIVES

1. Identify practices in contract administration and construction that distract owner and contractor personnel from focusing on quality.

2. Evaluate whether many of the pay adjustments (disincentives and incentives) used on highway projects are effective in promoting quality performance.

3. Identify innovative methods to motivate owner and contractor personnel to produce top-quality highway projects.

4. Recommend the most promising innovative methods.

COST AND TIME ESTIMATE: $450,000 - 3 man years

COMMITTEE COMMENTS

The steering committee suggests that the research be completed in 18 months. After identifying the innovative methods, the researchers should then develop the 5 to 10 most promising methods.

Although incentives are usually considered to be positive measures, incentives for early completion could have a negative impact on quality.

Priority No. 6: Statement No. PC-11

TITLE

Alternate Methods To Facilitate Timely Reconstruction

PROBLEM

The reconstruction of high traffic density travel corridors results in costly delays and inconvenience to the traveling public. Reconstruction also results in increased costs because not all of the project site is available to the contractor for work at any one time; this can cause scheduling problems. Agencies continue to use designs and specifications tailored to new construction work rather than reconstruction, which often discourages or precludes innovative approaches by contractors.

OBJECTIVES

1. Analyze (through CPM or another appropriate method) the time and cost involved in completing highway projects using designs and specifications originally developed for new construction versus those specifically developed to allow timely reconstruction, taking into account user costs.

2. Identify key items that may influence design procedures and specifications with regard to reducing user costs and expediting project completion.

3. Evaluate the cost/benefit ratio for each approach.

COST AND TIME ESTIMATE: $600,000 - 4 man years

COMMITTEE COMMENTS

Although some agencies have revised a few project designs to facilitate reconstruction, there has been no effort to thoroughly review existing designs and specifications for changes needed to facilitate these types of projects. The steering committee believes that this issue needs to be addressed as soon as possible because agencies' rehabilitation and reconstruction programs will continue to increase.

Priority No. 7: Statement No. QA-2

TITLE

Responsibilities for Quality Management

PROBLEM

The reduction in personnel resources at State highway agencies has prompted the transfer of roles and responsibilities for process control testing to contractors and material suppliers. The clear transfer of these roles and responsibilities has not taken place, leading to contractual and quality problems. In addition, the costs and benefits of this trend have not been measured, particularly as they relate to quality of the end product and performance of the transportation system.

OBJECTIVES

1. Conduct a study to determine the current state of the practice of the roles and responsibilities of State highway agencies, contractors, and materials suppliers for quality functions (design, quality control, acceptance, etc.).

2. Evaluate the effects on quality (performance of the product) using quality management systems (including quality assurance and method type specifications), refining benefits, and inherent costs. Direct and indirect costs should be determined in the research.

3. Develop a model plan for contractor quality control, and define the roles of the contractor and State highway agencies. Include State highway agency plans for acceptance of materials and verification of contractor quality control programs.

4. Determine certification needs for contractor and/or State highway agencies. In addition, assess the needs for trainers.

COST AND TIME ESTIMATE: $3,300,000 - 22 man years

COMMITTEE COMMENTS

The steering committee believes that this project should include an evaluation of quality management systems for a broad range of materials, including paving materials (asphalt mixtures and portland cement concrete), aggregates, soils, and structural materials. The approximate cost estimate breakdown for each objective is as follows:

Objective	Man Years	Cost Estimate
1	1	$150,000
2	10	$1,500,000
3	10	$1,500,000
4	1	$150,000

It was recognized that research covering objectives 2 and 3 would probably be designed to address each of the materials indicated above.

Priority No. 8: Statement No: OI-1

TITLE

Effectiveness of the Disadvantaged Business Enterprise (DBE) Program

PROBLEM

There are many problems associated with the implementation and administration of the Federally mandated DBE Program including a lack of qualified DBE firms, poor quality work, higher costs, and so forth. A major problem is the lack of a procedure to determine the effectiveness of the DBE Program. There is also a high degree of variability in the methods used by different transportation agencies to manage their programs.

OBJECTIVES

1. Develop methods to measure and evaluate the effectiveness of the DBE Program.

2. Evaluate the current effectiveness of the DBE Program.

3. Develop detailed recommendations for alleviating current deficiencies in the DBE Program, such as enhancing the capability of DBE firms to do quality work, more uniform procedures for DBE certification and goal setting for specific construction projects.

COST AND TIME ESTIMATE: $900,000 - 6 man years

COMMITTEE COMMENTS

Millions of dollars are being spent nationwide on this program each year; therefore, this study should be initiated as soon as possible and completed within a 2-year period.

Priority No. 9: Statement No. MN-6

TITLE

Evaluating the Effects of Specifications and Other Contract Requirements on Staffing

PROBLEM

Often, commonly used specifications or other contract requirements are enforced without fully evaluating the staffing requirements to carry them out. In addition, once implemented, specifications and requirements often continue in force when they no longer contribute to project performance.

Before implementation of specifications and other contract requirements, an estimate of the impact on construction staffing and an evaluation of the benefits of the specification and requirements in relation to the costs should be undertaken.

OBJECTIVES

1. Review specifications from several State highway agencies and identify the requirements that provide marginal benefits to project performance.

2. Identify which specifications from item 1 require a high level of manpower to provide the enforcement or inspection required.

3. Evaluate the benefits realized from the specifications and requirements identified from item 1 and the manpower to enforce them. Develop recommendations for continuing use of the specification or modifying or eliminating the requirements.

COST AND TIME ESTIMATE: $450,000 - 3 man years

COMMITTEE COMMENTS

The committee suggests that this research be completed in 18 months.

Priority No. 10: Statement No. MN-9

TITLE

Retaining Quality Professional and Technical Personnel

PROBLEM

The quality of professional and technical personnel in most State highway agencies (SHA) depends to a large degree on the agencies' ability to retain trained and experienced personnel.

Private firms quickly realize that the training and experience of technical employees would be costly or impractical to develop on a short-term basis. Experienced employees are often enticed to the private sector by incentives that outweigh the security and satisfaction of public service associated with SHA employment. With the emerging shortage of experienced technical employees, it is essential that agencies take immediate steps to encourage employees to remain with the SHA.

OBJECTIVES

1. Interview a cross section of recently resigned and retired public employees from several States to determine their reasons for leaving or remaining with the agency.

2. Identify selected public agencies and private firms that have outstanding employee retention records and study the methods used to maintain staffing stability.

3. Identify methods proven successful by SHA's in retaining experienced personnel.

4. Develop guidelines to be used by agencies as methods to improve career employment.

COST AND TIME ESTIMATE: $300,000 - 2 man years

COMMITTEE COMMENTS

This research need is timely and urgent; it should be completed in one year. Among the factors discussed by the committee that affect agencies' ability to retain construction engineering personnel were adequate salaries, opportunities for professional growth and political implications. The negative impact of "early out" programs should also be considered.

Priority No. 11: Statement No. ST-3

TITLE

Constructibility and Operability of Pavement Drainage Systems

PROBLEM

Significant emphasis is being placed on the need for pavement subsurface drainage systems. The impact of this emphasis on pavement designs and construction is substantial. Evaluation of different systems, their costs, and performance is needed.

OBJECTIVE

Prepare state-of-the-art guidelines on construction techniques, materials specifications, and so forth, for pavement drainage systems to ensure operability, cost effectiveness, and constructibility.

COST AND TIME ESTIMATE: $300,000 - 2 man years

COMMITTEE COMMENTS

One of the main reasons for pavement failure is inadequate subsurface drainage. Various types of subdrains and installation methods are being used, and many installations appear to have some type of problem. The committee believes that adequate performance is contingent on the method of installation, including the construction activities associated with adjacent materials. It also appears that cost of installation has often been a controlling factor in selection of the type of subsurface drainage used. The type of subdrains selected may eventually affect operational effectiveness and future maintenance.

Priority No. 12: Statement No. ET-2

TITLE

Certification Programs for Construction Engineering Technicians

PROBLEM

Because of staffing limitations, many agencies supplement in-house staff with consultants and commercial testing labs and specify quality control procedures that place more responsibility on contractor personnel. Methods are needed to train and certify these technicians. Either in-house programs or the National Institute for Certification in Engineering Technologies (NICET) is used by several agencies to determine the abilities and qualifications of their technicians. These programs should be evaluated for effectiveness.

OBJECTIVES

1. Identify the various industry certification programs available to highway construction agencies, plus those programs needed.

2. Evaluate how well the certifications predict actual performance of the technicians.

3. Develop recommendations for use in establishing and implementing certification programs, including the necessary training programs to assist personnel in qualifying.

COST AND TIME ESTIMATE: $300,000 - 2 man years

COMMITTEE COMMENTS

NCHRP Project 20-25, "Training Needs for Highway Construction Personnel" is being conducted and could meet the objectives of this proposed study. The committee believed that this problem should remain on the priority list in case additional work needs to be done.

Priority No. 13: Statement No. ST-2

TITLE

Rut-Resistant Asphalt Concrete Pavements and Overlays

PROBLEM

A few asphalt concrete pavements and overlays are rutting prematurely, sometimes immediately after construction. This problem may be minimized by using better mix design, new mixture types (e.g., big stone mixes), and improved construction procedures for new pavements. In the case of overlays, the conditions of pavements and bases receiving the overlay also influence the final product. Additional factors may contribute to this problem, such as the large vehicle loads on today's highways and possible adjustments in mix designs to accommodate automated construction equipment.

OBJECTIVES

1. Review available literature and identify causes of premature asphalt concrete rutting.

2. Determine the best current practices for asphalt concrete mix design, and examine new mixture types and improved construction practices that will ensure proper compaction and the use of proper compaction equipment for new pavements and overlays.

3. Identify critical field tests that ensure good quality asphalt concrete pavement construction.

COST AND TIME ESTIMATE: $450,000 - 3 man years

COMMITTEE COMMENTS

- NCHRP 20-7/36 Task 36.
- WASHTO Report on Rutting.
- NCHRP 9-6(1) AAMAS.
- SHRP A-003A.
- Various State research efforts, for example, in Louisiana, Virginia, and Maryland.
- National Center for Asphalt Technology (NCAT).
- FHWA Technical Advisory on Field Control of Asphalt Mixtures.

The committee believed that considerable research on this problem is under way as indicated by the projects and organizations listed above and that a key element is the need to apply and implement known technology. There are, however, opportunities to examine new mix types.

Priority No. 14: Statement No. ET-3

TITLE

Management Skills for Construction Personnel

PROBLEM

Construction engineering management personnel, such as resident engineers and project engineers, generally have adequate engineering knowledge and experience to respond to the varied technical demands of large highway construction projects. However, they may have accumulated only limited experience in dealing with other management responsibilities such as public relations, verbal and written communications, environmental issues, resource management, labor relations, and multiple contracts. There is a need for training of construction engineering management personnel in other professional areas of responsibility.

OBJECTIVES

1. Identify the major responsibilities of construction engineering management personnel that require knowledge and experience in areas other than engineering.

2. Identify available training tools for development of the necessary skills for dealing with those responsibilities.

3. Identify additional training in response to limitations of available tools.

4. Prepare a curriculum for training of construction managers in transportation construction organizations.

COST AND TIME ESTIMATE: $750,000 - 5 man years

COMMITTEE COMMENTS

The product of this study should be a proposed curriculum of study, course topics and outlines, case studies, sequencing of topics, qualifications of attendees, and total time of the program. Strong input is required by highway construction practitioners with known management expertise. A trial program should be conducted to evaluate the proposed program before the curriculum recommendations are finalized.

Priority No. 15: Statement No. MN-1

TITLE

Recruiting Qualified Highway Construction Engineering Personnel

PROBLEM

Highway agencies are finding it increasingly difficult to retain qualified construction engineering personnel because of early retirements and losses to contractors and consultants. There is a need for improved techniques for recruiting young people to replace retiring personnel or those lost to contractors and consultants.

OBJECTIVES

Develop new techniques for emphasizing the opportunities, challenges, rewards and personal satisfaction of construction engineering work to enhance the recruiting of young engineers and technicians.

COST AND TIME ESTIMATE: $300,000 - 2 man years

COMMITTEE COMMENTS

A team composed of members with skills in public relations, human resources, and administration is needed to carry out this research. The committee disagreed on whether there is a problem with the image of the highway construction engineering profession. However, the committee agreed that greater effort is needed to acquaint young engineers and other potential employees with the personal satisfaction and rewards that can accrue through a career in highway construction engineering.

Priority No. 16: Statement No. PC-7

TITLE

Optimizing the use of Consultant Versus In House Staff for the Design and Construction of Public Works.

PROBLEM

The use of consultant services for design and construction of public works has increased because of constraints on public agencies. These constraints include reduced staffing and expanded capital programs. Decisions to use consultant services are, in many instances, not based on a conscious policy, but rather on immediate needs. The decision may or may not be the optimal choice when factors such as increased costs, loss of in-house expertise, and managing consultant work are considered.

OBJECTIVES

1. Conduct project and design engineering cost analyses of representative projects from States that use consultants extensively, moderately, and rarely.

2. Identify key items that influence the successful use of consultants and that have an effect on the public agency when consultants are used.

3. Based on results from item 1 and item 2, develop guidelines and criteria that will assist public agencies in deciding when it is beneficial to use consultant services.

COST AND TIME ESTIMATE: $250,000 - 18 months

COMMITTEE COMMENTS

The steering committee believes that this is an issue that will become increasingly important in the future. Although a few studies of this type have been done, they were viewed as biased and as having no national impact. It is vital that this research be objective and address all aspects of the issue. The desired end product should provide credible guidelines on the use of consultants for SHA's and State governments (both legislative and executive). To achieve this result, it is essential that the contractor not be perceived as having a vested interest in the outcome. A respected management consultant would be one possibility.

CHAPTER 1: INTRODUCTION

Good construction engineering management is the key to quality construction. Although construction management represents only about 12 percent of the cost of the construction program, it is a most critical element to ensure the quality of the total program.

More than $1.2 billion is spent each year on Federal-aid projects plus the additional costs for nonfederal projects. Ten years ago when the previous Research and Development Program for Highway Construction Engineering Management was developed, it was anticipated that the types of construction projects would change. Today, that change is a reality. The emphasis has shifted from completion of the Interstate to preservation of the highway infrastructure. Projects have become extremely complex not only from an actual engineering standpoint but also from the standpoint of environmental, traffic protection and maintenance, Disadvantaged Business Enterprise (DBE) and toxic materials requirements. This complexity has placed a whole new layer of requirements and conditions on contractors, engineers, and sponsoring agencies. Historic relationships and administrative procedures are changing and should be reviewed. At the same time, most State highway agencies' staffs are affected because of hiring restrictions, retirements, and the agencies' inability to compete for young graduate engineers despite generally increasing construction programs. This has necessitated certain changes, such as the development and use of better quality assurance programs and the use of consultants for construction engineering and inspection.

Previous Efforts

In 1979, 21 States pooled their research funds to support a study to identify the research and development needs in construction engineering management. The study resulted in Report FHWA-HO-79-1 which defined 63 research and development needs.[1] A research program of the 17 highest priority needs was recommended for funding. Those needs were the result of input from more than 100 workshop participants--experts representing highway agencies, contractors, materials suppliers, consultants, and academia from all regions of the nation (see appendix F).

As a result of a resolution of the AASHTO Highway Subcommittee on Construction, the status of research and development results for the 17 high priority needs was reviewed in 1986 and reported in NCHRP Project 20-7, Task 26[2]. The Task 26 Report showed that Report FHWA-HO-79-1 served as a basis for FHWA approval of research projects. The report was so effective in presenting credible research and development needs for construction engineering management that a significant amount of research was completed or under way as a direct result.

One objective of the Task 26 review was to determine the need for updating research and development needs. Recognizing the importance of construction engineering, (shifting emphasis to preservation, staffing retention, and recruitment problems, and transfer of quality assurance responsibilities to contractors and consultants), the AASHTO Construction Subcommittee passed a resolution to begin a new study to update research and development needs. The FHWA initiated the study sponsored by 19 States. The results of that study are reported here.

Current Study

A steering committee consisting of representatives from the industry--State highway agencies, related Federal agencies, contractors, universities, and consultants--was selected to direct the study. A literature search was undertaken to identify research conducted in addition to that reported in the Task 26 Report. The steering committee reviewed the research uncovered in the literature search. After considering various approaches for determining current research and development needs, workshops were selected because they were believed to provide the most credible results.

To ensure a broad, all-encompassing discussion of issues and research, a carefully structured invitation list was developed. It was essential to involve all segments of the transportation construction industry. In addition, a limited number of attendees from related areas, such as the building industry, were invited to provide for possible technology transfer where applicable.

Workshops were held September 25-28, 1988, at the Xerox Training Center, Leesburg, Virginia, and October 30-November 2, 1988, at the Asilomar Conference Center, Pacific Grove, California. The format used at both workshops involved each participant in four discussion groups, chaired by members of the Steering Committee, that covered all of the topics. These groups identified problems and drafted the initial problem statements.

CHAPTER 2: DETERMINATION OF RECOMMENDED PROGRAM OF RESEARCH AND DEVELOPMENT NEEDS

Statements of needs were prepared by the participants in the Asilomar and Leesburg workshops. Not unexpectedly, there were many closely related statements as well as a few duplicates. Approximately 200 need statements were submitted by the workshop participants. The TRB staff categorized them into several broad groups, and the steering committee met to consider the merits of each statement. At this meeting, the steering committee consolidated the 200 statements into 72 problem statements that were divided into seven categories: preconstruction(PC), specifications and tests (ST), quality assurance-quality control (QA), education and training (ET), manpower qualifications and needs (MN), contract administration (C), and outside influences (OI).

The steering committee decided that a modified Delphi technique would be satisfactory for ranking the proposed needs statements. Workshop participants were asked to complete two ballots for the research needs. The materials sent to workshop participants for the first ranking (see appendix A) included a letter from TRB, instructions for completing the ballots, ballots for the seven established needs categories, and copies of the 72 needs statements grouped according to category.

Workshop participants were asked to study the needs statements proposed for a category and to perform two evaluations. First, participants were asked to assign an importance index to each statement in each category by using the following index values: A = very important; B = important (not urgent); and C = little importance. Second, participants were asked to rank the statements within each category from 1 to N, where N is the total number in the category. A value of 1 was to be assigned to the proposal the participant would fund as the highest priority within the category, and ascending values were to be assigned to the remaining proposals within the category. For example, if a category included 18 statements, then the participant would rank them from 1 to 18 in priority order.

Participants were also asked to take their highest priority statement from each of the seven categories and rank them from 1 to 7, giving the highest priority a rank of 1. A total of 102 questionnaires were mailed for evaluation on this first iteration, and 72 were summarized by a subcommittee of the steering committee to determine whether a second iteration was desirable for input to the final evaluation of the research and development needs.

Each category was evaluated separately for priority ranking and importance index. Each statement within a category was summarized by calculating its normalized mean priority rating, which was its average rating by all the participants, and by calculating its weighted importance index. The latter index was obtained by assigning a value of 3 to all A-ratings received by a statement, a 2 to all B-ratings, and a 1 to all C-ratings and then summing these values and dividing by the total number of votes cast for that statement to obtain a total weighted value. These 16 problems constitute the recommended program and are given in table 1 on page 5. The results of the priority ranking and importance index evaluations for each category are given in tables 2 through 8 in which the statements are ordered by their statement number. Column 4 in tables 2 through 8 contains the product of columns 2 and 3. A rating of the highest ranking priority statements from each category was made, and the results were used to

determine the weighted overall priority value given in column 5 of tables 2 through 8.

The statements from each category to be used in the second iteration were selected from the best half of the calculated population distribution of ratings from the statements circulated in the first iteration. This was done by calculating the mean and the median of the priority index and the weighted overall priority value for each category.

The criteria for selection of the statements to be included in the second balloting:

- Priority index and weighted overall priority value were equal to or greater than the mean for the category.

- Priority index was between the mean and median value for the category, and weighted overall priority value was equal to or greater than the mean value.

- Priority index was greater than or equal to the mean for the category, and equal to the priority index of a higher rated statement as determined by rule 1.

Three marginal problem statements were included in the second ballot; all three were again eliminated by the balloting. The materials sent to the workshop participants for the second iteration included a letter of instruction from TRB and the ballot containing the 36 problem statements processed as the highest priority in the first iteration (appendix B). Each participant was asked to rank the 15 highest priority statements from the list of 36.

Seventy-nine questionnaires were returned for the second iteration. The ratings of each of the 36 problems were summarized, and a weighted mean priority rating was calculated for each statement. This was accomplished by assigning a weighted value of 15 to a statement for every ranking of 1 received, a value of 14 for every ranking of 2 received, and so on, to a value of 1 for each ranking of 15 it received. The results of this evaluation are given in table 9. The Standard Z-score was then calculated for each of the 36 problem statements by using the weighted rating values given in table 9.

At the next meeting of the steering committee, each needs statement was reviewed for clarity and objectivity. Some editorial work was performed but the purpose and need were not modified. Analysis of the second ballot showed that a break occurred following the 14 statements that were above the mean of the weighted ratings (table 9). Discussion by the committee led to the adoption of the 14 plus the next two. The committee considers these 16 needs to be the most important research and development needs in construction engineering management. The 16 individual work statements with revisions and comments by the steering committee appear in the executive summary. The cost and time estimates represent the best judgement of the steering committee and were made after the balloting on priorities. The 72 work statements mailed with the first ballot appear in appendix A. Cost and time estimates were added by the committee. A value of $150,000/man year was used in estimating costs.

It is not practical to expect that any project would identify 100 percent of the research needs. However, it is believed that the broad range of expertise of workshop participants ensured that all segments of the industry were represented.

Table 2. Summary of preconstruction evaluations.

Problem Statements	Weighted Importance Index Mean	Normalized Priority Mean	Priority Index	Weighted Overall Value	Priority Rank
PC-1	1.90	0.48	0.91	4.83	14
PC-2	1.77	0.53	0.94	1.77	13
*PC-3	1.80	0.60	1.08	3.22	10
PC-4	1.88	0.53	1.00	4.19	12
*PC-5	2.23	0.63	1.40	6.76	4
*PC-6	2.20	0.62	1.36	1.93	6
*PC-7	2.20	0.63	1.39	3.54	5
PC-8	1.95	0.53	1.03	0	11
*PC-9	2.26	0.63	1.42	4.35	3
PC-10	1.83	0.45	0.82	0	16
*PC-11	2.35	0.68	1.60	5.15	2
*PC-12	2.23	0.72	1.61	12.24	1
*PC-13	1.95	0.56	1.09	2.74	8
PC-14	1.95	0.56	1.09	0.81	9
PC-15	1.41	0.29	0.41	0.32	22
PC-16	1.69	0.40	0.68	1.93	19
PC-17	1.66	0.40	0.66	0.48	20
PC-18	1.82	0.48	0.87	2.09	15
PC-19	1.75	0.44	0.77	1.12	17
PC-20	1.65	0.39	0.64	1.77	21
*PC-21	2.12	0.63	1.34	4.19	7
PC-22	1.76	0.44	0.77	0	18
		Mean	1.04	2.88	

* Selected for second ballot

Table 3. Summary of manpower qualification and needs evaluations.

Problem Statement	Weighted Importance Mean	Normalized Priority Mean	Priority Index	Weighted Overall Value	Priority Rank
*MN-1	2.15	0.60	1.29	10.92	3
*MN-2	2.29	0.54	1.24	6.05	4
*MN-3	2.09	0.59	1.23	6.22	5
*MN-4	1.93	0.49	0.95	3.87	9
*MN-5	2.09	0.56	1.17	2.86	6
*MN-6	2.30	0.63	1.45	7.39	2
MN-7	1.96	0.50	0.98	2.18	8
MN-8	2.01	0.51	1.03	2.86	7
*MN-9	2.36	0.65	1.53	6.05	1
MN-10	1.82	0.45	0.82	0.84	11
MN-11	1.82	0.44	0.80	3.36	12
MN-12	1.89	0.48	0.91	2.18	10
		Mean	1.12	4.56	

* Selected for second ballot

Table 4. Summary of contract administration evaluations.

Problem Statement	Weighted Importance Mean	Normalized Priority Mean	Priority Index	Weighted Overall Value	Priority Rank
*C-1	2.51	0.75	1.89	17.31	1
*C-2	1.93	0.53	1.03	6.38	9
*C-3	1.97	0.57	1.12	4.87	7
*C-4	2.18	0.56	1.21	4.71	6
C-5	1.80	0.44	0.80	0	16
C-6	1.82	0.47	0.86	1.01	15
C-7	1.96	0.48	0.93	0.17	12
C-8	1.90	0.50	0.95	0.67	11
C-9	1.72	0.46	0.79	0.50	17
*C-10	2.16	0.59	1.27	4.87	5
C-11	1.95	0.47	0.92	1.01	13
*C-12	2.38	0.58	1.38	5.88	4
C-13	2.04	0.45	0.92	0.84	14
C-14	1.97	0.51	1.00	1.18	10
*C-15	2.35	0.65	1.54	8.24	3
*C-16	2.28	0.68	1.55	13.95	2
C-17	2.13	0.52	1.10	0	8
C-18	1.67	0.39	0.65	3.03	18
C-19	1.58	0.34	0.54	0	19
		Mean	1.08	3.93	

* Selected for second ballot

Table 5. Summary of specifications and tests evaluations.

Problem Statement	Weighted Importance Mean	Normalized Priority Mean	Priority Index	Weighted Overall Value	Priority Rank
ST-1	2.18	0.60	1.31	7.39	3
*ST-2	2.32	0.68	1.58	8.57	2
*ST-3	2.43	0.70	1.70	10.76	1
ST-4	2.05	0.50	1.03	5.21	5
ST-5	2.00	0.52	1.04	6.22	4
		Mean	1.33	7.63	

* Selected for second ballot

Table 6. Summary of outside influences evaluations.

Problem Statement	Weighted Importance Mean	Normalized Priority Mean	Priority Index	Weighted Overall Value	Priority Rank
*OI-1	2.44	0.78	1.90	14.12	1
OI-2	2.39	0.72	1.72	8.24	2
		Mean	1.81	11.18	

* Selected for second ballot

Table 7. Summary of quality assurance - quality control evaluations.

Problem Number	Importance Index Average	Normalized Priority Average	Product of Imp. Index & Priority Average	Normalized Priority Ranking	Rank
*QA-1	2.66	0.75	2.00	15.97	1
*QA-2	2.43	0.62	1.51	12.10	3
*QA-3	2.21	0.59	1.30	2.35	4
*QA-4	2.57	0.68	1.75	14.45	2
*QA-5	2.21	0.52	1.15	3.36	5
QA-6	2.13	0.50	1.07	2.69	6
QA-7	2.13	0.45	0.96	2.86	7
		Mean	1.39	7.68	

* Selected for second ballot

Table 8. Summary of education and training evaluations.

Problem Number	Importance Index Average	Normalized Priority Average	Product of Imp. Index & Priority Average	Normalized Priority Ranking	Rank
*ET-1	2.31	0.63	1.46	12.61	3
*ET-2	2.42	0.67	1.62	13.45	2
*ET-3	2.42	0.68	1.65	10.08	1
*ET-4	2.32	0.63	1.46	6.22	4
ET-5	1.93	0.41	0.79	1.01	5
		Mean	1.40	8.67	

* Selected for second ballot

Table 9. Summary of ranking from questionnaire two.

Weighted Rating	Priority Rank	Problem Statement	Z-Score
572	1	QA-1	2.52
492	2	C-1	1.87
452	3	QA-4	1.54
445	4	PC-12	1.49
441	5	C-16	1.45
378	6	PC-11	0.94
375	7	QA-2	0.92
369	8	OI-1	0.87
365	9	MN-6	0.83
352	10	MN-9	0.73
333	11	ST-3	0.57
325	12	ET-2	0.51
312	13	ST-2	0.40
304	14	ET-3	0.34
251	15	MN-1	-0.10
248	16	PC-7	-0.12
245	17	QA-5	-0.15
235	18	QA-3	-0.23
230	19	PC-5	-0.27
228	20	PC-21	-0.29
222	21	MN-2	-0.33
221	22	PC-3	-0.34
208	23	PC-6	-0.45
180	24	ET-1	-0.68
178	25	ET-4	-0.69
174	26	PC-9	-0.73
160	27	PC-13	-0.84
158	28	C-3	-0.86
158	29	MN-3	-0.86
155	30	C-13	-0.88
148	31	C-2	-0.94
131	32	C-4	-1.08
121	33	C-17	-1.16
118	34	MN-5	-1.18
98	35	MN-4	-1.35
83	36	C-11	-1.47

MEAN
262.92
STD.DEV
122.44

CHAPTER 3: COMPARISON WITH 1979 RECOMMENDED PROGRAM

The 1979 project to define research that would reduce construction engineering management costs identified a program of 17 highest priority needs, which were published in Report FHWA-HO-79-1, "Research and Development Program for Highway Construction Engineering Management." In 1988 a project was undertaken to prepare an updated program of needs. The report of that project included a program of 16 highest priority research needs in highway construction engineering management. The cost estimate for the 1979 recommended program was $17,525,000; the cost estimate for the 1989 recommended program is $45,225,000. It should be noted that, on the basis of cost estimates, the general problem area of Quality Assurance represented 57 percent of the 1979 program and 87 percent of the 1989 program.

NCHRP Project 20-7, Task 26, "Research and Development Needs in Construction Engineering Management," was completed in 1987 with the following objectives: (1) review and evaluate published literature and research in progress in relation to the 1979 recommended highest priority problems, and (2) assess accomplishments in mitigating the 1979 problems and effectiveness in motivating research on these problems. Some of the major findings of the project report were

1. A significant amount of research has been undertaken in most of the 1979 high priority needs areas. A total of 92 such projects were identified.

2. The FHWA was particularly effective in establishing research programs that were consistent with the 17 high priority needs.

3. Because conditions and priorities are continually changing, a new study was recommended to determine current construction engineering management research needs.

The Project 20-7, Task 26 report also contains an extensive listing of reports and research in progress information pertaining to the 1979 high priority needs.

A comparison of the 1979 and the 1989 high priority research needs in construction engineering management provides insight into continuing as well as changing concerns. Table 10 (table 1 from Report No. FHWA-HO-79-1) and table 1 in this report list the highest priority problems for 1979 and 1989, respectively, including category area, problem title, and estimated cost.

As indicated earlier, the most striking observation is that quality assurance research needs were previously and continue to be the major concerns of the highway construction engineering community.

Table 10. Highest priority research and development needs from 1979 study.[3]

Priority Rank	Statement Number	Project Title	Cost ($)*	Time (years)*
1	QA-2	Cost Effectiveness--Sampling and Testing	$125,000	2
2	PC-1	A Study to Redefine the National Transportation ram for the Next 15 Years	500,000	3
3	C-1	Construction-Zone Traffic and Safety Problems	200,000	2
4	I-1	Minority-Business-Enterprise Quota Indemnification by Federal Funds--Study of Feasibility and Procedures for Implementation	200,000	2
5	QA-16	Review of Sampling and Testing Procedures in Regard to Quality Related to Performance of the End Product	5,000,000	5
6	MN-5	Recruiting, Testing, Promoting, and Retaining Qualified Personnel in Highway Construction	50,000	1
7	PC-6	Development of a Preconstruction-Activity Planning and Scheduling System	200,000	2
8	I-5	The Effect of Nontransportation rams and Outside Influences on the Design and Construction of Transportation Facilities	250,000	2
9	T-1	Training, Certification, and Retention of Nonengineering Personnel for Quality Assurance	300,000	3
10	C-16	Guidelines for Administrative Settlement of Contract Claims	200,000	2
11	MN-4	Productivity Standards for Construction-Engineering Personnel	100,000	1½
12	C-10	Development of Feasible Incentive and Disincentive Contract Provisions Covering Time for Ensuring Timely Completion of Project	200,000	2
13	MN-3	Productive Utilization of Construction Manpower During Off-Peak Seasons	50,000	1
14	T-4	A Training Program and Guidelines for Specification Specification Writers	50,000	1
15	QA-15	Benefits and Disbenefits of Quality Control in Inspection and Testing by the Contractor and Feasibility lof Extending Contractor's Responsibility for Quality Control	150,000	2
16	QA-6	Development of More Effective Rapid Test Methods and Procedures	5,000,000	5
17	17-C	Identification and Causes of Contract Claims	150,000	2
		Total	$17,525,000	

*Cost and time estimates indicate general levels of effort deemed appropriate by the Steering Committee and were prepared without benefit of detailed project scopes. Wide variation in cost and time may result from alternative and more detailed evaluation of each project.

Other topics that appear in both lists are construction claims, disadvantaged business enterprise programs, and retaining and recruiting engineers in the highway construction field. Substantial research has been conducted and is in progress in all of these areas except disadvantaged business enterprise programs, but they were again identified by the workshop participants as high priority problems needing further research. An illustration of the effectiveness and results of the previous program is problem C-1, "Construction-Zone Traffic and Safety Problems," ranked as the third priority problem in 1979. The NCHRP Project 20-7, Task 26 report, completed in 1987, identified 40 items of completed research and 16 items of research in progress in this problem area. Although not completely resolved, it is significant that this problem is not included in the 1989 list of highest priority problems. Examples of new problems in the highest priority ranking are PC-11, "Alternate Methods to Facilitate Timely Reconstruction," PC-12, "Constructibility Review," and ST-3, "Constructibility and Operability of Pavement Drainage Systems." These problems reflect the increasing emphasis on reconstruction of existing facilities and on subsurface drainage of pavements.

A further comparison of the recommendations in the 1979 and 1989 programs pertaining to quality assurance confirms that the major construction engineering management problem in 1979, quality control, related to the end product (performance), and development of rapid test methods to control quality is still the major problem today. It is the consensus of the committee that a well-funded, major national program of research, development, and training will be required to satisfy the needs expressed in problem statements QA-1, QA-2, and QA-4 listed in table 1. These three problems represent $39,300,000 or 87 percent of the estimated cost of the 1989 recommended program.

CHAPTER 4: RECOMMENDATIONS

On the basis of its findings, the committee makes the following recommendations:

1. The priority program of research and development produced by this study should be funded and completed as soon as possible.

2. The priority program should be immediately included as a funded category in a Federal program for research and development.

3. This research also should be conducted through other agencies such as Highway Planning & Research (HP&R), pool fund studies, NCHRP, SHRP, and the Federal highway research program.

4. In addition, all other sectors of the highway industry should become involved in the funding, accomplishment, and implementation of the program.

5. Planned research should be focused on the 16 problems in the priority program because this would produce meaningful and readily implementable results.

6. The program consists of both medium- and short-term research projects. Many will provide results that can be implemented in a short time frame.

7. Although the 16 needs constitute the recommended program of research and development, there are 56 other needs included in appendix A that should be considered by organizations funding research programs.

8. A well-funded, major, national program of research, development, and training will be required to satisfy the needs expressed in priority Statement 1: Performance-Based Specifications for Highway Construction, Statement 3: Development of More Effective Rapid Test Methods and Procedures, and Statement 7: Responsibility for Quality Management, and

9. Given the relatively poor success rate in the past from trying to create new rapid test methods by normal research contracts, a program of funding unsolicited proposals to foster innovative approaches may prove to be more fruitful.

This multiyear priority program of research and development will cost $45 million. The annual cost of construction engineering for highways is more than $1.2 billion. A 1 percent saving over a period of 5 years would amount to $160 million or almost four times the research and development costs. These facts support the urgency of the foregoing recommendations.

APPENDIX A: MATERIALS DISTRIBUTED TO PARTICIPANTS WITH FIRST QUESTIONNAIRE

March 6, 1989

MEMORANDUM

TO: All Participants from Xerox and Asilomar Workshops on R&D Needs in Highway Construction Engineering Management

FROM: Bill Gunderman

SUBJECT: Balloting to Determine Priorities of Needs

Will you please read these instructions and examine all of the enclosed materials carefully before you mark any of the ballots.

At the workshop you were advised that you would be asked to help determine the priorities for the research needs coming from the workshops.

These needs have been grouped into the following subjects:

Preconstruction	PC
Specifications and Tests	ST
Quality Assurance - Quality Control	QA
Education and Training	ET
Manpower Qualifications and Needs	MN
Contract Administration	C
Outside Influences	OI

A separate ballot is enclosed for indicating priority within each of these subjects. The statements are listed on the ballots by "statement number," which matches that shown at the top of the statement. A brief title is also given to help avoid confusion.

After determining the priority order of the statements in each of the groups, using the No. 1 priority statement from each group, and only those, please complete the overall priority rating form indicating your ranking from 1 (top priority) to 7 (lowest priority) for these statements.

After completing all of the ballots (7 total) please return one copy of the ballots only to me.

KEEP THE STATEMENTS. We are using a modified delphi technique for determining priorities and we may ask you to ballot again on the needs statements so you should retain them for further use.

We appreciate your prompt handling of this material so that we can meet our contract deadlines as well as your continued technical input to the project. We would like to have your ballots returned by March 31, 1989, in the enclosed stamped envelope.

Instructions for Completion of Ballots

The ballots you are completing are invaluable to our task force; please give close attention to items 2 and 3, which you are supplying (see figures 1 through 7, appendix A).

1. Statement Number: Number assigned to indicate needs statement.

2. Importance Index: For each of the needs statements listed, please assign an index value reflecting your evaluation of the importance or urgency of performing such a study. Use only the following index values: A = Very Important, B = Important (not urgent), C = Little Importance.

3. Priority Ranking: Rank the statements within each topic group from 1 through N, where "N" is the total number of proposals for the group you are evaluating. Assign a value of 1 to the research proposal you would fund as your highest priority and then assign descending values of priority to the others within the group, assigning a value of "N" to the proposal you feel merits the lowest priority of support. (Example: if 7 proposals were included in one group, then you would rank them 1, 2,. . . . , 7.)

4. Brief Descriptive Title: This title is intended to identify the topic of research suggested in the individual research proposal.

NOTE: If you have any questions concerning the instructions for completing the ballots, please contact William G. Gunderman, TRB, 800-424-9818.

Statement No. PC-1

TITLE

Utility Location and Relocation

PROBLEM

As many highway agencies begin rebuilding urban streets and arterials, they are faced with many problems that are the result of utility lines occupying the highway rights-of-way. This raises the following questions: Who pays for the move and the coordination with the highway contractor? How can the work be accomplished in the most economical fashion?

OBJECTIVES

Develop a policy to cover the location of utilities (private and public) on the rights-of-way of highways. Include responsibility to pay for adjustments and/or relocation if caused by highway work. Include responsibility of paying for contractor claims due to utility conflicts. Include standardized marking of utility conduits.

Statement No. PC-2

TITLE

Develop Guidelines and/or Procedures to Enhance the Permit Process on Transportation Projects to Ensure Implementation During Construction

PROBLEM

The permit process requires significant resources of both time and personnel and often causes delays and cost increases to construction projects. There are numerous programs to allow for advanced coordination, public participation, and interagency agreements. All are geared to optimize issuance of required permits.

OBJECTIVES

Evaluate current programs to enhance the permit process. Identify innovative procedures and potential implementation problems. Develop guidelines for use on transportation construction projects to assure optimized permit issuance during preconstruction activities, and follow-up procedures for implementation of permit provisions during construction.

Statement No. PC-3

TITLE

Performance Guarantee for Construction Projects

PROBLEM

Contractors in Europe are guaranteeing construction performance. The application of this procedure to U.S. highway construction needs to be determined; benefits should be identified; as well as impediments to implementation. This should include legal, technical, organizational, bonding, and so forth.

OBJECTIVES

1. Conduct an evaluation of the current practices of performance guarantees in highway construction, including practices in foreign countries.

2. Identify the benefits, limitations, and impediments to implementation.

3. Develop guidelines for test program.

Statement No. PC-4

TITLE

Appropriate Selection of Projects for Design-Build Contracts

PROBLEM

Design-build contracts have the potential for reducing project costs, decreasing total project duration, and encouraging innovation. It is unclear, however, which types of projects provide the greatest opportunity to realize these benefits.

OBJECTIVES

1. Conduct case-history study of past projects utilizing design-build contracts, noting project characteristics and evaluating success of project.

2. Research characteristics of projects that are conducive to realizing benefits from design-build.

3. Recommend guidelines for project selection to utilize design-build contracts.

Statement No. PC-5

TITLE

Timely Use of Research Results

PROBLEM

Historically, research results have not been successfully implemented on a broad basis or in a timely manner. The reasons for this have not been studied extensively, but probably relate to the form of reporting, funding for implementation, failure to recognize the extent of effort required, and the commitment of the research team to develop research in a usable format. Improved methods must be developed to allow for timely implementation of research results. These methods may include changing the statement of research work to include the development and delivery of implementation packages by the research team to interested audiences.

OBJECTIVES

1. Identify current implementation methods practiced at the Federal, State, and local government levels.

2. Identify methods that historically have provided timely implementation.

3. Develop funding and staffing requirements and delivery systems for successful Federal, State and local government level implementation.

Statement No. PC-6

TITLE

Overseeing Consultant Design/Inspection Work for Public Agencies

PROBLEM

Given staff reductions and increased workloads faced by state DOT's, the use of consultants for design and plan preparation and contract administration and inspection has become widespread. Agencies face problems in overseeing the process and assuring a quality product.

OBJECTIVES

1. Define current practices by public agencies for overseeing consultant design/contract administration.

2. Develop guidelines to oversee consultant work to assure that the public agencies' needs are met and that a quality product is acquired.

3. Develop guidelines for dealing with consultants when problems are encountered, for example, liability for errors, lost time due to corrections, and so forth.

Statement No. PC-7

TITLE

Cost Effectiveness of Consultant Design/Contract Administration

PROBLEM

Most public agencies have turned to consultant design and contract administration under the assumption that consultants are more cost effective than increasing in-house staff. Considering the long-term effects of possible reduced quality work, increased overhead due to more "layers" of management, and time needed to oversee work, this may or may not be true.

OBJECTIVES

1. Conduct case studies where consultants have been used (versus State DOT in-house capability) to determine the long-term advantages and disadvantages of both approaches.

2. Develop guidelines for when it is cost effective to use a consultant instead of in-house staff.

Statement No. PC-8

TITLE

Post-Construction Review

PROBLEM

Lack of communication between designers and construction personnel contributes to recurring problems with construction projects. By reviewing changes or design problems encountered during completion, future designs can be improved.

OBJECTIVES

1. Define current practices for reviewing design problems during construction that may affect future design and specifications.

2. Identify benefits to be obtained by such a review and who should be involved.

Statement No. PC-9

TITLE

Contractor Prequalification as a Method for Increasing Quality

PROBLEM

The current prequalification requirements for contractors on publicly funded projects let under the low bid system deal mostly with bonding capacity. The low bid contractor may not be the best technically qualified to construct the project.

OBJECTIVES

1. Develop synthesis of current practice with regard to contractor prequalification.

2. Identify and evaluate prequalification criteria for various types of projects.

3. Recommend standardized systems for prequalifying contractors.

4. Evaluate effect of prequalification on project cost, quality, small business participation, and so forth.

5. Evaluate legal sufficiency of contractor prequalification process.

Statement No. PC-10

TITLE

Contractor Risk Assessment in Project Pricing Strategy

PROBLEM

A number of factors affect the risk contractors assume in pricing any construction project. Some items may be such that the State DOT or contracting agency should set a calculated lump sum quantity and request unit prices for amounts above the lump sum amounts, for example, traffic control devices.

OBJECTIVES

1. Examine State DOT practices on work items where contractor risk could be considered excessive to cause unbalanced bidding.

2. Evaluate several examples of states where lump sum items and unit price adjustments are used successfully versus only lump sum options.

3. Develop strategy to assist State DOT's to predict potential bid items which, when assessed for large variance potential, would cause the design to be uneconomical to build.

Statement No. PC-11

TITLE

Design and Specification Improvements Needed to Facilitate Reconstruction Projects

PROBLEM

Reconstruction of high-traffic density Interstate freeways results in costly delays and inconvenience to the traveling public. Agencies are not taking advantage of time saving design/specs to expedite project completion. "Layer-cake" designs and routine specifications that were developed for new construction not involving many phases to maintain traffic through construction are routinely applied regardless of the critical need for early completions. Increased costs result from the contractor's having to schedule overtime and figure liquidated damages into the bid.

OBJECTIVES

Examine, through CPM or similar, the time to complete projects under standard versus "fast-track" design and specifications. Identify time- consuming requirements such as curing time for concrete pavements, delays to install joint sealants; subgrade treatment-base-pavement design versus a combined subgrade-base or base-pavement design eliminating one or more courses of construction. Evaluate cost/user benefit for each approach.

Statement No. PC-12

TITLE

Plan Constructibility

PROBLEM

Design plan and specification inadequacies affect construction costs and project completion time. In order to reduce disputes and minimize delays, agencies are looking for ways to improve the preconstruction process with regard to plan constructibility.

OBJECTIVES

1. Review current procedures in assessing constructibility.

2. Identify items or issues that affect constructibility.

3. Establish guidelines for a review procedure that would improve constructibility, including who should review plans, when they should be reviewed, and what items should be reviewed.

Statement No. PC-13

TITLE

Impact of Construction Projects on the Public

PROBLEM

The motoring public, businesses, and residences that are affected along a highway corridor have exhibited a growing intolerance for construction inconveniences and negative impacts. These impacts may vary from minor (major in the motorist's mind) delays or detours to significant fiscal impacts such as loss of business (for which most agencies cannot reimburse).

OBJECTIVES

Research and assess the cost of impacts on both motorists and businesses affected by construction activities. Also assess the frustrations of motorists and residents. The study should make recommendations for techniques to minimize both the frustrations and fiscal impacts. These should include public relations techniques, public communication, design concept analysis, incentives, and traffic handling, along with justification for expenditure of additional transportation funds to minimize or mitigate negative construction impacts.

Statement No. PC-14

TITLE

Use of Alternative Construction Materials

PROBLEM

By specifying only standard or traditional materials for use in construction, owner agencies do not encourage innovative new materials, methods, or approaches to construction that may result in cost savings or an improved end product.

OBJECTIVES

Develop procedures that would encourage innovation in contractors' abilities to offer alternative materials or methods without diminishing the design integrity or construction work performance life.

Statement No. PC-15

TITLE

Three-Dimensional Plans

PROBLEM

Visualization of structures from two-dimensional drawings is difficult. With more urban and rehabilitation projects expected in congested areas in the future, the use of concepts and information generated by computers will assist bidders in visualizing and estimating projects.

OBJECTIVES

Synthesize current work in computer-generated, isometric and perspective views and highway departments' use of this information in plans, public hearings, and pre-bid conferences. Determine availability of computer programs to generate these presentations.

Statement No. PC-16

TITLE

Preconstruction Engineering Management Systems

PROBLEM

About 10 years ago, an AASHTO pooled-funded study was completed that identified a model preconstruction engineering management system. Several States have since developed a system to meet their individual needs. There remains a need to summarize experience to date and assist those agencies that have not developed a system. Many improvements have taken place in automated data processing in this time period as well.

OBJECTIVES

Develop a synthesis or "state of the art" in States and/or local agencies that use preconstruction engineering management systems with identified benefits to assist those agencies not currently using a system. The synthesis could include the building sector of the construction industry.

Statement No. PC-17

TITLE

Establishing Construction Project Completion Dates

PROBLEM

The States use several different methods to establish construction project completion dates; for example, working days, calendar days, fixed dates.

OBJECTIVES

Develop a synthesis to evaluate all the methods currently being used. Identify positive and negative features of each method. If possible, identify

the types of projects that may be best suited for a particular type of completion date. NCHRP Synthesis 79 (1981)

Statement No. PC-18

TITLE

Smoothness or Rideability Criteria for Construction Acceptance and Periodic Evaluation

PROBLEM

One of the main components that the public perceives when evaluating the quality of construction is pavement rideability. With today's technological advancements in computers and electronic systems, the need arises for a repeatable, high speed, and light-weight measuring device that will better estimate rideability.

OBJECTIVES

1. Study current methods used for measuring smoothness of ride for construction acceptance.

2. Determine feasibility and acceptance of the development of a standardized system.

3. Determine if same system is applicable to periodic evaluation of rideability of the pavement.

Statement No. PC-19

TITLE

Variability of Specifications from State to State.

PROBLEM

Although there are AASHTO Guide Specifications, every State DOT has been expending significant effort and resource in writing its own standard specification. Sometimes no justification can be found for differences. Requirements may be different in two or more adjoining States.

OBJECTIVES

1. Conduct a study to determine the extent of the problem.

2. Evaluate the need for development of uniform specifications.

3. Estimate the savings that may be realized from adopting more uniform specifications such as reduced duplication of effort and resources.

4. Develop a system to more rapidly update specifications.

Statement No. PC-20

TITLE

Construction Engineering Costing

PROBLEM

Federal limitation on construction engineering (15 percent) has caused a problem in some States as they are not being reimbursed by the FHWA for engineering costs that they have incurred, particularly on smaller projects.

OBJECTIVES

1. Assess the cost experience of State highway agencies in construction engineering and identify innovative measures that are being used to provide high quality engineering for low cost.

2. Identify production standards (if any) used to lower costs, and what may then be used to support a request for a change in Federal legislation.

Statement No. PC-21

TITLE

Incentive/Disincentive Clauses

PROBLEM

The concept of using incentive/disincentive clauses is believed to be appropriate for some projects. However, better guidance is needed on when and how to use incentive/disincentive clauses.

OBJECTIVES

1. Identify the types of projects that can benefit from the use of incentive/disincentive clauses.

2. Provide more specific guidance on the content of the clauses.

3. Provide information on determining the proper amount and justification for the clauses.

Statement No. PC-22

TITLE

Preconstruction Engineering Estimates of Project Costs

PROBLEM

All State transportation agencies are required to develop project cost estimates for comparison with contractors' bids. Weighted averages are normally applied to identified items of work with no regard to unique project features or conditions that may cause the weighted average values to be grossly over- or understated.

OBJECTIVES

Develop procedures to determine factors that should be considered in adjusting weighted average prices to specific project conditions and assure better applicability of engineer's estimate to actual construction bids.

Statement No. ST-1

TITLE

Portland Cement Concrete Pavement Construction Engineering Problems

PROBLEM

There are problems with the construction of fast track concrete pavement, cold weather protection of concrete, curing of PCC pavement, cement factors, and curing time.

OBJECTIVES

1. Develop new products that will provide curing time/temperature confirmation; consider 4 to 6 hour curing time.
2. Research material relationship between R value, temperature retention, and cost--consider biodegradable or reusable materials.
3. Investigate recycling concrete pavements, including quality of existing material, costs of recycling, and possible reuses as a coarse aggregate base material.
4. Develop a low-cost, dependable, accelerated set concrete (fast track).
5. Determine how the use of fly ash affects constructibility, durability, and strength of PCC.
6. Investigate the effect of variations in concrete mix design (cement factor and aggregate gradation) on strength and long-term durability.

Statement No. ST-2

TITLE

Rut Resistant Asphalt Concrete Pavements and Overlays

PROBLEM

Asphalt concrete pavements and overlays are rutting prematurely. It is believed that this problem can be minimized by using good mix design and construction procedures for new pavements. In the case of overlays, the conditions of pavements receiving the overlay might influence the final product. It is believed that proper compaction of the overlay might not be possible if the old pavement has low density.

OBJECTIVE

1. Review available literature and identify causes of premature asphalt concrete rutting.

2. Determine best current practices for asphalt concrete mix design and construction practices that will ensure proper compaction and use of proper compaction equipment for new pavements and overlays.

3. Identify critical field tests that ensure good quality asphalt concrete pavement construction.

Statement No. ST-3

TITLE

Constructibility and Effectiveness of Pavement Drainage Systems

PROBLEM

Significant emphasis is being placed on the need for pavement subsurface drainage systems. The impact of this emphasis on pavement designs and construction is substantial. Additional work is needed to examine all options and monitor performance.

OBJECTIVES

Prepare state-of-the-art guidelines on construction techniques and material specifications for open-graded drainage layers and internal drainage systems to ensure cost-effective benefits and constructibility.

Statement No. ST-4

TITLE

Replacement of Hydrocarbon Solvent Extractor for Asphalt Cement Content and Gradation

PROBLEM

Concerns exist about the use of hydrocarbon solvents for asphalt cement content and gradation evaluation of hot mix asphalt. These concerns revolve around health and safety aspects of working with these solvents, disposal of the used solvent as a hazardous waste, and lack of precision of the test procedure.

OBJECTIVES

Develop and evaluate rapid and reliable test methods for asphalt content and gradation of hot mix asphalt concrete that replace the conventional hydrocarbon solvent-based process.

Statement No. ST-5

TITLE

Common Testing Facilities

PROBLEM

State agencies, the FHWA, the Corps of Engineers, and the like require independent evaluation and testing of construction materials and products. This causes lengthy and costly processing and discourages the use of new or alternate materials and products.

OBJECTIVES

1. Develop a program of national or regional testing and evaluation of new materials and products. Use a joint development process that will provide agreement among the agencies and a cost sharing plan to reduce overall costs.

2. Include an implementation plan and the method of establishing a continuing governing board.

Statement No. QA-1

TITLE

Performance-Based Specifications for Highway Construction

PROBLEM

Many sampling and testing procedures used in highway construction are rooted in tradition and may not be adequately controlling the quality of materials and construction activities in relation to ultimate performance of the facility. Some materials and construction activities may be undertested and others could be excessively tested without regard to the relationship between the tests and performance of the end product. Although significant research is currently being conducted on performance-based specifications (sampling and testing of materials and construction activities in relation to performance of the end product), substantial research and field experience continues to be needed to further develop these procedures and to encourage their acceptance and use.

OBJECTIVE

The objective of research in this problem area is to improve quality control of highway construction by the development and implementation of performance-based specifications. This will involve:

1. Analysis and assessment of sampling and testing procedures currently used by State highway agencies for the acceptance or rejection of materials and construction activities with regard to influence on performance of the end product.

2. Further development of performance-based specifications.

3. Determination of cost effectiveness of performance-based specifications.

Statement No. QA-2

TITLE

Contractor Responsibility for Quality Control - Benefits/Disbenefits

PROBLEM

The reduction in personnel resources at State highway agencies has prompted the transfer of roles and responsibilities for testing and process control to contractors and material suppliers. The clear transfer of these roles/responsibilities has not taken place, resulting in contractual and quality problems. In addition, the costs and benefits of this trend have not been measured, particularly as they relate to quality of the end product--performance of the transportation system.

OBJECTIVES

1. Determine the current state of the practice of the roles/responsibilities of State highway agencies, contractors, and materials suppliers for quality functions (design, quality control, acceptance, etc.).

2. Evaluate the effects on quality (performance of the product) of this trend, refining benefits and inherent costs, both direct and indirect.

3. Develop a model plan for contractor quality control, defining the roles of the contractor and State highway agencies (SHA's). Include SHA plan for acceptance of materials and verification of contractor QC programs.

4. Determine certification and training needs for contractor and/or SHA for administering the program.

Statement No. QA-3

TITLE

Quality of Construction as Related to Incentive/Disincentive Payments to Contractors

PROBLEM

The timeliness and availability of test results affect the ability of contractors to provide quality and respond to incentive/disincentive payments.

OBJECTIVES

1. Develop incentive/disincentive procedures for quality of work using state-of-the-art techniques that will provide rapid and timely construction test results.

2. Develop procedures for incentive/disincentive payments to contractors for quality of work, applying the latest state-of-the-art techniques that provide rapid and timely construction test results.

Statement No. QA-4

TITLE

Development of More Effective Rapid Test Methods and Procedures

PROBLEM

Modern high-production plants and equipment have outdistanced the ability to adequately test and control production. There is a need to provide quick, reliable field test results so that the contractor can modify the operation on a timely basis.

OBJECTIVES

1. Develop a new or modified rapid testing procedure for each of the various types of construction activities.

2. Develop innovative techniques to measure quality on an as-you-go basis during the construction.

Statement No. QA-5

TITLE

Method Specifications versus quality assurance/quality control (QA/QC) or Performance Related Specifications

PROBLEM

States have traditionally used method-type standard specifications. Several States (about 20) have some type of QA/QC specifications. There has been much speculation that QA/QC specifications provide benefits for the owner and the contractor. These benefits have not been documented in a manner that would provide States meaningful assistance as they contemplate using QA/QC specifications.

OBJECTIVES

1. Examine method specifications versus QA/QC specifications.
2. List advantages/disadvantages of each (to owner and contractor).
3. Determine when each type may be used to advantage.
4. Determine problems with use of each type and potential solutions.
5. Determine roles and responsibility of owner and contractor.

Statement No. QA-6

TITLE

Identification of Equitable Pay Adjustment Provisions for QA/QC or Performance Related-Specifications

PROBLEM

The use of QA/QC or performance-related specifications with pay adjustments or pay factors for those items controlling long-term durability is acknowledged as one way to ensure appropriate compensation to the contractor for the product received by the owner. However, neither the items that will most influence long-term performance (durability) nor the appropriate pay adjustments for the corresponding range of test results has been identified.

OBJECTIVES

1. Identify current types of specifications with pay adjustments or pay factors.
2. Identify those that may be considered equitable for the product received.

3. Identify the appropriate range of test results for each pay adjustments/pay factor in order to allow for the normal variability of materials, sampling, and testing.

4. Identify the legal ramifications of pay adjustments that are not equitable.

5. Identify procedures and methods for reconciling and evaluating differences between contractors process control test results and the owners acceptance of test results.

Statement No. QA-7

TITLE

Evaluation of Effectiveness of Reduced Payments for Acceptance of Non-specification Materials or Substandard Workmanship

PROBLEM

It is often technically or politically impractical to remove or replace marginal materials or construction of marginal quality. Many times State highway agency price reductions are considered minimal compared with the potential reduction in service life. Often long-term monitoring is required to determine the effects of construction quality.

OBJECTIVES

1. Define existing policy or direction currently being used by State highway agencies and the FHWA to accept less than desired products.

2. Identify performance-related research that supports the criteria for reduced payments.

3. Develop various engineering evaluations, techniques, or NDT testing procedures that could support the basis for:

   (a) Work and materials acceptable--full payment.

   (b) Generally acceptable, no anticipated reduction in service or performance. With minor corrections--full payment.

   (c) Significant specification deviations and reduced construction quality. Anticipate reduced performance or increased maintenance--determine appropriate pay reduction before acceptance.

   (d) Substantial specification deviations and reduced construction quality. Anticipate major reduced performance--require removal and replacement.

Statement No. ET-1

TITLE

Transportation Engineering Skill Required Versus Education Talent Available

PROBLEM

The transportation industry has a work program that requires certain educational backgrounds and abilities. Colleges and universities are not producing a match of tools in their graduates to meet the requirement, nor do they appear to be guiding students to the correct curriculum to meet this need.

OBJECTIVES

1. Develop a method to communicate the needs of the transportation industry to institutions of higher learning.

2. Determine a method of obtaining the commitment of universities and colleges to a program that meets the needs of the transportation industry including offering proper guidance to students in the development of their careers.

3. Develop a program to match the two industries in providing a balanced workforce.

Statement No. ET-2

TITLE

Certification Programs for Construction Engineering Techniques

PROBLEM

Because of staffing limitations, many agencies supplement in house staff with consultants and commercial testing labs and specify quality control procedures that put more responsibility on contractor personnel. There is a need for methods to predict the capabilities of the technicians assigned to certification programs. In-house and NICET programs are used by some agencies to evaluate and improve their confidence in the abilities and qualifications of the assigned technicians.

OBJECTIVES

1. Identify the various certification programs used by the various highway construction agencies.

2. Evaluate how well the certification programs predict actual performance.

3. Develop recommendations for use in establishing and implementing certification programs, including the necessary training programs to assist personnel in qualifying.

Statement No. ET-3

TITLE

Management Skills for Construction Personnel

PROBLEM

Construction engineering management personnel (e.g, as resident engineers and project engineers) generally have adequate engineering knowledge and experience to respond to the technical demands of large highway construction projects. However, often they may have accumulated only limited experience in dealing with other management responsibilities such as public relations, environmental issues, resource management, labor relations, and multiple contracts. There is a need for training of construction engineering management personnel in other than technical areas of responsibility.

OBJECTIVES

1. Identify the major responsibilities of construction engineering management personnel (resident engineers and project engineers) that require knowledge and experience in fields other than engineering.

2. Identify available training tools for development of the necessary skills for dealing with those responsibilities.

3. Develop additional training tools in response to limitations of available tools.

4. Prepare recommendations for implementation of construction engineering management skills.

Statement No. ET-4

TITLE

Identifying Innovative Training Techniques for Construction Personnel

PROBLEM

Most State highway agencies (SHA) are experiencing a drastic loss of experienced construction personnel caused primarily by the large number

of engineers retiring. In addition, advancing technology has brought about new techniques in construction, materials, and equipment. Because of these two situations, it is important that SHA's place new emphasis on training and development of construction personnel.

With the development of more training technology such as video equipment, teleconferencing, and computer-assisted training, new techniques are available for SHA's and should be identified, evaluated, and cataloged.

OBJECTIVES

1. Identify and evaluate new training techniques used by U.S. firms in training employees and determine those that could be used effectively by SHA's.
2. Review and evaluate techniques being used by foreign agencies to address training problems.
3. Catalog and rate new methods of training that could be used to develop training systems for SHA's.

Statement No. ET-5

TITLE

Training in Specialized Areas

PROBLEM

A number of areas in which specialized construction engineering training is needed have been identified:

- Preparation for litigation depositions.
- Avoidance of change orders.
- Continuing education.
- Ethics.
- Statistical principles.

OBJECTIVES

1. Identify training needs in specialized construction engineering.
2. Assign priorities.
3. Develop training courses.
4. Make the courses available to highway agencies.

Statement No. MN-1

TITLE

Recruiting Qualified Highway Construction Engineering Personnel

PROBLEM

Highway agencies are finding it increasingly difficult to retain qualified construction engineering personnel because of early retirements and losses to contractors and consultants. The lack of glamour, poor image, and relatively unstable schedules of construction engineering work makes it difficult to attract young people to maintain adequate levels of qualified highway construction engineering personnel.

OBJECTIVES

Develop new techniques for overcoming the lack of glamour and poor image of construction engineering work that can be used to recruit young engineers and technicians.

Statement No. MN-2

TITLE

Workforce Needs for Future Highway Construction Programs

PROBLEM

The changing trends in the mix of work in highway programs and changing technology in highway design have created the need for new skills among highway engineers and technicians. In addition, new tools for analyzing data and communications are now available to improve technical capabilities. Education curricula and training methods should be assessed to identify needs to meet future highway programs. Methods to develop optimum educational and training strategies should be identified.

OBJECTIVES

1. Study task distributions and skill levels required to meet future highway programs.

2. Identify specific subject areas emerging into construction engineering and inspection that require new emphasis in technical development.

3. Identify newly developed or emerging tools and techniques that are of increasing value to highway construction personnel.

4. Develop strategies for optimizing the development of construction technical personnel.

Statement No. MN-3

TITLE

Optimizing Construction Engineering Staff Size and Mix

PROBLEM

Highway agencies need to maintain certain levels of construction engineering staffing and skills. Guidelines are needed to define the appropriate levels.

OBJECTIVES

1. Develop guidelines for determining optimum in-house staff size, considering type, size, and complexity of projects.

2. Develop guidelines for the optimum ratios between engineers and technicians for various types of projects.

3. Define guidelines for minimum size and complexity for assignment of professional engineers in construction engineering.

4. Define the duties for key construction engineering positions.

Statement No. MN-4

TITLE

Major Portion of Engineering Time Spent on Non-Engineering Activities

PROBLEM

In addition to construction contract engineering, the engineer on construction projects has to be an expert in many areas such as financial administration, Disadvanteged Business Enterprises requirements, labor compliance, management, public relations, environmental problems, wage rate compliance, training requirements, and other social problems. This could be to the detriment of quality construction.

OBJECTIVES

1. Explore the options that could be used to properly manage and handle the nonconstruction engineering phases of construction projects.

2. Provide guidelines for the type of people to be used, such as specialists in given areas, on what type of assignment vis-a-vis geographic area, specific project, or item of work.

Statement No. MN-5

TITLE

Construction Engineering Manpower Management

PROBLEM

A design manual for developing construction engineering manpower management systems (CEMMS) was sponsored as a pooled-fund project in the late 1970s. A number of States implemented CEMMS based on this manual. Other States developed construction engineering manpower management systems separately. There is a need to evaluate the effectiveness of these systems and identify the procedures that worked and those that did not.

OBJECTIVES

1. Determine which States have construction engineering manpower management systems.
2. Identify the successes and failures in implementing CEMMS.
3. Evaluate selected systems to determine the effectiveness of those systems for determining construction project staffing.
4. Identify strengths and weaknesses in the systems.

Statement No. MN-6

TITLE

Evaluating the Effects of Specifications and Other Contract Requirements on Staffing

PROBLEM

Often commonly used specifications or other contract requirements are put into force without fully evaluating the staffing requirements to carry them out. In addition, once implemented, specifications/requirements often continue in force even when they no longer contribute to project performance.

The value of commonly used specifications/requirements should be calculated to determine whether they contribute to project performance and compare their contribution with the manpower demand of the specification/requirement.

OBJECTIVES

1. Review specifications from several State highway agencies and identify those specifications/requirements that have potential for providing marginal benefits to project performance.

2. From item 1 identify the specifications that require a high level of manpower to provide the enforcement or inspection required.

3. Evaluate the benefits realized from the specification/requirements identified from item 1 and the manpower necessary to enforce them and develop recommendations relative to continuing use of the specification or modifying or eliminating the requirements.

Statement No. MN-7

TITLE

Using Specific Knowledge and Experience in Construction Engineering

PROBLEM

The accumulated knowledge and experience of many construction engineering personnel is being lost to highway agencies due to retirements and transfers. In addition, there may be a need for specific expert knowledge and experience not generally available from State agency construction engineering personnel. There is a need for determining how the knowledge and experience of retiring construction engineering personnel and experts in other fields can best be utilized by highway agencies.

OBJECTIVES

1. Determine the specific knowledge and experience categories in construction engineering in which the use of personnel other than that from State agencies would be effective.

2. Develop techniques for capturing the knowledge and experience of retiring and recently retired personnel in these categories.

3. Develop techniques for transfer of the knowledge and experience of experts in fields other than highway construction engineering to these categories.

Statement No. MN-8

TITLE

Motivating Construction Employees

PROBLEM

Many construction employees are not motivated to effectively perform their duties and responsibilities to attain quality construction. Among other reasons, dead-end career paths and lack of recognition for work well-done are believed to contribute to the problem. There is a need to identify ways to motivate employees.

OBJECTIVES

1. Review and evaluate current career paths for construction personnel.

2. Develop career path guidelines for use by supervisors in conducting training and by employees to qualify for promotions.

3. Identify incentives used by public and private agencies to motivate employers and evaluate their use for construction employees.

4. Develop recommendations and guidelines for implementation.

Statement No. MN-9

TITLE

Retaining Quality Technical Personnel

PROBLEM

The quality of technical staff personnel in most State highway agencies depends to a large degree on the agencies' ability to retain trained and experienced personnel.

Privately owned firms are quick to realize that the training and experience of technical employees would be costly or impossible to develop on a short-term basis. Top experienced employees are often enticed to the private sector by incentives that outweigh the security associated with employment in a State highway agency.

With the emerging shortage of experienced technical employees, it is essential that agencies identify immediate steps to encourage employees to remain with the State highway agency.

OBJECTIVES

1. Interview recently resigned and retired employees to determine their reasons for leaving or remaining with the agency.

2. Identify private firms that have outstanding employee retention records and study the methods that they use to maintain a stabilized staff.

3. Identify methods that have proven successful in retaining experienced personnel.

4. Develop guidelines to be used by agencies to improve employees' continuous employment.

Statement No. MN-10

TITLE

Production Measurements for Construction Inspection and Materials Sampling/Testing

PROBLEM

There are few productivity standards for field operating personnel recognized by the industry. Without production standards, the workload is indeterminate by engineering definition and generally forecast from historical records.

OBJECTIVES

1. Establish a method of developing "engineered" standards for construction inspection and materials inspection and testing.

2. Develop a system to measure "efficiency" and "effectiveness" using standards.

3. Develop a system using standards to determine budgetary needs.

4. Develop productivity standards for uniform construction inspection, materials inspection, and materials testing activities.

Statement No. MN-11

TITLE

Retaining Construction Engineering Personnel in High Cost Geographical Areas

PROBLEM

Because of the high cost of living in many urban areas of the country, it is difficult to get qualified construction engineering personnel to

accept permanent assignments in such areas. The problem is further exacerbated by the fact that construction contracts in these areas are often more complex and thus require a greater degree of experience.

OBJECTIVES

Determine the approaches that are being used by various agencies to encourage qualified construction engineers to accept assignments in high cost-of-living urban areas.

Statement No. MN-12

TITLE

Productive Utilization of Construction Manpower During Off-Peak Seasons

PROBLEM

In northern States, many construction projects shut down during the winter, releasing a major portion of State construction personnel. A large number of such employees are not adequately trained or educated to be absorbed effectively into other department activities.

OBJECTIVES

1. Assess the total needs for engineers and technicians and the basic skill requirements for construction, design, planning, survey, maintenance, inventory, and other department activities.

2. Develop training programs that would allow effective rotation of construction personnel during off-seasons.

3. Consider the use of design and construction personnel as a single pool for deliberate rotation of personnel or the assignment of crews to design and construct their assigned projects.

4. Consider the use of seasonal, low-level personnel for those tasks for which rotation to other activities in the winter is not feasible.

Statement No. OI-1

TITLE

Effectiveness of the WBE/DBE Program

PROBLEM

In today's perspective, no one will deny that there are problems associated with the implementation and administration of the present Women's Business Enterprises/Disadvantaged Business Enterprises

(WBE/DBE)-mandated programs. Many problems associated with cost, lack of quality, and loss of time are caused by the lack of qualified WBE/DBE firms. No successful methods have been devised to reduce costs, increase quality, and reduce lost time associated with these programs.

OBJECTIVES

1. Define and measure success for the programs.

2. Using this as a basis, determine methods such as the mentor/protege relationships that may be legally used to increase the quantity and quality of WBE/DBE's.

3. Define more fully the responsibility (owner versus contractor) for program implementation.

4. Develop educational tools and training programs that may be used to enhance the program.

Statement No. OI-2

TITLE

Minimizing the Impact of External Factors on Highway Construction Contract Administration

PROBLEM

Many external factors are now affecting the administration of highway construction projects, such as special interest groups, environmental regulations, historical or archeological restraints, interpretation of Davis-Bacon requirements, and utilities relocation. These factors have greatly increased the complexity of administering highway construction projects. Research is needed to identify these factors, their potential impact on construction projects, and to develop guidelines for effectively dealing with them.

OBJECTIVES

1. Identify the various external factors that are commonly encountered on today's highway construction project.

2. Identify the impact that these factors have on construction projects.

3. Identify methods used to minimize the negative impacts of these factors on projects.

4. Develop guidelines for handling factors on a uniform basis, especially across State boundaries, if feasible.

Statement No. C-1

TITLE

Construction Claims and Their Resolution

PROBLEM

The shift of emphasis from new construction to rehabilitation, especially in urban areas, has appeared to increase the numbers and costs of construction claims. In this setting, increased user costs due to delays in the construction process can easily exceed the costs of the claims as the level of resolution is raised to higher echelons.

OBJECTIVES

1. Research is needed to define the universe of construction claims in terms of their causes (e.g., inadequate plans, overly competitive contractors, contractor/owner personnel conflicts, lack of decision-making guidelines), and their ultimate costs.

2. Several areas of expertise exist for claims resolution, such as in tunneling work and the alternate dispute resolution work of the Center for Public Resources. These and other resolution methods need to be researched to determine those that would be best suited for the highway construction industry.

3. Initiate research to determine the lowest practical level at which claims can be resolved to ensure project integrity versus the cost of delays.

Statement No. C-2

TITLE

Contractor/Owner Adversarial Relationship as a Producer of Construction Claims

PROBLEM

Inherent in the public works competitive bid system is an adversarial relationship between owner and contractor. When this relationship translates to the project level, it would appear to foster disputes and claims that delay the project and increase costs with no corresponding increase in quality.

OBJECTIVES

1. Study the adversarial relationship to determine which methods would identify and eliminate conflicts that would produce delays and claims.

2. Study methods, such as joint training, that could produce a more productive and less adversarial climate at the project level.

3. Study the effects of nonuniform project administration on the adversarial relationship.

Statement No. C-3

TITLE

Communications and the Construction Team

PROBLEM

The competitiveness of the construction market, the nonuniformity of contract administration, and the complexity of urban rehabilitation highway construction have fostered an adversarial owner/contractor relationship. More important, this tends to "shut down" communications between the owner and the contractor, causing delays, disputes, and increased costs. In this atmosphere it is imperative that communications remain open and formal.

OBJECTIVES

1. Identify needed communication and the most appropriate methods to handle it.

2. Formalize the communication process to improve information quality and the relationships between parties, and to promote trust.

3. Determine the sociological, psychological, and communication skills necessary for effective project engineer/contractor relationships.

4. Determine methods to identify and/or teach the skills identified.

Statement No. C-4

TITLE

Evaluate Policies and Procedures for Identifying and Administering Hazardous Waste Problems in Highway Construction

PROBLEM

Handling of hazardous waste is becoming an increasing problem in construction projects. Some States assume responsibility for disposal while others assign the responsibility to contractors, which can cause

expensive delays. Identification of the hazardous material and obtaining an approved permit to dispose of it by an acceptable subcontractor is time consuming. It is also necessary to develop and train technicians to keep adequate records for compliance with Federal and State regulations.

OBJECTIVES

1. Develop guidelines for identification of hazardous waste.

2. Develop guidelines for selection of subcontractors to dispose of hazardous waste.

3. Develop policies for assignment of liabilities.

4. Develop procedures for assurance that all agencies involved approve the process being performed.

5. Develop materials to train technicians for the inspection process.

Statement No. C-5

TITLE

Changed Conditions Clause

PROBLEM

The 1986 Surface Transportation Act requires that all States adopt a changed conditions clause. The FHWA has developed guidelines for this procedure, which should be administered uniformly or it will cause delays in construction. Interpretation of the requirement could vary among the States and FHWA regions.

OBJECTIVES

1. Develop a procedure to uniformly administer changed conditions policy to provide assurance of uniformity to contractors that bid in any State in order to reduce causes for claims.

2. Develop a procedure to present loss of construction time when changed conditions occur.

Statement No. C-6

TITLE

Effects of Change Orders

PROBLEM

Change orders affect the quality of workmanship and dollar value of construction contracts, and the number of change orders appears to be increasing. It is generally agreed that many of these change orders could be eliminated by adequate preconstruction evaluation. Research is needed to determine the best way to handle change orders and reduce their impact on claims and the quality of workmanship on a project.

OBJECTIVES

1. Evaluate the frequency of change orders on projects.

2. Evaluate the type of change orders on projects.

3. Determine the effect of change orders on the quality of construction and on the value of work performed.

Statement No. C-7

TITLE

Develop Manpower Requirements to Provide Adequate Administration, Inspection, Schedules, and Documentation

PROBLEM

Additional responsibility is continually placed on project engineers at the job site. This reduces the time available for inspection and development of documentation. The use of automatic field computers should be investigated for speed and accuracy of recording with adequate storage of data for future use and reduced paper work.

OBJECTIVES

1. Develop guidelines, methods, and procedures for documentation, quantity measurements, and quality control.

2. Monitor savings that result from these new procedures.

3. Determine priority activities for effective management by project engineers.

Statement No. C-8

TITLE

Determine Adequate Working Time on a Project as it Relates to the Most Economical Administration of the Construction Contract

PROBLEM

Various systems are being used to determine allowable contract working time and the systems of charging this time on a project as related to performance of the work. An acceptable system should be established for the development of an adequate number of working days to ensure timely completion of the contract with assurance that the facility will be available to the traveling public as soon as possible.

OBJECTIVES

1. Evaluate systems of determining working time on construction projects.

2. Evaluate methods of relating work progress to the working days assigned to a project.

3. Develop information to identify user's benefits when projects are completed early as the results of better schedules and control (NCHRP Synthesis 79 (1981)).

Statement No. C-9

TITLE

Project Control by Contract Scheduling, Planning, and Implementation.

PROBLEM

Some of the biggest delays and losses on construction projects can be attributed to failure to plan an adequate construction schedule and to maintain this schedule with necessary adjustments as the project progresses. This system must be as simple as possible to encourage its use.

OBJECTIVES

1. Evaluate a sufficient number of completed projects to determine the impact of the contractor's scheduling, planning, and implementation of the plan.

2. Develop effective guidelines to be used by owners in evaluating a contractor's schedules and progress.

3. Evaluate monthly schedules to determine the percentage of progress for payment.

Statement No. C-10

TITLE

Optimum use of Consultants for Construction Supervision

PROBLEM

Reduced operational budgets, an aging work force, and constraints on hiring over the past several years have eroded most State highway agencies construction field forces. These factors together with increased capital programs to repair and renew the rapidly deteriorating transportation infrastructure have created immediate and acute staffing problems for management of construction programs. In the past, consultants had been hired primarily during peak periods. Today, the question is how much work should be contracted to consultants versus how much work should the agency staff undertake.

OBJECTIVES

1. Evaluate States' current practice of using consultants for construction supervision to determine existing policies and results.

2. Determine the short-range economic consequences of contracting construction management services versus renewal of State work forces through hiring and training.

3. Evaluate the long-range impacts of the use of consultants on cost, organization, and quality of work.

4. Recommend guidelines for determining optimum balance of work between consultants and in-house staff in State highway agencies.

Statement No. C-11

TITLE

Consultant Selection Process for Construction Supervision

PROBLEM

Nearly all States retain consultants for engineering work to some degree. The processes for designation or choice, however, vary widely. In addition, the degree of professional responsibility a consultant

assumes for liability is a key aspect of the contract process as well as the length of time the process takes from start to finish.

OBJECTIVES

1. Survey and critique current practice by State transportation agencies for consultant selection.

2. Determine the degree of liability a consultant must assume as well as any other significant limitation such as maximum overhead rates, maximum salaries, and so forth.

3. Develop guidelines for selecting and designating consultants for construction supervision and agency management of consultant contracts.

Statement No. C-12

TITLE

Accelerated Construction Versus Quality and Cost of Finished Project

PROBLEM

Under any number of scenarios, such as high traffic volumes, potential bridge failure, and community demands to minimize disruption, contracts are frequently let with very short completion times. This introduces a number of issues on penalties for the contractor, but also of significant import to the State transportation agency, are the costs for the work as well as the quality of the finished project.

OBJECTIVES

1. Identify and evaluate contract administrative problems associated with accelerated construction.

2. Evaluate the cost impact of extremely tight contract deadlines on bid prices.

3. Evaluate the quality of the finished project associated with accelerated construction.

Statement No. C-13

TITLE

Night Construction Guidelines

PROBLEM

Nighttime construction has been used sparingly in the past for transportation projects. Often nighttime construction has not been a contract requirement but is used at the discretion of the contractor to meet a critical schedule date. With increasing emphasis being placed on maintenance and protection of traffic during peak periods, nighttime construction has begun to look attractive; however, it has other community impacts (noise and lights) that must be considered.

OBJECTIVES

1. Survey the existing practice of current nighttime construction.
2. Identify benefits and problems associated with nighttime construction.
3. Investigate cost implications of nighttime construction.
4. Develop guidelines and specifications for use in nighttime construction for state highway projects.

Statement No. C-14

TITLE

Evaluation of Roles, Duties, and Compensation of Project Engineers

PROBLEM

Of all the staff required to manage and supervise a construction project, the resident engineer or engineer-in-charge is the key person in the total chain of command. The role and duties of this position have changed significantly with the ever-evolving technology as well as social agendas such as the Minority Business Enterprises program. In addition, through Federal and State legislation, many new environmental and other procedural requirements have been placed directly on the list of responsibilities that the resident engineer must administer and manage.

OBJECTIVES

1. Survey a representative sample of resident engineers to determine a time allocation and profile of job responsibilities.
2. Survey State highway agencies to determine the official role and duty description of duties for resident engineers (official delegation of responsibilities).
3. Survey and analyze salary for work responsibilities and compensation for similar work in the private sector.

4. Develop guidelines for resident engineer role, duties, and salary.

Statement No. C-15

TITLE

Improving Innovation in Highway Construction

PROBLEM

Many new technological developments or new management methods are not being used today in the transportation construction industry. Both agency personnel and contractors are reluctant to try new ideas because of inertia or fear of taking risks. With the loss of many top experts as a result of upcoming retirements and inadequate funding, transportation agencies need to encourage the adaptation of new ideas to seek more quality for their scarce funds.

OBJECTIVES

1. Identify new technologies that could be used in transportation construction.

2. Identify new management techniques that could be used to administer transportation construction projects.

3. Identify and/or recommend ways to encourage the adaptation of new ideas into the transportation construction process by agency personnel and contractors. Rewards and recognition procedures could be identified.

Statement No. C-16

TITLE

Improving the Quality of Work on Highway Projects

PROBLEM

The quality of work performed on transportation projects has declined in recent years because of a lack of emphasis by owner and contractor personnel on the importance of quality. Instead, more emphasis is being placed on legal and contractual protection for all parties. High-quality construction results will optimize the return to all parties involved much quicker than negative concerns. With the future demand for increased transportation construction work and inadequate funding to support it, innovative methods are needed to motivate all parties involved to produce a high quality product.

OBJECTIVES

1. Identify practices in contract administration or construction methods that discourage owner and contractor personnel from doing their best.

2. Evaluate whether many of the negative measures (disincentives) used on highway projects are effective in promoting quality performance.

3. Identify and/or recommend innovative methods to motivate owner and contractor personnel to strive to produce top quality results on highway projects.

Statement No. C-17

TITLE

Construction Engineering Services by Contractors

PROBLEM

Contractors are currently providing many services to transportation agencies that traditionally were performed by agency personnel, for example, field engineering, quality inspection, materials testing, and field design, as needed. It is uncertain as to what practices are being undertaken and the advantages or disadvantages of such practices. Research is needed to verify the impact of such practices on the quality of the construction product and the cost savings to owners, if any. Many transportation agencies are considering services and could benefit greatly from such research.

OBJECTIVES

1. Identify the extent of services, now being provided by contractors for transportation agencies, that were traditionally performed by the agency.

2. Identify advantages and disadvantages, including cost impact, of contractors providing construction engineering and management services for transportation projects.

3. Recommend guidelines for agencies to follow when considering or actually contracting out services to contractors for transportation projects.

Statement No. C-18

TITLE

Administration of Highway Construction Projects Involving Both Public and Private Owners

PROBLEM

Constrained funding has led to increased participation of private owners for financial support of transportation construction projects. This involvement of private owners and local government units has increased the complexity of the administration of such projects. Different interests of the participants often lead to conflict, delays, inconsistent quality, and higher costs. Better guidelines are needed for the administration of such projects.

OBJECTIVES

1. Identify the extent of transportation construction projects that involve joint government and private funding.

2. Identify and evaluate the administration practices being used for these projects and the results obtained.

3. Develop guidelines for the administration of joint private and multigovernment agency construction projects, including uniform procedures to follow and standard agreements and contract documents.

Statement No. C-19

TITLE

Evaluation of Bonding Practices Used for Highway Construction Projects

PROBLEM

Transportation agencies have required many forms of contract bonds on projects for years to protect themselves from financial loss. These bonding practices traditionally have included performance, bid and/or material bonds, plus the prequalification screening provided indirectly for free by bonding agencies. Many questions are raised concerning bonding requirements: Are they necessary? Are they cost effective? Are they performance effective? Are DBE's being bonded? A study is needed to evaluate the current state of the practice and costs of construction bonding for transportation construction and possible improvements in the system.

OBJECTIVES

1. Evaluate current practices used to bond construction of transportation projects.

2. Evaluate the cost of bonds for projects.

3. Evaluate the difficulty of contractors obtaining bonds.

4. Identify or recommend improved practices for providing financial security on transportation projects, including bonds or other methods.

(1) Statement Number	(2) Importance Index A-B-C	(3) Priority Ranking 1,2 ... N	(4) Brief Descriptive Title
PC-1			Utility Location and Relocation
PC-2			Development Guidelines and or Procedures ...
PC-3			Performance Guarantee for Construction Projects
PC-4			Appropriate Selection of Projects...
PC-5			Timely Use of Research Results
PC-6			Overseeing Consultant Design/Inspection Work ...
PC-7			Cost Effectiveness of Consultant Design/Contract...
PC-8			Post-Construction Review
PC-9			Contractor Prequalifications as a Method ...
PC-10			Contractor Risk Assessment in Project Pricing ...
PC-11			Design and Specification Improvements Needed ...
PC-12			Plan Constructibility
PC-13			Impact of Construction Projects on the Public
PC-14			Use of Alternative Construction Materials
PC-15			Three-Dimensional Plans
PC-16			Preconstruction Engineering Management System
PC-17			Establishing Construction Project Completion Dates
PC-18			Smoothness or Rideability Criteria ...
PC-19			Variability of Specifications from State to State
PC-20			Construction Engineering Costing
PC-21			Incentive/Disincentive Clauses
PC-22			Preconstruction Engineering Estimates of Project...

Figure 1. Ballot on R&D needs in construction engineering management (preconstruction).

(1) Statement Number	(2) Importance Index A-B-C	(3) Priority Ranking 1,2 ... N	(4) Brief Descriptive Title
ST-1			Portland Cement Concrete Pavement Construction ...
ST-2			Rut Resistant Asphalt Concrete Pavements ...
ST-3			Constructibility and Effectiveness of Pavement ...
ST-4			Replacement of Hydrocarbon Solvent Extractor ...
ST-5			Common Testing Facilities

Figure 2. Ballot on R&D needs in construction engineering management (specifications and tests).

(1) Statement Number	(2) Importance Index A-B-C	(3) Priority Ranking 1,2 ... N	(4) Brief Descriptive Title
QA-1			Performance Based Specifications for Highway ...
QA-2			Contractor Responsibility for Quality Control ...
QA-3			Quality Construction as Related to Incentive ...
QA-4			Development of More Rapid Test Methods ....
QA-5			Method Specifications vs. QA/QC or Performance ...
QA-6			Identification of Equitable Pay Adjustment ...
QA-7			Evaluation of Effectiveness of Reduced Payments ...

Figure 3. Ballot on R&D needs in construction engineering management (quality assurance - quality control).

(1) Statement Number	(2) Importance Index A-B-C	(3) Priority Ranking 1,2 ... N	(4) Brief Descriptive Title
ET-1			Transportation Engineering Skills Required ...
ET-2			Certification Programs for Construction ...
ET-3			Management Skills for Construction Personnel
ET-4			Identifying Innovative Training Techniques ...
ET-5			Training in Specialized Areas

Figure 4. Ballot on R&D needs in construction engineering management (education and training).

(1) Statement Number	(2) Importance Index A-B-C	(3) Priority Ranking 1,2 ... N	(4) Brief Descriptive Title
MN-1			Recruiting Qualified Highway Construction ...
MN-2			Workforce Needs for Future Highway Construction ...
MN-3			Optimizing Construction Engineering Staff ...
MN-4			Major Portion of Engineering Time Spent ...
MN-5			Construction Engineering Manpower Management
MN-6			Evaluating the Effects of Specifications ...
MN-7			Utilizing Specific Knowledge and Experience ...
MN-8			Motivating Construction Employees
MN-9			Retaining Quality Technical Staff
MN-10			Production Measurement for Construction ...
MN-11			Retaining Construction Engineering
MN-12			Productive Utilization of Construction Manpower ...

Figure 5. Ballot on R&D needs in construction engineering management (manpower qualifications and needs).

(1) Statement Number	(2) Importance Index A-B-C	(3) Priority Ranking 1,2 ... N	(4) Brief Descriptive Title
C-1			Construction Claims and their Resolution
C-2			Contractor/owner Adversarial Relationship ...
C-3			Communications and the Construction Team
C-4			Evaluate Policies and Procedures for Identifying...
C-5			Changed Condition Clauses
C-6			Effects of Change Orders
C-7			Develop Manpower Requirements as Required ...
C-8			Determine Adequate Working Time on a Project ...
C-9			Project Control by Contract Scheduling Planning ...
C-10			Optimum Use of Consultants for Construction ...
C-11			Consultant Selection Process for Construction ...
C-12			Accelerated Construction vs. Quality and Cost ...
C-13			Night Construction Guidelines
C-14			Evaluation of Roles, Duties, and Compensation ...
C-15			Improving Innovation in Highway Construction
C-16			Improving the Quality of Work on Highway Projects
C-17			Construction Engineering Services by Contractors
C-18			Administration of Highway Construction Projects ...
C-19			Evaluation of Bonding Practices Used for Highway...

Figure 6. Ballot on R&D needs in construction engineering management (contract administration).

(1) Statement Number	(2) Importance Index A-B-C	(3) Priority Ranking 1,2 ... N	(4) Brief Descriptive Title
OI-1			Effectiveness of the WBE/DBE Program
OI-2			Minimizing the Impact of External Factors ...

Figure 7. Ballot on R&D needs in construction engineering management (outside influences).

APPENDIX B: MATERIALS DISTRIBUTED TO PARTICIPANTS WITH SECOND QUESTIONNAIRE

May 22, 1989

MEMORANDUM

TO: All Participants from Asilomar and Xerox Workshops

FROM: William G. Gunderman

SUBJECT: Final Ballot on R&D Needs in Highway Construction Engineering Management

This is the second and last time you will be asked to vote in priority order for the R&D needs statements from the construction engineering management workshops.

Analysis of the data from the first ballots has clearly established the top priority statements in each of the groups. These are listed on the enclosed ballot in priority order within the groups. A total of 36 statements are listed.

Please use this ballot to designate in priority order (1-15) your preference for the 15 most important statements from the 36 listed on the ballot. The statement numbers are keyed to the statements mailed with the first ballots. Please refer to those statements for details. If you have any problems call me or my secretary at (800) 424-9818.

We ask that you return this ballot to us by June 2, 1989, so that we may complete the data analysis before our final steering committee meeting in July. This will enable us to clearly establish the top priority needs in the final report. When the report is finished, a copy will be sent to you.

I would like to thank you, on behalf of the Transportation Research Board, for your interest and help in completing this project. Without people like you the Board could not carry on its work.

Enclosures

WGG:kc

Statement Number	Priority Ranking Use only 1 thru 15	Brief Descriptive Title
PC-12		Plan Constructibility
PC-11		Design and Specification Improvements Needed...
PC-9		Contractor Prequalifications as a Method...
PC-5		Timely Use of Research Results
PC-7		Cost Effectiveness of Consultant Design/Contract
PC-6		Overseeing Consultant Design/Inspection Work...
PC-21		Incentive/Disincentive Clauses
PC-13		Impact of Construction Projects on the Public
PC-3		Performance Guarantee for Construction Projects
OI-1		Effectiveness of the WBE/DBE Program
C-1		Construction Claims and their Resolution
C-17		Construction Engineering Services by Contractors
C-16		Improving the Quality of Work on Highway Projects
C-13		Night Construction Guidelines
C-11		Consultant Selection Process for Construction...
C-4		Evaluate Policies and Procedures for Identifying...
C-3		Communications and the Construction Team
C-2		Contractor/owner Adversarial Relationship...
ST-3		Constructibility and Effectiveness of Pavement...
ST-2		Rut Resistant Asphalt Concrete Pavements...
MN-9		Retaining Quality Technical Staff

Figure 8. Final ballot on R&D needs in highway construction engineering management.

Statement Number	Priority Ranking Use only 1 thru 15	Brief Descriptive Title
MN-6		Evaluating the Effects of Specifications...
MN-1		Recruiting Qualified Highway Construction...
MN-2		Workforce Needs for Future Highway Construction...
MN-3		Optimizing Construction Engineering Staff...
MN-5		Construction Engineering Manpower Management
MN-4		Major Portion of Engineering Time Spent...
ET-3		Management Skills for Construction Personnel
ET-2		Certification Programs for Construction...
ET-1		Transportation Engineering Skills Required...
ET-4		Identifying Innovative Training Techniques...
QA-1		Performance Based Specifications for Highway...
QA-4		Development of More Rapid Test Methods...
QA-2		Contractor Responsibility for Quality Control...
QA-3		Quality Construction as Related to Incentive...
QA-5		Method Specifications vs. QA/QC or Performance...

Name_____

Return to: William G. Gunderman
Engineer of Materials & Construction
Transportation Research Board
2101 Constitution Avenue, N. W.
Washington, DC 20418

PLEASE RETURN BY: JUNE 2, 1989

Figure 8. Final ballot on R&D needs in highway construction engineering management (continued).

APPENDIX C: WORKSHOP PARTICIPANTS

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Doyt Bolling, Federal Highway Administration
Dwight Bower, Colorado Department of Highways
Bernard Brown, Iowa Department of Transportation
Bobby Buser, Florida Department of Transportation

James Cable, Iowa State University
William Cape, James Cape and Sons Co.
Frank Carroll, Missouri Highway and Transportation Department
Glen Carter, Greiner Engineering
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APPENDIX D: LITERATURE REVIEW, BIBLIOGRAPHY, AND RESEARCH IN PROGRESS

The initial activity of this task was a Highway Research Information Service (HRIS) search for recent items pertaining to construction engineering management research. A total of 29 items were identified of which 11 were deemed to be highly relevant to the project. These documents have been reviewed and annotated bibliographies prepared and included with this literature review. A critical assessment of the documents reviewed to date results in the following observations:

1. The first phase of the initial FHWA pooled-fund project begun in 1976 resulted in the publication of the Construction Engineering Manpower Management-System Design Manual distributed to State highway agencies. A number of States have used this manual but its application to individual State practices has not been fully evaluated. Consideration should be given to such an evaluation and any need for updating the manual to improve its usefulness.

2. As indicated in the NCHRP Project 20-7 task 26 report, there is a continuing need to encourage State highway agencies to implement the results of construction engineering management research. Consideration should be given to the development of procedures in response to this need.

3. Guidelines should be developed for State highway agencies to contract with consulting firms and contractors for certain construction engineering services and quality control activities.

4. Is "constructibility" adequately considered during the planning and design processes of highway projects?

5. "Goals for Basic Research in Construction," has identified some possibilities for this study, such as "develop methods to motivate construction personnel," "develop better procedures to assess risk in construction," and "investigate methods for evaluating productivity."

6. Use of computers in construction engineering management is definitely a major topic.

7. Along with computers, the use of expert/knowledge based systems is a fast growing technology.

"Construction Engineering Manpower Management - System Design Manual," Report No. FHWA-TS-78-226, April 1978.

The first phase of an FHWA pooled-fund project on construction engineering management resulted in this report. It is a synthesis of the procedures employed in several State highway agencies, including specific suggestions on manpower planning, staffing, and scheduling and how to adapt the procedures to individual user needs.

"Research and Development Program for Highway Construction Engineering Management," Report No. FHWA-HO-79-1, May 1979.

This report describes a 1978 study conducted by the TRB for the FHWA, the second phase of a pooled-fund project. Two workshops were planned and conducted to identify research and development needs in construction engineering management and to prepare a program of recommended research. A list of 63 research needs was generated by the study and a priority program of 17 needs is recommended in the report.

"Construction Management System," (5 volumes) Tippin et al, Public Administration Service, 1978.

The Public Administration Services (PAS) organization was retained to work with personnel of the Arkansas State Highway and Transportation Department to develop a construction management system specifically suited to the needs of the State agency. The contract produced a Basic Scheduling system, a Long-Range Forecasting System, a Resident and District Engineer Operations Manual, a Construction Office Operations Manual, and an Implementation Manual. The only real consequence of these documents as they pertain to the present study is an evaluation of the extent of their implementation by the State agency to improve quality of highway construction and/or to reduce construction engineering costs.

A possible activity of the present study might be a critical assessment of this and similar projects by other State highway agencies.

"Research and Development Needs in Construction Engineering Management," Newman, R. B. and Hejl, F. D., NCHRP Project 20-7/26, 1986.

This report documents an NCHRP study recommended by the AASHTO Subcommittee on Construction to (a) evaluate the progress of the research program recommended in Report FHWA-HO-79-1, and (b) determine the need for revisions of the program in response to a changing emphasis of highway construction activities. The objectives of the study were to:

1. Evaluate recently completed and current research in comparison with that recommended in Report FHWA-HO-79-1.

2. Assess accomplishments and effectiveness of the recommended research to solve the identified problems.

3. Evaluate the need for a similar project to update research and development needs in construction engineering management.

The report contains an extensive listing of recently completed and ongoing research activities, various implementation activities, and personal contacts pertaining to the 17 highest priority needs identified in Report FHWA-HO-79-1. Some of the major findings of the project are as follows:

1. A significant amount of research has been undertaken in most of the areas covered by the 17 high-priority needs. A total of 92 such projects were identified.

2. The FHWA was particularly effective in establishing research programs undertaken with Federal funds that were consistent with the 17 high-priority needs.

3. There is a continuing need to encourage highway operating agencies to implement results of construction engineering management research.

4. Because conditions and priorities have changed since 1979, a new study is recommended to determine current highway construction engineering management research needs.

5. The workshop approach to the conduct of the study is recommended as the best method of developing credibility.

"Staffing Considerations in Construction Engineering Management," Newman, R. B., NCHRP 20-5, Topic 17-13.

Priority problem Number 6 of the previous study was entitled, "Recruiting, Testing, Promoting, and Retaining Qualified Personnel in Highway Construction." The objectives were to determine skills needed, develop training and recruiting programs, and determine conditions for retaining qualified personnel. This synthesis report addresses that problem and objectives.

A major conclusion of the project, that given adequate design plans and specifications, was that the quality of highway construction depends on construction engineering and inspection. The quality of inspection personnel--how well they are trained and motivated--is more important than the quantity. It is better to have intermittent inspection by a qualified inspector than full-time inspection by one who does not know what or how to inspect.

Technician-level training and certification by the National Institute for Certification in Engineering Technologies (NICET) appears to be on the increase. Also, many states are requiring contractors to assume more of the quality control responsibilities, partly to overcome the shortage of inspection personnel and partly to assign responsibility for control of the manufacturing process. Construction technicians should be certified, either by in-house procedures or NICET, whether working for a State agency, consultant, or contractor.

"Value Engineering in Preconstruction and Construction," Turner, O. D., NCHRP Synthesis 78, 1981.

This topic was ranked 19th on the list of priority problems during the previous study. This report reviews successful experiences and present guidelines for the application of value engineering during preconstruction and construction activities. The findings support the position that the application of value engineering concepts, principles, and techniques is effective in reducing costs. Increased use by state highway organizations is warranted. Further research in this area does not appear to be needed.

"Third Party Construction Engineering," Kiljan, J., Colorado Department of Highways, March 1986

This interim report on a study of the advantages and disadvantages of contracting with a consulting firm for construction engineering services covers overall administration, construction surveying, and materials testing. No specific findings are included but any further reports will be reviewed.

"Integrating Construction Resources and Technology into Engineering," The Business Roundtable, New York, NY 1982.

This report covers one of a series of studies performed by the Business Roundtable aimed at improving cost effectiveness in the construction industry, primarily the utility, industrial, and commercial segments. The major finding is that the integration of the planning, design, and construction phases of a project by use of a "constructibility" program can result in significant savings of many times the cost of the "constructibility" activities. Other studies conducted by this organization include, "Measuring Productivity in Construction," "Construction Labor Motivation," and "Modern Management Systems."

"Goals for Basic Research in Construction," Paulson, B. C., Jr., Stanford University, 1975.

A workshop on basic research in the management of construction was held at Stanford University, April 3 and 4, 1975. It was funded by a grant from the National Science Foundation. Participants included

representatives from the construction industry (contractors and consultants), government agencies (including one from the California Department of Transportation), users of construction services, and academic institutions. Participation and thus discussion was heavily oriented to problems of very large construction projects such as pipelines, nuclear plants, and dams. However, several suggestions from this report may be of interest to the highway construction industry. In 1972, construction industry receipts were $150 billion, or more than 12 percent of the Nation's gross national product. Expenditure of only 1/10 of 1 percent of this amount for research would be $150 million. Several of the suggested basic research needs that might be applicable to highway construction are:

- Develop methods to motivate construction personnel (managers and inspectors) to be more productive and effective in producing a quality product.
- Study the owner-design-constructor interplay to determine means to improve communications and cooperation.
- Develop more innovative use of computers. (Substantial progress has been made in this area since the 1975 workshop.)
- Improve use of statistical sampling in quality assurance programs. (This has also improved since 1975.)
- Develop better procedures for assessing risk and uncertainty in construction and thus reduce costs.
- Develop methods to accelerate testing and make results more reliable, for example, the testing of concrete in the plastic state.
- Investigate methods for evaluating productivity such as time-lapse photography and closed circuit TV.
- Develop economic means for reducing seasonality in construction.
- There is a need for closer cooperation between university and industry people working in construction. Study the close relationships between universities and industry in Northern Europe for possible implementation in North America.

"Resource Analysis Using Microcomputers (Construction Engineering)," Halpin, D. W., Georgia Institute of Technology, 1985.

This report describes work on a National Science Foundation project. A microcomputer-based system has been developed for the analysis of resource requirements on highway construction operations. The system consists of five interactive modules that allow the definition of construction process and the evaluation of resource combinations using a sensitivity approach. A special feature of the research has been the

development of 26 standard networks for various types of construction processes. The modules were tested using actual field data. The report contains several lists of references indicating extensive activity in this field.

"Survey of the State-of-the Art Expert/Knowledge Based Systems in Civil Engineering," Kim, S.S., et al, American Society of Civil Engineers and Carnegie-Mellon University, 1986.

This survey assesses the current use and development of expert systems for approaching and solving civil engineering problems. The engineering disciplines discussed are construction engineering and management, structural engineering, geotechnical and environmental engineering, and transportation engineering. Although artificial intelligence technology is relatively new for research and development of expert systems for construction, they offer new and potentially valuable capabilities to support decision making in civil engineering with the goal of reducing costs.

APPENDIX E: KEYNOTE ADDRESS: PREPARING FOR THE FUTURE

(Presented at the workshop held at the Asilomar Conference Center, Pacific Grove, California, October 30 through November 2, 1988.)

There was an article in Fortune magazine called "Those Expensive Highways." It began, "The U. S. Highway Problem, succinctly stated, is that the most mobile nation on earth is in some danger of becoming immobilized." That statement appeared in May 1955.

Just a year earlier, President Eisenhower had introduced his "grand plan" for the Nation's highways in a speech to a governor's conference in July 1954. It ultimately led to the landmark Federal-aid highway act of 1956 and the highway trust fund, the mechanism that has allowed us to build the Interstate system. But at the time, people could not see how the system would transform the country. In fact, before the "grand plan" speech could be presented, the governors had to be persuaded to drop a resolution opposing any more Federal-aid for highways.

Today, 32 years and $120 billion later, the Interstate system is 98 percent open. We can see the end in sight. And we are all proud--justifiably--of what we've done and of the part we've played in accomplishing the greatest public works project ever. When I say "we," I mean Federal and State highway officials, national road booster and industry groups, the politicians who have supported this program, and the highway construction, equipment, and consultant industries.

Still, this is no time to lean back, put our feet on our desk, and reminisce about the glory days when thousands of miles of Interstate highway were under construction. Just last month, 34 years after that Fortune article, Time magazine had a cover story, "Gridlock!" that stated, "The congestion, which is certain to grow worse in the coming decade, is hampering Americans' cherished mobility and changing the way they travel and do business." So much for the progress of the past.

The entire highway community is looking to the future, trying to shape the highway program for the next generation. We see it in several areas. One of the most prominent is the 2020 effort by the Highway Users Federation for Safety and Mobility (HUFSAM) and the American Association of State Highway and Transportation Officials (AASHTO), with cooperation from a number of other industry groups. This is a national attempt to achieve a consensus on the future highway program. The FHWA has been working through its own "futures" task force to identify current problems, future needs, and the role of the Federal Government in meeting them.

But that's not all. The Strategic Highway Research Program is another attempt to face the future. If this program is a success, and I think it will be, we will make major advances in understanding how to build long-lasting pavements, how to keep them in shape through maintenance, and how to rehabilitate them when needed for continued service. This program has wide support at the Federal and State levels, as well as from the industry.

Meanwhile, we have been advocating pavement management systems for a number of years and have begun encouraging development of comparable bridge management systems. These systems allow highway departments to

evaluate overall conditions and put resources where they are most needed. They eliminate the "squeaky wheel" approach to highway programs, at least to the extent that that can be done.

The computer explosion is revolutionizing many aspects of highway and bridge development. We're just at the start of this revolution, but already a highway engineer who pulls out a slide rule has to spend 5 minutes explaining what it is. Bridge and pavement design, capacity analysis, pavement condition reporting, inventory needs--these are just a few of the areas that computers are affecting.

But there is one problem with all of this planning for the future. After we decide the shape of the future highway program, after we figure out the best techniques for building and rehabilitating highways and bridges, after we decide which highways and bridges to work on, after we throw away our slide rule--the effort will have been wasted if the projects are not built right. What is the use of knowing how to design a pavement or bridge if the specifications are not right or are not followed?

That brings us to the Workshop on R&D Needs in Construction Engineering Management. Construction engineering is a vital topic today and for the future because if construction engineering fails, all the other efforts fail, too. Construction engineers are our last line of defense.

The role of construction engineers has been changing since the last study of the subject was completed about 10 years ago. Partly, this change is a result of the changing highway program during that time. Today, the emphasis is on preserving our investment in the Interstate system and our other roads and bridges, and that emphasis is likely to remain a critical element of the national program for many years to come. A high percentage of highway construction is and will continue to be of the 4R-type (resurfacing, restoring, rehabilitating, and reconstruction).

While the need for better construction engineering has been increasing, Federal and State agencies have been experiencing cutbacks in staff and reshuffling of resources. This has complicated the task of day-to-day construction engineering. The computer has reached the job site, and it is helping to relieve some of the burden caused by staff reductions, but it cannot replace a dedicated construction engineer.

At the same time that these changes have been occurring, the cost of construction engineering has increased. Approximately $1.2 billion a year is spent on construction engineering on Federal-aid projects, compared with $600 million 10 years ago. To an extent, this cost has become a problem as the program has changed to include a higher percentage of smaller projects that require as much engineering effort as the larger ones.

To be effective, we must approach these changes through a comprehensive program that ensures that the performance of the final product is consistent with the resources invested in it. During this workshop, we have an opportunity to identify the problems that face us so we can take steps to minimize or eliminate them.

Let's look at some of those problems. States are losing personnel through budget cuts, retirements, and a lack of challenge for young people who are going to private sector jobs. At the Federal level, we are experiencing our own version of the baby boom cycle of the

population at large. Our baby boom took place in the 1950's and 1960's. Now we're experiencing a "baby bust" at a time when the original "boomers" are turning gray. More than 50 percent of FHWA management personnel at the field office level are eligible to retire or will become eligible within the next year.

Contractors are in the same boat. Through our construction monitoring efforts, we have found that inadequate numbers or quality of staffing contribute to low quality in many States. It is that simple. We already know how to build pretty good roads and we are always learning how to do better, but if the staff is not there to implement that knowledge, you cannot get the job done. That is why we have to continue looking for ways to work more effectively with fewer people and to attract more qualified people both to government and industry.

More and better training is one answer. Some have suggested a sort of "merit pay" approach where training and proficiency, instead of just longevity, translate into dollars. Many States participate in certification programs offered by the National Institute for Certification of Engineering Technologies to improve the quality and quantity of engineering services. We have to look at these approaches, and perhaps think of others, to see how we can get better trained personnel.

We have to look at the cost of construction engineering at the same time. This has been a sore spot in a few States already. Under Federal law, we can reimburse the States for construction engineering expenses only up to 15 percent of construction costs. The States have to pick up the tab for anything above 15 percent. This can be a problem on smaller projects. We have also seen problems on some larger projects, such as major new bridge projects, where construction engineering costs have exceeded 15 percent. Further, the use of consultants as construction engineers to supplement reduced agency staff often makes it difficult to stay within the 15-percent limit.

The AASHTO construction subcommittee has thought of one way around this problem. It passes a resolution asking Congress to change the Federal limit to 15 percent of the annual cost of construction for the entire Federal-aid program in the State, rather than for individual projects. Is this the way to go? Are we spending too much on construction engineering? Too little? Would other approaches be better than the subcommittee's recommendation?

We also have to look at contractor claims. They are an inevitable part of the contracting field, but the number of claims continues to increase. We are wasting--to put it bluntly--valuable project time and money defending ourselves, documenting our actions, and trying to avoid claims. Let's face it. A large number of claims could easily be avoided, in part through better design and construction engineering. Another aspect of this is whether construction engineering is technically behind design engineering. As advances occur--CPR, crack and seat, cable-stayed bridges--is the word getting out to construction engineers so they can monitor a construction project properly? Can they build it?

In the area of contractor relations, we want to find ways to reward rather than stifle innovation and quality. From our own experience and from experience in other countries, we can identify several ideas for

exploration. Some of these are not permitted under current law, but maybe the time has come to change the law.

For example, let's take a look at how we award contracts. Most construction contracts are awarded on the basis of low bid. Instead of considering the low-bid award process a sacred cow, maybe we should ask ourselves if low-bid procedures encourage or even tolerate poor or marginal work.

There are alternatives. For example, some States are exploring the possibility of including quality of past work in prequalification requirements. If companies have a history of poor quality work, don't qualify them. Of course, we have to be sure a qualifications-based factor can be administered fairly. Is such a factor practical for national application? We have some experience with qualifications-based selection of consultants. Maybe we can learn from that experience.

Aside from qualifications-based procedures, we can look at bid provisions. For example, we could factor in road user costs in calculating the best, as opposed to the lowest, bid. By using incentive-disincentive clauses related to project completion time, we already have begun to take into account the cost to the community from disruption and detours caused by highway projects. In determining low bid, perhaps we should take into account reduced community disruption, not just the bid amount, if a higher bidder proposes a shorter construction period or a superior traffic management plan. This has been used to a limited extent with some success.

Another approach might be to award contracts based on the design-construct method. This approach has been used successfully in Europe, but in this country, it has been confined mainly to nonhighway contracting. Contractors have a strong incentive to do the job right because they are involved from beginning to end. We may be able to draw on experience, particularly on highway and bridge projects in Europe, to tell us whether this approach would result in innovative practices and better highways and bridges.

Another suggestion involves an idea that is commonly used in other fields, from automobiles to toaster ovens, but is illegal under the Federal-aid highway program. I am referring to the idea of making the contractor fully responsible for maintaining the completed project for a specified time, say 3 to 5 years, after construction. We cannot participate in warranty arrangements because Federal law prohibits us from paying for the maintenance they involve. This concept, however, might give the contractor a strong incentive to do a quality job.

From the other side, are penalties for poor quality sufficient? Are current incentives adequate? Some people feel they are not. On the other hand, maybe this whole idea of the carrot and the stick just doesn't work in our age of litigation. In any event, we have to take a look at which incentives and penalties work, and which do not.

For the long run, as Tom Deen mentioned, the Transportation Research Board has set up a task force on contracting practices to examine the practices under which both U.S. and foreign agencies contract for construction and how these practices affect quality and costs. Dwight Bower is the chairman of the task force, which is scheduled to complete its work in 1990. Construction engineering will be one aspect of the [Task Force's] report.

One result of the State staffing changes I mentioned earlier is a shortage of testing personnel. This shortage puts a premium on cost-effective sampling and testing programs. It also puts pressure on remaining staff, which can lead to lower quality. We must make certain that sampling and testing programs can reliably predict the performance of the end product in a timely manner. Failure to do so is another example of counting staff savings today and overlooking increased costs tomorrow.

This problem is even more serious because contractors are continually improving their methods and equipment to increase production. Testing and controlling must keep up. As agencies require more contractor process control testing, we need a more complete definition of agency acceptance to assure that only specified material is accepted and that State personnel are used more effectively in the acceptance process. Current specifications are geared to major construction, not 4R work. They need to be examined.

Another effect of the shortage of experienced staff is that several states are using consultants for construction engineering and administration. these consultants can do a great job. What I said earlier about quality contractors, however, applies in this area, too. We need assurance that consultant personnel have the vital technical background needed and that they have adequate knowledge of operating procedures and specifications.

One complication in all this is that legislation has taken us away from the days when we considered primarily traditional highway construction concerns, such as geometrics and mix-design. Over the years, legislation has shifted the Federal-aid program more toward social and aesthetic engineering. You can probably tick these off as well as I can--EIS provisions, the DBE program, the Davis-Bacon act, mandatory contract clauses, such as the changed-site provision, and so on. The AASHTO construction committee has passed a resolution citing the detrimental effects of these mandated requirements and strongly opposing such legislation.

Such resolution is fine, but I can tell you from my experience in Washington that this type of requirement is probably here to stay. For our purposes today, it is not important to argue the merits of these requirements or to debate whether their goals could be achieved through voluntary compliance. Our purpose is to see how these requirements are taking up the engineers' time--time that is diverted from quality control of the projects. One area we can explore during this workshop is how to comply with these mandated requirements while still using our resources to ensure that the projects are constructed properly.

I was interested in a recent survey that the AASHTO construction subcommittee conducted. Of 31 States that responded to the survey, 29 indicated that joint training by State, FHWA, and industry personnel could enhance productivity and quality. What is particularly interesting about this result is the high percentage of responding States that agreed with this point. We already are participating in some joint training, but let's explore ways to enhance the three-way partnership approach. What areas would be particularly adaptable to joint training? Who should sponsor the training, government or industry?

Before closing, I want to comment on a few general topics that might be of interest to you. As we approach the 1990's, we are going to have to make some difficult decisions. Some can be made in the context of the 2020/futures initiatives I mentioned at the start of my presentation. One area of great concern, though, is the increasing number of special-interest provisions Congress has been including in recent highway legislation. The 1987 act included 152 so-called "demonstration projects" as well as another species of special interest--the feasibility study. Appropriations acts since then have added to the list. I could talk at length about this development, but I will be brief because I would only be "preaching to the choir." The Federal role should be defined to ensure that our limited resources are distributed in the fairest, most equitable, and least disruptive way possible, not on the basis of political power.

One thing I am sure of--the 2020/futures initiatives are not going to recommend more special-interest demonstration projects. Whether we can switch our program back to the more traditional Federal-State partnership remains to be seen.

Recently, a great deal of the discussion concerning the highway program has been about getting it off-budget. I understand the point, but such discussions are a waste of time in my view. They divert our attention from what should be the real concerns of the Nation's highway managers. These concerns include doing more with less, confronting urban and suburban congestion, keeping the existing system in top shape, and effectively supporting the highway's role as a major factor in our national well-being.

The future highway program must be sold on that basis. There is a continuing struggle for limited resources in the State and Federal legislatures. That is not going to change. How to cut the limited pie--whose program gets the biggest "slice" of the funds is the issue. For all our success, we cannot sit back and wait for pats on the back and more money. We have to compete, and we can prevail only if we provide a top quality product that lasts. I can tell you, premature failures and slipshod work do not win much support. Good, sound, construction engineering is essential to the competition.

As I have indicated, the highway construction industry faces significant challenges. Change is under way, new problems are continuing to present themselves, and many old problems have become both chronic and monumental. Successful resolution of these challenges requires that we all get involved, that all voices be heard.

This workshop brings together 45 experts from all disciplines involved in highway construction. Each of you has been chosen to attend because of the unique contribution you can make. I urge you to participate fully. Your involvement in the open give-and-take over the next 3 days will help guide the research and development effort for the next decade. A lot is riding on you. Good luck.

APPENDIX F: RECOMMENDED PROGRAM OF RESEARCH AND DEVELOPMENT (1979)

The 17 most important research and development needs are as follows:

Priority No. 1: Statement No. QA-2
Title: Cost Effectiveness-Sampling and Testing

Problem: The quantity of sampling and testing is not always commensurate with the cost or importance of the product. Sampling and testing should relate to factors such as initial cost of product, cost of testing, cost of not testing, variability of manufactured or project-produced product, percentage of failures of material tests performed, and criticality of performance, for example, bridge deck failures, bearing pad failures or potholes in pavements. Sampling and testing are very expensive, and programs should be cost effective.

Committee Comments: It is the opinion of the steering committee that this statement addresses factors such as frequency of tests, costs of tests and materials tested, and product variability. QA-16 addresses the need to evaluate materials tests insofar as they are related to material properties and performance. The steering committee also suggests that any researcher study QA-12.

Priority No. 2: Statement No. PC-1
Title: A Study to Redefine the National Transportation Program for the Next 15 years

Problem: In the mid-1950's, a study of future needs was conducted that led the Nation on a course of unified action. A study to integrate all modes of transportation is necessary to prevent waste and overlap while developing or perfecting the system. Every year, when the transportation bill comes before the Congress (from the President), it appears that decisions are made on day-to-day arguments rather than on concise thought-out policies.

Committee Comments: The steering committee suggests that any study contain the consequences of not having a long-range transportation program, such as personnel utilization, prevention of materials shortages, contractor needs, and proper use of subsidies.

Priority No. 3: Statement No. C-1
Title: Construction-Zone Traffic and Safety Problems

Problem: During the reconstruction of existing highway facilities, the problems of handling traffic and providing for the safety of the construction workers and motorists are increased. Present traffic and user practices mandate the need for traffic management studies for each project to ensure safety and minimize delays to users. Guide plans should be developed to aid agencies in satisfactorily conducting these studies.

Committee Comments: The steering committee believes that issuance of regulations, revision of the Manual of Uniform Traffic Control Devices (part 4), current research under way, and expanding training efforts by Federal, State, and local agencies will effectively improve traffic control in construction zones so that objectives 1,2,3, and 5 in the problem statement will be achieved. The steering committee is hopeful that efforts under way will reduce accidents in construction zones, but recognizes that current methods to collect and evaluate accident data are weak. Therefore, research is needed to establish a method to collect and evaluate accident data and to relate these data to the most efficient and effective ways to reduce accidents in work zones.

Priority No. 4: Statement No. I-1
Title: Minority-Business-Enterprise Quota Indemnification by Federal Funds-- Study of Feasibility and Procedures for Implementation

Problem: (a) A statement of the scope of statutory authority is lacking, (b) there is a lack of uniformity in quotas established from State to State and from project to project, and (c) the question of prebid and postaward quality control over subcontractors who are involved solely because of minority business enterprises (MBE) as compared with the type of work to be financed under the most recent Federal legislation. Inflationary costs of MBE regulations should also be studied.

Priority No. 5: Statement No. QA-16
Title: Review of Sampling and Testing Procedures in Regard to Quality of Performance of the End Product

Problem: Many testing and sampling procedures are rooted in tradition and may not be controlling the performance of the end product. Some materials are being undertested and others are being excessively tested without regard to performance-related material properties.

Committee Comments: It is the opinion of the steering committee that this statement addresses the need to evaluate material tests insofar as they are related to material properties and performance, whereas QA-2 addresses other factors such as frequency, costs of materials and tests, and product variability rather than the validity of tests.

Priority No. 6: Statement No. MN-5
Title: Recruiting, Testing, Promoting, and Retaining Qualified Personnel in Highway Construction

Problem: In an era of budget reductions and personnel cutbacks, desirable employees tend to seek other employment. A more definitive program is needed to ensure qualified personnel for larger future programs that will be handled by smaller staffs.

Priority No. 7: Statement No. PC-6
Title: Development of a Preconstruction-Activity Planning and Scheduling System

Problem: Preconstruction is commonly defined as all of the activities completed before a project is let to contract. These activities include design, environmental impact statements, purchase of the right of way, preliminary survey work, programming, and so forth. Each of these activities must be completed before a project is let to contract. Because of various influences, it has always been difficult to forecast an accurate letting schedule for a construction program.

Committee Comments: FHWA proposes to undertake a similar study in the near future.

Priority No. 8: Statement No. I-5
Title: Effect of Nontransportation Programs and Outside Influences on the Design and Construction of Transportation Facilities

Problem: The time and cost to construct transportation facilities has escalated considerably because of outside influences. Can the present situation be improved?

Committee Comments: Based on discussions at the workshops, outside influences include nontransportation-related considerations such as environmental impact statements, U.S. Army Corps of Engineers' 404 permits, archeological studies, national historical registers, Occupational Safety and Health Administration, Environmental Protection Agency, and MBE regulations, and wage rates (Davis-Bacon Act of 1931).

Priority No. 9: Statement No. T-1
Title: Training Certification and Retention of Nonengineering Personnel for Quality Assurance

Problem: There is a need for training packages that include manuals and audiovisual aids for all levels of contractors' and owners' personnel engaged in the quality assurance area of construction management. Standard levels of training for various levels of performance are developed for certain areas only. These developed training courses, some of which require personnel certification, are not being used by all departments of transportation. National agencies or industries are also developing quality assurance certification for program personnel. Coordination of these programs would be beneficial to all involved, including contractors' personnel.

Committee Comments: Discussions in the workshops indicate that the major problem is to retrain trained technicians.

Priority No. 10: Statement No. C-16
Title: Guidelines for Administrative Settlement of Contract Claims

Problem: A simple claim often occurs on a project and is not settled at the various levels from project engineer to chief administrative official. The result is a lengthy and expensive court action.

Committee Comments: The steering committee suggests that early attention to this research would be extremely beneficial to owners and contractors.

Priority No. 11: Statement No. MN-4
Title: Productivity Standards for Construction Engineering Personnel

Problem: There is a need, particularly as the shift occurs from a small number of major Interstate projects to a large number of smaller rehabilitation projects, to achieve better control of the productivity of highway agency personnel.

Committee Comments: The steering committee suggests a review of NCHRP Synthesis 51 (Construction Contract Staffing) and the Pooled-Fund Construction Engineering Manpower Management System Design Manual. The research objectives of this statement have been essentially satisfied. The needs can be met by implementation of the system by interested agencies.

Priority No. 12: Statement No. C-10
Title: Development of Feasible Incentive and Disincentive Contract Provisions Covering Contract Time for Assuring Timely Completion of Projects

Problem: For years, States have had problems in enforcing liquidated damages on highway contracts that involve contractors who do not complete projects within the specified time. For reconstruction, rehabilitation, and resurfacing and bridge replacement programs, early or timely completion of highway construction projects will be required.

Priority No. 13: Statement No. MN-3
Title: Productive Use of Construction Personnel During Off-Peak Seasons

Problem: In northern States, many construction projects shut down during the winter, releasing a large portion of the personnel from construction. Many of these employees are not adequately trained or educated to be absorbed effectively into other department activities.

Priority No. 14: Statement No. T-4
Title: Training Program and Guidelines for Specification Writers

Problem: Ambiguity in specifications is the cause of many construction contract claims. Despite this, little effort in agencies is devoted to training specification writers. Special emphasis is needed on statistical specifications.

Priority No. 15; Statement No. QA-15
Title: Benefits and Disbenefits of Quality Control in Inspection and Testing by the Contractor and Feasibility of Extending Contractor Responsibility for Quality Control

Problem: As with most new programs many contractors and State highway agencies are still rather skeptical about the contractors performing their own quality control or quality assurance programs. This issue has generated much controversy and has polarized opinions, but there are not many facts to support the arguments on either side of the issue. The problems are the lack of definition of terms and the lack of knowledge of benefits obtained (such as cost, ease of contract administration, and speedy construction). Construction engineering costs are only one aspect of the problem. Lack of personnel may be even more critical. State administrators need this information as basic input before deciding which contract administration philosophy is proper.

Priority No. 16: Statement No. QA-6
Title: Development of More Effective Rapid Test Methods and Procedures

Problem: Modern high-production plants and equipment have outdistanced the ability to adequately test and control production. There is a need to provide quick, reliable test results so that the contractor can modify the operation on a timely basis.

Committee Comments: The steering committee suggests that consideration be given to improving tests for durability of concrete, consolidation of plastic concrete, asphalt content, soils densities, smoothness of pavements, and water-to-cement ratios.

Priority No. 17: Statement No. C-17
Title: Identification of Causes of Contract Claims
Problem: Throughout public works, there is a rapidly increasing number of administrative claims and court actions in connection with construction contracts. There is a need to reduce the number of claims.

REFERENCES

1. Research and Development Program for Highway Construction Engineering Management. Executive Summary and Final Report. Report FHWA-HO-79-1. FHWA, U.S. Department of Transportation, May 1979.

2. Research and Development Needs in Construction Engineering Management. NCHRP Project 20-7, Task 26, Final Report. TRB, National Research Council, Washington, DC (unpublished).

3. Research and Development Program for Highway Construction Engineering Management. Executive Summary and Final Report. Table 1, Report FHWA-HO-79-1. FHWA, U.S. Department of Transportation, May 1979.