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CIRCULAR

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RESEARCH PROBLEM STATEMENTS

modes

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2 public transit
3 rail transportation
4 air transportation

subject areas

21 facilities design
22 hydrology and hydraulics
23 environmental design
24 pavement design and performance
25 structures design and performance
31 bituminous materials and mixes
32 cement and concrete
33 construction
34 general materials
35 mineral aggregates
40 maintenance
41 construction and maintenance equipment
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61 soil exploration and classification
62 soil foundations
63 soil and rock mechanics
64 soil science

GENERAL NOTE

This circular supplements Circular 179 dated September 1976 in which 75 priority research needs were identified by thirty-eight of the Group's committees. Although a few statements are repeated in this circular to emphasize their importance as top committee contributions, those remaining in Circular 179 and in Circular 160 are considered by the Group Council to be of current value and worthy of serious consideration for research effort.

INTRODUCTION

An important function of the Transportation Research Board is the stimulation of research toward the solution of problems facing the transportation industry. One of the techniques employed by technical committees in support of this function is the identification of problems and the development and dissemination of research problem statements. The aim of this activity is to provide guidance to financial sponsors such as governmental agencies, research institutions, industry, the academic community, and others in allocating scarce funds and manpower to the solution of transportation problems. The Group 2 Council endorses this activity and has established a Standing Committee on Research Needs to provide guidance and direction to its committees and to coordinate their efforts.

The problem statements in this circular represent a composite of efforts by forty-seven of the Group's committees. They should not be considered an all inclusive recognition of research needs within the scope of Group 2's activities. Since many of the statements may touch upon the scopes of several other elements of the Board, the circular is being distributed to a wide range of interest areas.

PRIORITY RATINGS

In assembling these problem statements the Standing Committee on Research Needs has attempted to develop a best consensus of the top priority research needs. Each contributing committee was asked to identify, by its own method, not more than two problem statements falling in this category. All statements were then screened at the Group Section level for overlap and duplication. Two top priority statements were then chosen from the collective efforts of the section. All problem statements were then submitted to the Standing Committee for final review and processing. As a result of this review and based on the committee and section recommendations the problem statements have been rated in priority categories:

The top priority statements from each section
The top priority statements from each committee
Miscellaneous other statements

Although a diligent effort was made by the committees to examine all pertinent activity related to each problem, it is likely that some current research in progress and recently completed research was overlooked which may have altered the recommended priorities. It should also be noted that subjective evaluation of research needs in which "Urgency," "Relevancy" and "Implementability" were considered, probably created a bias in favor of applied research as opposed to theoretical studies.

While the problem statements have been assigned a number and arranged within categories by alpha-numeric designation of contributing committees, this arrangement does not establish recommended priorities within categories. The ordering of statements under individual committee listings does reflect that committee's evaluation of priorities.

RESEARCH PROBLEM STATEMENTS

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PROBLEM NO. 1 - COMMITTEE A0002

I. NAME OF PROBLEM - DESIGN STANDARDS FOR LOW-VOLUME ROADS

II. THE PROBLEM - The design standards for low volume roads are frequently inappropriate, quite subjective, and cannot be defended scientifically. Most of these standards are extrapolated, projected and rationalized from information developed for and from higher type roads. There is an urgent need to develop roads. There is an urgent need to develop standards and criteria that specifically relate to the design of low volume roads.

There are over 2 million miles of roads in the United States carrying less than 400 ADT. Each year many thousands of miles of low volume roads are added to this extensive system. There are over 30,000 agencies in the United States that are involved with low volume roads. Because of this extreme decentralization, it is difficult, if not impossible, to reliably estimate the total investment or annual expenditures for low volume roads. Nevertheless the United States already has a multibillion dollar investment in its low volume road system. Each year a significant portion of the country's gross national product is committed to the design, construction and administration of low volume roads. It is alarming to contemplate the continuing development of a low volume road transportation system in this country may be based on extrapolated and sometimes irrelevant design criteria and standards. Appropriate design standards should fully recognize the extreme cost sensitivity of low volume roads. The standards need to be not only technically sound but cost effective as well. For example, the following research needs have been identified that relate to design standards. These needs are by no means meant to be all inclusive or comprehensive. They are but the "tip of an iceberg" of research needs for appropriate, technically sound and cost effective design standards for low volume roads.

Level of Service: There is a need for a methodology that relates the selection of the level of service and design speed for a low volume road with the related costs and benefits associated with the selected design

speed and service level.

Geometry: There is a need for determining an optimum turn-out spacing for single lane roads which would be consistent with safety and economy.

There is a need for identifying and quantifying the parameters, such as traffic volume and geometric which require changing from a single lane design to a double lane design.

Hydraulics: There is a need to develop a systematic approach for selecting the design flood frequency for low volume roads which would consider the interrelationship of the costs of various size drainage structures and the costs of interfering with traffic.

Materials: There is a need to evaluate existing highway material specifications to determine whether they are appropriate, relevant and economically feasible for low volume roads.

Pavement: There is a need to develop a pavement thickness design method for specifically determining the thickness of aggregate surfacing and other low type pavements for low volume roads.

There is a need for procedures to (a) evaluate the remaining structural pavement capacity in existing low volume roads and (b) design cost effective surface overlays for such roads.

III. OBJECTIVES -

A. To analyze commonly used design standards for low volume roads with respect to their applicability, technical soundness and cost effectiveness for the low volume road situation. All standards that govern or control low volume road design should be examined, including but not limited to, the standards that affect design speed, road geometry, capacity, surfacing thickness, drainage and materials.

B. To identify those standards that are inappropriate for the low volume road situation.

C. To prepare a systematic approach and methodology for accumulating the necessary information and data base from which new and revised standards can be developed for those present standards that are deemed inappropriate for the low volume road situation.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 15, 22, 23, 25 and 26 have been scanned in preparing this statement.

B. Suggested key words: low volume roads, design standards, design criteria, design speed, design capacity, traffic, road geometry, surfacing thickness, drainage design, and construction materials.

C. Related research activities: No known research activity that is making a unified assessment of the applicability of commonly used standards for low volume roads.

V. URGENCY - The overwhelming majority of roads in the United States are low volume roads. Every day, many more miles of low volume roads are being designed, and built and added to this system. It is urgent that the standards that control or govern the design of these roads be appropriate and cost effective. The existing standards should be analyzed to determine their appropriateness and cost effectiveness. For those standards found to be lacking, steps should be taken to develop the necessary data base and information so that more realistic standards can be developed.

PROBLEM NO. 2 - COMMITTEE A0002

I. NAME OF PROBLEM - SAFETY CRITERIA FOR LOW VOLUME, LOW SPEED ROADS

II. THE PROBLEM - In the United States, the safety criteria for low volume, low speed roads are directly or indirectly traceable to four publications — (1) A Policy on Geometric Design of Rural Highways, AASHTO, 1965, (2) Highway Design of Operational Practices Related to Highway Safety, AASHTO, 1974, (3) Manual of Uniform Traffic Control Devices, FHWA, 1971 and (4) Geometric Design Guide for Local Roads and Streets, AASHTO, 1971. The safety criteria contained in these publications may not be applicable or relevant because low volume, low speed roads are extremely cost sensitive. There is a need to specifically consider the safety requirements for roads carrying very low volumes of traffic at very low design speeds. For example, for a road with a design speed in the range of 10-15 mph and a projected traffic volume of around 100 ADT, a series of simple, direct questions could be asked:

1. How much, if any, clear roadside recovery area is needed?

2. Assuming the road is aggregate surfaced, what factors should be used in determining stopping distances, resistance to skidding and superelevation requirements?

3. What effect, if any, will a rough riding, aggregate surface have on vehicle control and driver safety?

4. What are the warrants and design criteria for installing guardrail, guide posts, and bridge railing? Should they be installed at all? Where?

5. What should the requirements be for installing signs containing warning and regulatory messages? How high should they be? What size? Should break-away signs be required?

Ignoring safety requirements for low volume roads has the potential of wasting the greatest resource of all -- human lives. On the other hand, to impose safety requirements on low volume roads that may be only applicable to higher type roads is wasteful of another important resource -- dollars.

III. OBJECTIVES -

A. To analyze the commonly used existing safety guidelines, standards and requirements with respect to their applicability

and relevancy for roads having extremely low design speeds and traffic volumes. Existing safety guidance will be analyzed to determine whether such guidance is delivering the desired safety performance in a cost effective manner.

B. To identify those safety guidelines, standards and requirements that are deemed inappropriate for low volume, low speed roads.

C. To prepare a systematic approach for accumulating the necessary information and data base from which new or improved safety guidelines, standards and requirements can be developed.

D. To recommend interim safety guidance criteria appropriate for low volume, low speed roads. Final Safety guidance criteria will be developed from the analysis of information collected over a long time basis as shown in Number 3 above.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress area 51 was scanned in preparing this statement.

B. Suggested key words: low volume roads, low speed roads, safety standards, safety criteria, design speed, stopping distance, sight distance, driver response, guardrail, guide posts, bridge railing, fixed objects, roadside recovery area.

C. Related research activities: There is no known research activity which make an overall assessment of the applicability of present-day safety guidelines, standards and requirements for low volume, low speed roads.

V. URGENCY - Imposing high type safety guidelines standards and requirements on roads carrying extremely low volumes of traffic at very low speeds results in expenditures of public funds that may not be cost effective. At the same time, the expenditures may not result in a road having any increased safety history or performance. Yet frequently legal restrictions prevent federal and state participation in low volume road construction or maintenance unless the existing safety standards and requirements are met. It is probable that many millions of taxpayer dollars have been and are continuing to be spent needlessly to achieve inappropriate safety requirements for low volume, low speed roads. It is urgent that this situation be thoroughly analyzed to prevent continued loss of these dollars and to take the necessary steps to produce cost effective safety benefits for low volume, low speed roads.

PROBLEM NO. 3 - COMMITTEE A2A01

I. NAME OF PROBLEM - USE OF TERRESTRIAL PHOTOGRAMMETRIC PROCESSES FOR MONITORING AND MEASURING ROADSIDE IMPROVEMENTS, HAZARDS, AND PROVIDING DESIGN INFORMATION

II. THE PROBLEM - Roadside repairs, improvements, and hazard identification are ongoing requirements that place unusual demands on survey crews and make for difficult design and analysis and program scheduling.

III. OBJECTIVES - To develop terrestrial photogrammetric mapping and other display systems to allow economic, minimum personnel impact, design, and analysis of roadside improvements. Specific areas of study will include backslope failures, roadside hazards, obstruction, and surveillance of non-point source pollutants. Use of techniques to study culvert and bridge entrances and exits. Surveillance of roadside flora to determine condition and losses and provide data needed for replacement plans.

IV. CURRENT ACTIVITIES -

None known at time of proposal. A non-extensive literature search of 1976 ISP proceeding has not revealed any processes directly related.

V. URGENCY - Highway and roadway maintenance is receiving high U. S. priority. This will require more field surveys in areas having high traffic volumes. This will increase cost of field data acquisition and expose personnel to high dangers. In the next three years processes need to be developed to reduce cost and hazards. It is expected that research should be complete in two to three years.

PROBLEM NO. 4 - COMMITTEE A2A01

I. NAME OF PROBLEM - USE OF AERIAL PHOTOGRAPHY AND PHOTOGRAMMETRIC PROCESSES TO MONITOR THE ENVIRONMENT RELATED TO TRANSPORTATION PROJECTS

II. THE PROBLEM - The effect transportation projects have on the environment are very important considerations and certain laws and regulations have to be met.

III. OBJECTIVES - Develop techniques to monitor air and water qualities, vegetation, restoration of base sources and water channels.

IV. CURRENT ACTIVITIES - There is extensive work being done in this area for activities other than transportation which need to be organized and specialized to fit the transportation project process.

V. URGENCY - The current emphasis on the effects of transportation facilities on all aspects of the environment make it imperative that technological capabilities be used to the best advantage. Photography and photogrammetric processes have not been fully utilized in this important area.

PROBLEM NO. 5 - COMMITTEE A2A01

I. NAME OF PROBLEM - AERIAL FREEWAY SURVEILLANCE FOR USE IN DETECTING PAVEMENT DETERIORATION

II. THE PROBLEM - Detection and quantification of pavement deterioration manually using on-the-ground methods can be very hazardous and expensive. There is a need to locate and quantify pavement deterioration from an aerial plattorm to minimize the traffic congestion created by on the ground surveillance.

III. OBJECTIVES - To explore and develop methods of detecting pavement problems and quantify these discrepancies from an aerial platform. This could be done through techniques developed using aerial photography and/or remote sensing scanners tuned to detect these problems.

IV. CURRENT ACTIVITIES -

"C" low level aerial flights have produced encouraging results for detection and quantification of certain types at pavement cracking.

V. URGENCY - This problem is not of a general emergency nature, but the technique would provide a safe and inexpensive means for obtaining information with the minimum exposure to traffic operations

PROBLEM NO. 6 - COMMITTEE A2A01

I. NAME OF PROBLEM - OPTIMUM EQUIPMENT AND METHODS FOR AERIAL SURVEYS BY TRANSPORTATION AGENCIES

II. THE PROBLEM - Agencies are using different flight heights to compile mapping to standard specifications using varying equipment and methods.

III. OBJECTIVES -

The objective is to gather practical information on optimum equipment and methods that should result in compliance with revised Reference Guide Outline (RGO) specifications.

IV. CURRENT ACTIVITIES-

A. Highway Research in Progress (Area 21-Photogrammetry) has been scanned in preparing this statement. (Last published July 1975).

B. Suggested Key Words: Aerotriangulation, Aerial Surveys, Camera Calibration, Digital Cartography, Image Processing, Orthophotos, Photogrammetry, Stereo-comparators, Stereo-plotters, surveying.

C. Many Transportation Departments have made tests of new instruments and technology.

It is the intention of this statement to evaluate alternate systems and make the findings generally known to Transportation Agencies.

V. URGENCY - Pertinent Technology was advancing rapidly during the period when Photogrammetric Activities were initiated in Transportation Agencies. Development has stabilized and Agencies can now reinvest with some assurance that equipment will not be obsolete.

PROBLEM NO. 7 - COMMITTEE A2A02

I. NAME OF PROBLEM - ADDITIONAL THROUGH LANES AT INTERSECTIONS

II. THE PROBLEM - A highway usually has much higher traffic capacity between intersections than it does at signalized at-grade intersections. To utilize the highway capacity between intersections, additional lanes can be provided at intersections. These additional lanes are usually designed for turning movements. However, there are certain situations that may require additional through lanes. There is need for a determination of length of the additional lane, both in advance of and beyond the intersections, to permit safe and efficient flow of through traffic. This determination must be recognized as a separate problem, and not associated with an auxiliary lane as derived in the highway capacity manual. The most uncertain part of the design is what length of lane is required beyond the intersection to provide a satisfactory traffic merge when the added lane is ended.

III. OBJECTIVES -

To make field studies and collect and analyze operational data over a sufficient range of lane lengths and traffic volumes to determine:

A. The required length of extra through lane (including taper requirements) beyond the intersection.

B. The required length of extra through lane (including taper) needed in advance of the intersection.

C. The refinements of the above lane length as they are affected by design speed, profile grade and percent of trucks.

D. The differences, if any, between high volume (peak hour) and low volume (off peak) design requirements.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 22, 51, 52 and 53 have been scanned in preparing this statement.

B. Suggested key words are: geometric design, intersection design, capacity, safety, traffic merge, truck factor.

C. Many studies have been made of traffic capacity at intersections but none to directly apply to this problem.

D. A reprint of "Public Roads" for the August, 1967 and October, 1967 issues provides a theoretical method of determining length requirements of widened intersection approaches in, Part 3 - Special Conditions, but research is needed to verify the suggested design is satisfactory.

V. URGENCY - This project warrants an immediate and high priority because existing highways can be provided with increased capacity at relatively minor cost if the designer is sure this deisgn is safe and efficient.

PROBLEM NO. 8 - COMMITTEE A2A02

I. NAME OF PROBLEM - ARTERIAL STREET WIDTHS

II. THE PROBLEM

The impact of the nationwide program of constructing freeway facilities through and adjacent to urban areas has pointed up the need to provide adequate distributor streets to feed and receive the high volume of traffic involved. Also, in the smaller

communities that do not have freeways or expressways, the arterial street system is relatively even more important because they must perform the dual function of carrying the majority of the traffic and also serve in developing a desirable land-use pattern. Determination of the number of moving lanes for a particular arterial street is only the first step in establishing the proper curb-to-curb street width. Other consideration will involve lane width, and possible provision for left turn lanes and parking. Still another consideration is whether or not to provide an emergency stopping lane (breakdown lane) so that a stalled or disabled vehicle will not block a through lane. These considerations are quite variable and often argumentative. There is a need for the establishment of warrants on which to base the design of these facilities.

III. OBJECTIVES -

Development of a standard evaluation procedure that will permit planners and designers to determine the most satisfactory street cross section for any given set of conditions. The procedure should be an orderly, vigorously defensible, step-by-step consideration of such factors as traffic volume, turning volumes, property values, land use (present and projected), intensity of adjacent development, anticipated posted speed limit, and importance of arterial street.

IV. CURRENT ACTIVITIES -

A. Highway research in areas 15, 22, 53 and 84 have been scanned in preparing this statement.

B. Suggested key words are: arterial streets, geometric design, land use, traffic volume, emergency stopping lane.

C. Some related studies have been made in accident analysis, economics, urban land use, etc., but nothing was found that answers the objective stated above.

V. URGENCY - This project is deserving of a high priority as the movement of traffic in our urban areas is a nationwide problem. An accepted evaluation procedure as called for in this objective would be of tremendous value to urban planners and design personnel.

PROBLEM NO. 9 - COMMITTEE A2A02

I. MINIMUM RAMP PAVEMENT WIDTH REQUIRED

II. THE PROBLEM - Present ramp design practiced nationally is extremely variable. The travelled way varies from 12 feet to 18 feet and the total pavement width (including the paved shoulders) varies from a minimum of 19 feet to a maximum of 30 feet. Also, it is a regrettable fact that highway costs are continuously increasing. Although one major concern of highway design engineers is cost, it should not be considered instead of safety and good engineering principles, but in conjunction with them. Presently there seems to be no data available addressing the problem of excessive and inconsistent ramp widths.

In view of this, there appears to be a need to determine, by a study on a national level, a required minimum ramp pavement width. This minimum width should allow a safe and efficient flow of traffic exiting and entering a major roadway.

The study should consider such factors as (1) pavement width - curvature relationships, (2) comparison of accident data on wide ramps versus narrow ramps, (3) frequency of stalled vehicles on ramps, (4) sound traffic engineering principles and construction economics, (5) the drivers expectability and capability regarding narrower ramps, (6) a clearer interpretation of Table VII-7 (Design Widths of Pavements for Turning Roadways), Page 338 of the 1965 edition of A Policy on Geometric Design of Rural Highways, and (7) paved shoulders on one or both sides.

III. OBJECTIVES -

To determine whether or not any problems would occur with horizontal or vertical alignment.

To determine what percent savings could be realized by using a minimum width ramp.

To determine why a wide ramp is necessary for one-way travel when the majority of the roads are two-way with 12 feet or less lane widths and only a four inch center line separating opposing vehicles. Also, many of these roads have posted speed limits that are the same as interstate highways.

To make field studies and collect and analyze operational data from narrow ramp locations.

To determine the necessity of providing for passing a stalled vehicle on a one-way ramp; or a comparison of paved shoulders versus grass shoulders for passing stalled vehicles.

To determine from a traffic operation, safety, and an economical viewpoint a minimum ramp width within AASHTO requirements that could be used by all states.

To determine how the narrower width ramps would affect the level of service of the ramp proper.

To determine whether or not normal operational features will be diminished.

Uniformity in ramp pavement width from state to state.

To determine whether or not necessary maintenance would be significant.

To determine what effect, if any, a narrower ramp would have on the ramp proper design speed.

IV. CURRENT ACTIVITIES - None

V. URGENCY - The urgency in this problem is a matter of economics. The urgency lies in the fact that the time required for meaningful and productive research into this problem will be lengthy.

PROBLEM NO. 10 - COMMITTEE A2A05

I. NAME OF PROBLEM - VALUE OF THE PSYCHOLOGICAL EFFECT OF VISUAL BARRIERS IN SOLVING NOISE ATTENUATION PROBLEMS

II. THE PROBLEM - There are many instances where fences or plants have been installed to provide privacy for abutting dwellings. Although these screens have not reduced the noise any appreciable amount, the affected resident has reported substantial reduction in noise. Is the "out of sight - out of mind" approach of value in solving the highway noise problem?

III. OBJECTIVES - Determine methods evaluating the psychological effect of visual screens.

Determine if health is truly protected through the use of visual screens which produce a psychological protection from noise.

IV. CURRENT ACTIVITIES -

A. Research in Progress - not determined.

B. Key Words for this problem - Visual, Barriers, Screens, Noise Attenuation, Noise Barriers, Fences, Tree Screens.

C. Related Research Activities: Not determined.

V. URGENCY - If results show that there is true value in providing visual barriers in lieu of more substantial noise barriers, there are many places where planting could be used as a cost-effective method for noise attenuation.

PROBLEM NO. 11 - COMMITTEE A2A05

I. NAME OF PROBLEM - SCENIC HIGHWAY SELECTION CRITERIA

II. THE PROBLEM - It is just a matter of time before the various states will need to identify a scenic highway. The identification should be determined by professional criteria rather than individual opinions. When the need to identify scenic highways occurs the criteria should be available.

III. OBJECTIVES - Develop general criteria for the selection, acquisition of control rights and management of scenic highways.

IV. CURRENT ACTIVITIES -

A. There have been no progress areas scanned in preparing the statement.

B. Suggested key words: aesthetics, inherent natural beauty, scenic easements, corridor environment, and unique.

C. Although there is no knowledge of a concentrated national approach to solving this problem, it is understood that several states have addressed themselves to the subject. The State of California had published a guide to scenic roads and the United States Forest Service published a technical bulletin relative to scenic highways.

V. URGENCY - The Federal Highway Administration on several occasions has alluded to a scenic highway program. This timely study would prepare the various states for such a program in addition to satisfying the numerous references towards scenic highways found in other transportation related programs.

PROBLEM NO. 12 - COMMITTEE A2A05

I. NAME OF PROBLEM - USE OF LANDSCAPE PLANTS BY WILDLIFE

II. THE PROBLEM - There is a great potential for highway rights-of-way to support populations of birds and small mammals. The importance of this habitat is greatest in urban and agricultural areas where little natural habitat exists. In urban areas large areas of rights-of-way are landscaped. In developing a landscape plan usually the wildlife potential is ignored.

III. OBJECTIVES - To determine the use of selected landscape plant species by wildlife. Research will not only consider their use for food and shelter, but optimum planting design.

IV. CURRENT ACTIVITIES -

No highway research has been conducted in this area.

V. URGENCY - Millions of dollars are spent annually in landscaping. Little or no consideration is given to the wildlife value of the plants. Proper right-of-way management should include consideration of this important aspect, especially in light of the importance of highway rights-of-way for wildlife.

PROBLEM NO. 13 - COMMITTEE A2A05

I. NAME OF PROBLEM - EVALUATION OF PLANTS FOR CITY STREETS AND REQUIREMENTS FOR HEALTHY SURVIVAL

II. THE PROBLEM - Harsh city environment requires special characteristics in trees and special planting methods. There seems to be a lack of dependable guidelines for selection and establishment of street trees which will remain healthy under City conditions.

III. OBJECTIVES -

Study of methods, materials and results of street tree planting in City environment. Recommend on regional basis, plant lists and planting methods for establishing trees in adverse City conditions. A synthesis of existing documents should be examined for a possible solution to the problem.

IV. CURRENT ACTIVITIES -

A. Research in progress - Not known

B. Suggested Key Words - Urban, Street Tree, Planting.

C. Related research activities - Not known

V. URGENCY - The results of this research could be used to advantage as soon as completed. There is a good possibility that the results would lead to immediate savings related to

improved cost-effectiveness.

PROBLEM NO. 14 - COMMITTEE A2A05

I. NAME OF PROBLEM - AESTHETIC IMPROVEMENT OF RAILROAD R.O.W. AND RELATED AREAS

II. THE PROBLEM - The view from passenger trains passing through many urban areas is of deteriorated, rubbish strewn back yards, vacant lots and commercial or industrial areas. Such conditions do not encourage the use of mass transit. Ways to improve the visual quality of the Railroad environment should be researched.

III. OBJECTIVES -

1. Determine scope of the problem.
2. Determine if there are legal means to clean up and otherwise improve deteriorated areas viewed from the train.
3. Determine how the proposed improvements can be financed.
4. Determine if enabling legislation is needed.
5. Determine feasibility of accomplishing the work through local clean-up - fix-up campaigns versus public funding or combination of both.

IV. CURRENT ACTIVITIES -

A. Research in Progress - not determined.

B. Key words for this problem: Railroad, Esthetics, Visual Improvement.

C. There has been much written about the visual improvement of the highway environment but little or nothing about the railroad environment.

V. URGENCY - Conserving energy has a high priority. If improving railroad transportation is an important energy conservation measure, it would seem that research leading to better railroads would have a high priority.

PROBLEM NO. 15 - COMMITTEE A2A05

I. NAME OF PROBLEM - ESTABLISHMENT OF MARSHES AS A MITIGATIVE TECHNIQUE

II. THE PROBLEM - The value of wetland systems has been established, and their protection mandated. Often, however, it is impossible to construct a highway which will not impinge upon a wetland. One mitigative technique employed is the construction of a new section of wetland. Little is known on how, when, where, and under what circumstances to build a new wetland.

III. OBJECTIVE - Develop a manual which fully outlines when construction of a new wetland is appropriate, how to construct it, and what needs to be considered before beginning. This needs to be done for all coastal and inland areas of the United States.

IV. CURRENT ACTIVITIES - Related research has been conducted on methods of propagating various wetland species. Consideration is currently being given to develop a regional training course on establishment of wetlands in Region 3. This material will be applicable primarily to the mid-Atlantic States. *

PROBLEM NO. 16 - COMMITTEE A2B01

I. NAME OF PROBLEM - STRUCTURAL OPTIMIZATION OF PAVEMENT CROSS SECTIONS

II. THE PROBLEM - Deterioration of highway pavements, in many instances, develops initially along the edges of the pavement and on the wheel paths. This deterioration develops because of adverse load placement and distribution conditions and inherent weaknesses in the pavement along the edges. The concentration of wheel loads along the pavement edges results in high stresses in the concrete and foundation, and oftentimes nonuniform support to the slab because of pumping which results in cracking and faulting along the edges while other areas of the cross section may be structurally sound.

III. OBJECTIVES - The objective of the research is to develop methodology which will provide equal service life over the full pavement cross section. Specific objectives are to evaluate the effects of load placement, shoulders, proper drainage across the section, nonuniform slab and/or base thickness, reinforcement in specified areas, and variable traffic distribution.

IV. CURRENT ACTIVITIES -

A. The U. S. Army Corps of Engineers Waterways Experiment Station currently has a project sponsored by the Federal Highway Administration to evaluate the effects on load placement, pavement cross sections, and traffic distributions on pavement performance (deterioration).

B. Suggested key words: Highway pavements, rigid pavements, structural design, performance, deterioration, cracking, pumping, fatigue, traffic distribution, load placement.

V. URGENCY - This study is considered important and of immediate value because of the deterioration of the interstate system and the need to rehabilitate this system in a fashion which will preclude development of similar deterioration. In addition, the need exists to fully utilize the entire pavement structure to avoid wastes of natural and monetary resources.

PROBLEM NO. 17 - COMMITTEE A2B01

I. NAME OF PROBLEM - EFFECTS OF AND PREVENTIVE MEASURES FOR NONUNIFORM FOUNDATION SUPPORT FOR RIGID PAVEMENT SLABS

II. THE PROBLEM - Distress in rigid pavement can be related to the nonuniformity of support for the slabs resulting from such phenomena as warping or curling of the slabs, localized weakening of the foundation materials due to

* See addendum p. 79

moisture, freezing and thawing, etc., differential subgrade movements, and erosion of foundation material due to pumping action. Since most, if not all, current design procedures assume uniform foundation support for thickness designs, the nonuniformity that develops results in premature slab cracking and/or unacceptable roughness requiring excessive maintenance or early rehabilitation.

III. OBJECTIVES - The objectives of this research are to assess the effects of nonuniform foundation support on rigid pavement performance and to develop methods for either preventing the occurrence of nonuniform support and/or consideration of the effects of nonuniform support in determination of the thickness of rigid pavement which will yield the desired performance.

IV. CURRENT ACTIVITIES -

A. Highway research in progress has already been scanned in preparing this statement.

B. Suggested key words: rigid pavements, distress, foundation support, warping, curling, pumping.

C. Several projects are determining the performance of rigid pavements and assessing both their structural and functional conditions; however, little, if anything, is being done to determine how much of the adverse performance is attributable to nonuniform foundation support. In addition, only limited work has been accomplished to identify the sizes of voids in pavements and to introduce methodology which will recognize and account for nonuniform foundation support in design procedures.

V. URGENCY - The study on nonuniform foundation support for rigid pavements is considered highly important to the development of designs which will have higher probability of planned performance and thus savings of maintenance or rehabilitation resources.

PROBLEM NO. 18 - COMMITTEE A2B02

I. NAME OF PROBLEM - RENEWABLE PAVEMENT SURFACES

II. THE PROBLEM - Many pavements are experiencing surface distress due to traffic loads, wear, polishing, and environmental effects. These surface distresses may be in the form of slick surfaces, inadequate texture, rutting, cracking and weathered paving materials. In many cases the remaining portion of the pavement is structurally adequate and only the surfacing needs some form of rehabilitation. Current emphasis on recycling has provided a viable alternative to additional overlays. There are a variety of recycling methods and these are bound to change in the future. The problem is how to design pavements to adequately take forecasted traffic and still afford the opportunity for renewing the surface by recycling or other methods. The need is to plan the surface restoration at the time of the initial pavement design and construction. The same need applies to future restorations at the time of reconstruction or major rehabilitation.

III. OBJECTIVES - The objectives of this study will be to develop design and construction procedures for renewable pavement surfaces which will provide long term structural capability while allowing the pavement surface to be renewed/recycled/rehabilitated at appropriate intervals.

IV. CURRENT ACTIVITIES -

A variety of ongoing work relates to the study of renewable pavement surfaces, but each is attacking only a single element of the problem. This work includes activities related to recycling (FHWA Demonstration Projects, NCHRP 1-17, etc.), overlay design (FHWA and many State highway departments) and flexible pavement research in general.

Suggested key words: pavement surfacing, surface rehabilitation, renewable surface, surface recycling, surface distress.

V. URGENCY - This study is considered important and of immediate value because of current interest in pavement recycling as well as pavement rehabilitation and the 3R program.

PROBLEM NO. 19 - COMMITTEE A2B02

I. NAME OF PROBLEM - FLEXIBLE PAVEMENT STRUCTURAL DESIGN REQUIREMENTS FOR LOW-VOLUME ROADS

II. THE PROBLEM - There are no flexible pavement design procedures that have been specifically tailored for low-volume roads. Those in use today were developed for higher-volume highways and are intended to determine the design required to provide satisfactory service for a specific period of time with only minor structural maintenance. These procedures are being extended to low-volume roads which constitute the majority of the total highway mileage but are funded at a lower level than most highway systems. Concern has been expressed that current procedures tend to overdesign pavements for low-volume roads relative to the overall needs and available funds. Because of the low traffic volumes, many believe that lower levels of service can be tolerated and, accordingly, more structural maintenance can be performed during the pavement service life on low-volume roads than on higher-trafficked highways, which will permit stretching the available dollars to more miles of roads to better meet the overall needs. Support for this belief is expressed by the practice of many local agencies in utilizing stage construction in the design of new roads and tending to postpone indefinitely the construction of the second stage.

III. OBJECTIVES - The objectives of this study are to determine satisfactory levels of service for low-volume roads that are consistent with the needs and available funds, and to establish criteria that can be used to either modify existing methods or develop new flexible pavement structural design methods specifically tailored to the needs of low-volume roads. *

* See addendum p. 79

PROBLEM NO. 20 - COMMITTEE A2B03

I. NAME OF PROBLEM - FIELD VERIFICATION OF MECHANISTIC REHABILITATION MODELS

II. THE PROBLEM - Various new mechanistic pavement rehabilitation models have been developed for both flexible and rigid pavements. Verification of these models would be aided by the development of field studies to provide essential feedback information.

III. OBJECTIVES - The objective is to develop a data base which can be used to verify, check and/or calibrate mechanistic rehabilitation design models for flexible and rigid pavements. Specific objectives include the application of these models, acquisition of the required data for such applications, comparison with other models and a follow-up of observed performance and behavior.

IV. CURRENT ACTIVITIES -

A. Current FHWA FCP includes a single contract to compare a mechanistic model for flexible pavements with other methods.

B. Suggested key words: pavement rehabilitation, mechanistic models, rigid pavement, flexible pavement.

V. URGENCY - The study is considered highly important to the actual implementation of mechanistic design methods. There is a national need for pavement rehabilitation design criteria with heavy emphasis on maintaining a level of service on the nations highway systems. Similarly this data is needed from airfield pavements.

PROBLEM NO. 21 - COMMITTEE A2B03

I. NAME OF PROBLEM - STRUCTURAL EVALUATION FOR OVERLAY DESIGN USING NONDESTRUCTIVE TESTING

II. THE PROBLEM - The evaluation of the in situ condition of existing pavement is required for overlay design. Modern nondestructive testing methods need to be evaluated to provide condition and behavior of the existing pavement and also provide a basis for determining inputs to overlay design models.

III. OBJECTIVES - The objective is to develop methods whereby nondestructive testing procedures can be used to determine in-place pavement condition and behavior. Specific objectives might include evaluation of relative performance of rigid pavement joints, development of in-place materials properties for use in rehabilitation design models, and diagnosis of other pavement structural problems.

IV. CURRENT ACTIVITIES -

A. Many agencies currently use nondestructive testing as a method of pavement inventory. The FHWA has developed a new dynamic deflection device which may offer new potential in relating other existing devices such as the Road Rater, Dynaflect, or Benkelman Beam. Heavy load deflection devices are in use and under development by the U.S. Army Waterways Experiment station.

B. Suggested key words: deflection, nondestructive testing, pavement evaluation, pavement condition evaluation.

V. URGENCY - The study is considered important and of immediate value because so many agencies are already involved in nondestructive testing evaluation of pavements. Also this program would provide very essential input data to pavement rehabilitation design methods and procedures.

PROBLEM NO. 22 - COMMITTEE A2B05

I. NAME OF PROBLEM - GUIDELINES FOR ESTABLISHING A PAVEMENT PERFORMANCE INFORMATION AND INTELLIGENCE SYSTEM

II. THE PROBLEM - pavement performance data, information, and intelligence are of paramount importance in decision-making related to the programming of rehabilitation and major maintenance, in the establishment of structural design methods, criteria, and policy, and in evaluating the levels-of-service provided by the highway network links. "Rational" management requires that all levels of management have available to them at the time it is needed not only the facts, but data which has been translated into usable information. Intelligence gained from the data through summary reports and various analyses can provide guidance for future actions.

Typically, in addition to performance data, a highway agency collects tremendous quantities of other data concerning contract execution, quality control, material and subgrade properties, traffic, and various other physical parameters, part of which can enhance the value of the performance data. Invariably, items of data are collected which are not relevant to the topic of performance, and often after a number of years data tends to be lost or is destroyed. An organized method is needed for the collection, storage, retrieval, analysis, and reporting of performance information. To be cost-effective, the information system must be restricted to only those items of data and only in such quantity as is needed to provide adequate coverage of performance and relevant other data. It seems clear however, that if other collected data not now considered to be relevant, are referenced by means of a common location referencing system, such data can be captured at any future time with a minimum of effort. A common location reference system provides essential flexibility in data retrieval and information processing. It is realized that because of differences in organizational structure, it is difficult to formulate one single pavement performance information system which will satisfy the requirements of individual agencies. Thus guidelines are needed which identify those items of data which are believed to concern performance, which define the timing and extent of data collection, which provide recommendations for system of data storage, up-dating, and retrieval, and which outlines those analysis procedures which yield useful and meaningful management information and intelligence.

This effort can perhaps be considered as a scaling-up of the ability of a single small township engineer to make decisions on the basis of his intimate knowledge of each piece of road, its performance over the years, together with all other factors, costs, manpower, etc.

III. OBJECTIVES - So that guidelines for establishing a pavement performance information and intelligence system can be formulated with confidence, the following tasks must be completed:

1. Review the literature and compile a list of material attributes or properties, construction, maintenance, traffic, environment, roadway geometrics, pavement structure, response to load, distress manifestations, riding comfort or serviceability, and other parameters which may influence pavement performance and/or management decisions on pavements. Describe for comparison, material on current agency practices in collecting, storing and retrieving data.

2. Identify and classify those items believed to be essential and relevant to a design/performance feedback system, and those which have bearing on management decision-making with respect to pavements.

3. Recommend where applicable, how, when, and at what frequency, to obtain the minimum amount of data which could fulfill the requirements of the objectives.

4. Recommend efficient and practical information system procedures based upon a co-ordinated location referencing system for collecting, recording, editing, up-dating, retrieving and reporting on data items. Where practical, make recommendations for automated data handling techniques. Suggest hardware and software packages.

5. Suggest methods of analysis and reporting which could provide feedback to "fine-tune" pavement design practices, and which could provide useful and meaningful information and intelligence for management decision-making. Develop a detailed concept of a Data/Inquiry Handling System to incorporate these suggestions.

6. Illustrate quantitatively through practical examples the benefits which stem from possession of such a system. Information exchange between agencies would become practical by wide use of standardized terminology, data collection and retrieval techniques.

7. Suggest methods for system evaluation through feedback.

IV. CURRENT ACTIVITIES -

Many states, notably Texas, Utah, Washington, California, and Ontario, either have a computerized information system, or have a system under development. There is a formidable amount of published information on how pavement performance and pavement distress is measured, on pavement materials parameters which are related to performance, on traffic load and on climatic effects as they relate to performance. There are numerous texts on information systems.

V. URGENCY - The potential of a performance information system cannot be fully exploited until that system has been fed with a great deal of historical pavement data. As well, since such a system will in effect be replacing an existing method of recording data, there is a period when both systems must exist side by side. This situation will exist until data retrieval from the new system is as easy, quicker and more complete than formerly.

In spite of these drawbacks, the potential benefits in such an investment should be attractive enough so that immediate implementation becomes essential.

PROBLEM NO. 23 - COMMITTEE A2B05

I. NAME OF PROBLEM - GUIDELINES FOR CONTROL AND ACCEPTANCE OF PAVEMENT RIDE QUALITY

II. THE PROBLEM - Research Problem Statement: There is mounting evidence that both maintenance and road user costs of highway pavements are related to the ride quality of those pavements. Other factors being equal, it can be assumed that pavements constructed with good ride quality will retain relatively better ride quality than pavements constructed rough. Therefore, pavements built with good ride quality should have relatively lower levels of maintenance and user costs for the life of the pavements.

There is little or no agreement within the highway industry as to how ride quality should be specified, how it should be controlled by the contractor, and how it should be accepted by the specifying agency. Many agencies have straightedge requirements on surface tolerances. These requirements, however, have not been shown to be directly related to ride quality as measured by most modern roughness measuring devices. Some agencies have instituted specifications where acceptance is based on the achievement of some minimum level of roughness as determined by a passenger car mounted device. At least two problems arise with these specifications: (1) the contractor has no way of knowing whether or not he is meeting the specification until after the fact, i.e., no good control method exists, (2) poor reproducibility of test results, particularly between supposedly identical devices, may mean that the accepting agency has a low level of confidence in its test results. It is anticipated that appropriate study would lead to the development of workable guide specifications for pavement ride quality.

III. OBJECTIVES - The objective of the research is to develop a workable guide specification for pavement ride quality. Such a specification would identify the parameters to be specified, the methods of contractor

control, and the approach to agency acceptance. It is anticipated that the specification itself would be of the end result type. Among the specific research activities one could define for the project are:

1. A literature search of the construction and rehabilitation factors influencing pavement ride quality.

2. The identification of methods whereby contractors can control the ride quality of pavements they construct or rehabilitate.

3. To assess the types of economically feasible equipment available for the determination of ride quality.

4. The identification of an acceptable level of ride quality.

5. The development of an appropriate specification with price adjustment factors, if appropriate. It is anticipated that price adjustment factors might be related to projected increase in maintenance or user costs as ride quality deteriorates below acceptable levels.

IV. URGENCY - Many highway agencies could make immediate use of the results of this project if successfully completed.

PROBLEM NO. 24 - COMMITTEE A2C01

I. NAME OF PROBLEM - ACQUISITION OF DATA ON CYCLIC STRESSES IN RAILROAD BRIDGES

II. THE PROBLEM - In order to provide a design methodology for railroad bridges, both analytical and experimental techniques for predicting the loading history and the resulting stress history of railroad bridges from samples of current loading are needed.

III. OBJECTIVES - The major objectives are:

1. To compile a state of art review of existing stress history data from the United States and abroad so that the trends and characteristics of the stress range frequency distribution and the cycles for train passage can be identified.

2. Develop a program for acquiring the stress history of a number of bridge elements identified as critical when subjected to current load conditions.

3. Evaluate the data acquired so that characteristic stress history-frequency distribution curves can be developed for the typical types of main load carrying and auxiliary load carrying members in railroad bridges.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas are not applicable to this problem.

B. Suggested key words: cyclic loading, stress history, railroad bridges.

C. Some work on this problem has been done in recent years by the Canadian National Railways. Other recent studies have been undertaken in Europe under the auspices of the Organization of the European Railroads.

V. URGENCY - Recent developments in new cars and train loadings, the use of higher strength steels, and new welded bridge designs which are lighter than the old rivoted structures may have resulted in substantial changes between the calculated design stress and the actual stress spectrum to which a railroad bridge is subjected. The response of older structures to new cars and train loadings needs further definition and there is an urgent need to acquire additional information on the stress range spectrum that is imposed on various railroad bridge components.

PROBLEM NO. 25 - COMMITTEE A2C01

I. NAME OF PROBLEM - SURVEY OF CHARACTERISTICS OF OVERLOADED AND OVERSIZED HIGHWAY VEHICLES

II. THE PROBLEM - There has been an increase in the use of overloaded and oversized vehicles in the transportation network. Furthermore, some of the vehicles that used to be considered as overloaded and/or oversized, that required permit applications, no longer require them due to the legal across the board increase in limits. This increase has been dictated because of the economical advantages that the larger vehicles offer. It will be prudent to expect that there may be requests in the near future for additional increases in the limits. Frequency of the traverse of the overloaded and/or oversized vehicles has not been compiled on a nationwide basis. The effect of these vehicles on the deterioration of the transportation network has not been quantitatively defined, regardless of how approximate it may be.

III. OBJECTIVES - The research is intended to provide a compilation of the pertinent characteristics of the oversized, and overloaded vehicles such as the dimensions, axle weights, axle spacings, number of wheels per axle. The information is to be provided by the Departments of Transportation, carriers, and the field observations that have been made. The vehicles are to be grouped depending upon their pertinent characteristics, and the frequency of travel of these vehicles is to be determined. With available methodology, what type of vehicles should be considered as severely effecting the safety of the transportation network and its operation is to be determined.

IV. A. Currently research is being conducted, and some has been completed, in a number of institutions such as Lehigh University, Case Western Reserve University, etc. Most "districts" of the states have been compiling information on overloaded and oversized vehicles. The predictions on the frequency of travel of these vehicles and the economic impact of the vehicles have already been completed by Roy Jorgensen and

Associates, and Western Highway Institute, amongst many others.

B. Suggested key words: overloaded vehicles, oversized vehicles, permit operations, bridge and pavement deterioration, safety.

V. URGENCY - In view of the use of different design standards by different states and the interstate nature of the problem, and especially because of the recent increases in the permissible limits, it is essential that the effects of these be both qualitatively and quantitatively defined, where possible. The recent increases and especially the future increases may grossly alter the safety and rate of deterioration of the highway system. This issue is widely known and has been reported in the media.

PROBLEM NO. 26 - COMMITTEE A2C01

I. NAME OF PROBLEM - SERVICEABILITY LIMITS FOR HIGHWAY BRIDGES

II. THE PROBLEM - Highway bridges need continuous maintenance, repair, and replacement. Uniform qualitative and quantitative criteria for the identification of the deteriorated components of the superstructure, and the amount of the deterioration, are not available. In view of the urgent need for bridge rehabilitation programs that may be implemented in the near future, it is essential that guidelines as such be developed through the integration of the contributions of the Departments of Transportations, reflecting their practices, and of the available research findings and field observations.

III. OBJECTIVES - The objective of the research is to develop broad based guidelines that can be used in the definition of the components of highway bridges that are in some state of distress and the extent of the deterioration towards the assignment of priorities in bridge rehabilitation. The research is to be confined to steel, reinforced or prestressed concrete bridges, or their combination thereof, with deck and girder systems.

IV. CURRENT ACTIVITIES -

A. There have been various research projects completed, being executed, and envisioned by research institutions. There also exist, to varying extents, guidelines that are being employed by the Departments of Transportation. The findings, however, have not been available in a unified form.

B. Key words: bridge superstructures, serviceability limits, deterioration, rehabilitation.

V. URGENCY - In view of the recent public cognizance of the distressed state of highway bridges, initiation of a nationwide bridge rehabilitation program is expected. A unified national effort will require the availability of guidelines that can be used for the identification of the bridges that need rehabilitation, and the urgency for any given bridge. To expedite these multibillion dollars worth of activities initiation and completion of the proposed research is imperative.

PROBLEM NO. 27 - COMMITTEE A2C01

I. NAME OF PROBLEM - DEVELOPMENT OF CONCISE CRITERIA FOR DETERMINING HIGHWAY BRIDGE DECK ACCEPTABILITY

II. THE PROBLEM - A massive national effort is about to be launched to rehabilitate or replace a major portion of the Nation's bridges -- and the methods for determining whether or not a deck is acceptable have not been clearly defined. As a result, public agencies consider themselves forced to engage in exhaustive tests before making a decision. The value and applicability of many of these tests, which are available for use on specific structures, has not been determined on the basis of an overall review.

III. OBJECTIVE - The objective is to develop a definitive statement relevant to this problem, so that future decisions to rehabilitate or replace a particular concrete bridge deck can be made in a minimum amount of time, utilizing a minimum of indicated test procedures.

IV. CURRENT ACTIVITIES -

Highway Research in Progress has not been investigated due to the lack of time available for preparing this statement. It is clear, however, that many research projects relating to the problem have been completed, or are in the process of being completed -- but the problem itself has not been addressed by a committee such as a TRB Committee which could formulate a procedure which could have a substantially-beneficial impact on this national problem were it adopted by other technical groups and public agencies.

V. URGENCY - Because of the rapidly-escalating effort to improve the condition of this Country's bridges, it is considered urgent that a criteria be developed such as that suggested in this statement.

PROBLEM NO. 28 - COMMITTEE A2C01

I. NAME OF PROBLEM - EFFECTIVENESS OF WATERPROOFING IN ARRESTING HIGHWAY BRIDGE DECK DETERIORATION

II. THE PROBLEM - Many engineers believe that bridge deck deterioration due to corrosion of embedded reinforcing steel is arrestable by the application of a waterproofing layer such as a high-density concrete overlay -- which, while permitting water vapor to escape, prevents water and deicing salts from continuing to penetrate the structural slab. There has been no definitive research to indicate whether or not such waterproofing will arrest concrete bridge deck deterioration once that deterioration has actually begun, if in fact a waterproofing system is developed which is truly "waterproof."

III. OBJECTIVE - The objective is to develop -- on a partially-deteriorated concrete deck -- a conclusive demonstration for two types of waterproofing (one which permits the passage of water vapor, and one which does not) to determine whether or not the deck deterioration continues or is arrested, in order that

the deck may remain in service. The development of specific techniques and products to achieve the result is another matter and has been the subject of much research, but a clarification of the result that could be expected has not been achieved.

IV. CURRENT ACTIVITIES -

Highway Research in Progress has not been investigated due to a lack of time available for preparing this statement. It is not believed, however, that the basic question has been undertaken: whether or not preventing moisture from continuing to reach a damaged structural slab will arrest further deterioration.

V. URGENCY - Because of the rapidly-escalating effort to improve the condition of this Country's bridges, it is considered urgent to develop a solution to the basic question posed in this statement. The question of the effectiveness of various waterproofing techniques has been researched without addressing the suggested basic question.

PROBLEM NO. 29 - COMMITTEE A2C02

I. NAME OF PROBLEM - INTERACTION OF BRACING AND SECONDARY MEMBERS WITH MAIN BRIDGE COMPONENTS

II. THE PROBLEM - Various assumptions made in bridge design are not born out by the actual bridge response. Recent experience indicates the need to more realistically predict loads and stresses in secondary members and what effect the secondary members have on load distribution to and stresses in main members. An additional critical consideration is the effect of displacements caused by secondary members on the main members.

Bridge specifications require various types of secondary members to resist wind and lateral loads. The secondary members are not counted upon in the analysis for primary loads. Furthermore, they may be responsible for displacement induced stresses that are not accounted for in the design.

III. 1. To study the need for secondary members and the results of designing a bridge with some or all secondary members omitted.

2. Develop an analytical model to predict the three dimensional response and load distribution with secondary member effects included.

3. Conduct laboratory and field experiments to verify the model.

4. Prepare design recommendations on the need for secondary members and how to fully utilize them in the design of steel bridges.

The main emphasis should be on composite and noncomposite girder bridge systems.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress Area 27 has been scanned in preparing this statement.

B. Suggested key words: load distribution, secondary members, girder bridges, loads and stresses.

C. Many projects have been undertaken to determine the cause of distress in main components in specific bridges which appear to be related to the effect of secondary members. Minimal additional studies have been undertaken on the beneficial effects of secondary members. There have been no studies of the effect of reducing or eliminating secondary members. None of the previous work has been general or systematic enough to produce meaningful analytical models or design recommendations.

V. URGENCY - Many recent failures of bridge components have been attributed to loads and stresses carried by secondary members which were not accounted for in design. Guidelines are urgently needed for the design of new bridges and for maintenance of existing structures.

PROBLEM NO. 30 - COMMITTEE A2C02

I. NAME OF PROBLEM - DESIGN LOADS FOR LONG SPAN STRUCTURES

II. THE PROBLEM - Current bridge design specifications account inadequately for the load spectrum of current and future highway traffic. This is particularly true for longer span structures where the current design lane loadings may not be an acceptable approximation of the actual loading which the structure will have to support.

III. OBJECTIVES -

The objective is to adequately define current and future load spectra and their probabilities for various structural limit states, in particular the loading for static strength and the spectra of load for repetitive considerations and other service conditions.

The spectra and their frequency of occurrence should be compared to current design practices and new design recommendations should be developed.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress Area 27 has been scanned in preparing this statement.

B. Key words: loads, spectrum & probabilities, frequency of occurrence, bridges, static and repetitive load criteria.

C. There have been a number of projects which have attempted to measure the weights of vehicles travelling the highway system.

V. URGENCY - Years of research have been devoted to the behavior of structural members, but very little has been done in determining the true loads which a bridge will be subjected to. This is particularly urgent in light of the increasing trend to greater legal load limits nationwide. Current design loads were developed over 30 years ago and no longer are applicable to our current and future highway system.

PROBLEM NO. 31 - COMMITTEE A2C02

I. NAME OF PROBLEM - MODULAR SHORT TO MEDIUM SPAN STEEL BRIDGES

II. THE PROBLEM - Because steel bridges represent less of the short to intermediate span bridge market now than was previously the case, transportation facilities may bear the future burden of less competition between steel and concrete which can result in higher costs for these bridges.

The problems that apparently exist are as follows:

1. Designers may erroneously conclude, in some cases, that a steel bridge will not be competitive; as a result of this opinion, will not consider steel as a solution or an alternate solution to their spanning problems.

2. Steel bridges may be less competitive because their components are fabricated in shops, then shipped unassembled to the site where they are assembled on the supports and a form constructed for placing reinforcing bars and pouring the concrete bridge deck. In contrast, concrete bridges are being fabricated into one or more entire bridge segments of full length which are shipped to the site and erected adjacent to another one or more elements completing the bridge except for placing a wearing course on the bridge deck.

III. NEED

1. It is proposed that literature be researched and steel bridge designs be reviewed to insure that the simplest, best designs are being employed for steel bridges in the short to intermediate span range which will make them the most economical. This review should also include the objective of encouraging design engineers to base their conclusions about the least cost material for a particular structure on relevant current facts related to competitive bidding. Some designers may conclude that steel bridges are not competitive in the short to medium span range and will not consider steel as a solution when in fact it might prove to be the most economical

2. New methods of constructing steel bridges should be studied with the objective of minimizing cost and time. This study should include the fabrication of preassembled bridge sections shipped from the fabricating plant to the site for the erection of one or more elements into the completed structure, needing only the placing of a deck wearing course. Also, both concrete and metal decks should be considered in the study.

When one or more proposed design methods are developed, funds should be made available to fabricate, ship, and erect the one which appears to offer the best potential for economy in a test and development program. The results and potential economies should then be published to the steel fabricating industry and bridge design engineers so that the economical benefits can be realized for transportation facilities through the benefit of improved competition.

IV. URGENCY - This work can result in considerable savings in time and costs for the transportation industry and the greatest benefits and savings can accrue the sooner that this work is undertaken.

PROBLEM NO. 32 - COMMITTEE A2C03

I. NAME OF PROBLEM - EVALUATION OF TIME DEPENDENT STRESSES IN SEGMENTAL BRIDGES

II. THE PROBLEM - Segmental concrete bridges are being constructed with increasing frequency in the United States. The analysis of these bridges for time-dependent conditions is highly complex, and it is often accomplished using computer programs of obscure origin and with unknown limitations. Consistency of these programs with current AASHTO and FHWA requirements is sometimes conjectural. As an example, however, determination of tension across joints is extremely critical.

III. OBJECTIVES - The objective of this research project is to develop analytical techniques for analysis of time dependent stresses in segmental bridges that are fully consistent with current AASHTO and FHWA requirements and which also are readily useable by transportation agencies or their consultants.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas: (unknown).

B. Suggested key words: analysis, design, segmental construction, bridges, time-dependent behavior, stresses, joints.

C. Related research activities: research at the University of Texas on the Corpus Christi bridge.

V. URGENCY - It is believed that the successful completion of this project would be of considerable value to transportation agencies.

A. General estimate of cost: $100,000

PROBLEM NO. 33 - COMMITTEE A2C03

I. NAME OF PROBLEM - FATIQUE STRENGTH OF BENT BARS IN CONCRETE BEAMS

II. THE PROBLEM - Bent bars, embedded within concrete beams having a spread V-shape in elevation, have been shown to have a considerably decreased fatique strength from that of straight reinforcing bars. It is not clear whether this reduction in fatigue is primarily due to the bending of the test bars or due to the test method. However, the test method used did not realistically represent the stress conditions to which a bent up bar in a reinforced concrete beam might be subjected.

III. OBJECTIVES - To determine the effect of cyclic stressing on bent up reinforcing bars. Furthermore, such an investigation would determine the relative susceptibility to fatigue fracture of the bent up and continuing reinforcement, as the latter will ordinarily be subjected to higher stresses.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress area 27 has been scanned in preparing this statement.

B. Beams, dynamic loads; fatigue, (materials); loads (forces) reinforced concrete; reinforcing steels; stresses.

C. NCHRP Projects HR4-7 and HR4-7/1 entitled "Fatigue Strength of High Yield Reinforcing Bars."

V. URGENCY - The project would show if bent bars in beams are more susceptible to fatigue fracture than straight bars. The findings might be implemented through code specifications.

PROBLEM NO. 34 - COMMITTEE A2C03

I. NAME OF PROBLEM - EFFECT OF TRAFFIC ON SETTING CONCRETE

II. THE PROBLEM - Widening and concrete overlaying of bridge decks often must be done while traffic is maintained on adjacent lanes. There is uncertainty as to how damaging traffic is to setting concrete. There have been no quantitative assessments of the effects of deflection and vibration due to maintain traffic on the strength and durability of concrete. An expensive and sometimes dangerous alternative to maintained traffic is the use of median cross-overs.

III. OBJECTIVES -

To determine the effect of deflection and vibration during placement and curing of concrete on compressive strength, tensile strength, bond strength and freeze-thaw durability, over a wide range of deflection and vibration.

IV. CURRENT ACTIVITIES -

None to the proposer's knowledge.

V. URGENCY - Much present-day highway construction, particularly on the interstate system, consists of widening of bridges to accommodate greater traffic volumes, and overlaying existing decks with latex modified or low slump concrete to effect a durable repair of premature disintegration. The longevity of this work could be increased or the cost reduced by the implementation of the findings of the proposed research.

PROBLEM NO. 35 - COMMITTEE A2C03

I. NAME OF PROBLEM - CORROSION OF TENDONS IN PRESTRESSED CONCRETE STRUCTURES

II. THE PROBLEM - Tendons embedded in prestressed beams were considered adequately protected against corrosion. Observation of older structures has revealed that moisture did infiltrate dense concrete cover and did penetrate along the tendons if exposed or through cracks in concrete cover in the beam end faces.

III. OBJECTIVES - To determine corrosion rates of tendons when protected by concrete, grouts, sheathings. To determine the remaining life of such tendons, the corrosion rate of such tendons and the allowable residual life (corrosion/pitting) of such tendons affected. Study effect of corrosion on failure due to stress corrosion and fatigue. Determine ways to prevent further moisture infiltration.

IV. CURRENT ACTIVITIES -

Some state of the art work is reported in the NCHRP Report 90 (1970).

V. URGENCY - To prevent cumulative damage of corroded tendons and entire structures this problem deserves immediate attention. Increasing age of P/S structures makes this an urgent problem.

PROBLEM NO. 36 - COMMITTEE A2C03

I. NAME OF PROBLEM - FATIGUE STRENGTH OF PRESTRESSING STRAND

II. THE PROBLEM - The acceptance of prestressed concrete where cracking is permitted under service load conditions has led to the need to consider fatigue in the design of the prestressing steel. Although some fatigue data is available for North American prestressing strand, further test is required to support realistic design criteria for the economical use of prestressing strand.

III. OBJECTIVES -

To gather fatigue test data for prestressing strand in an experiment designed and executed to permit a valid statistical appraisal of the factors influencing fatigue.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 27 and 32 have been scanned in preparing this statement.

B. Beams (supports); cracking, dynamic loads, fatigue (materials); loads (forces); prestressed concrete; prestressing steels; stresses; structural design.

C. Previous work at Lehigh and Iowa State Universities, and the Portland Cement Association Laboratories.

V. URGENCY - As the trend towards strength design procedures continues, the importance of fatigue consideration in design is becoming increasingly important. This program would lead to the establishment of a fatigue limit for all types of prestressing strand available in North America. Recent test results indicate that this problem should be classified as urgent.

PROBLEM NO. 37 - COMMITTEE A2C03

I. NAME OF PROBLEM - DESIGN CRITERIA FOR SHORT SPAN PRECAST BRIDGES

II. THE PROBLEM - State, county and other local transportation agencies are finding that use of standard precast concrete beams is an expedient means of reconstructing short span bridges on low volume roads. However, when these beams are designed using procedures applicable to long span, high volume bridges, unforeseen problems have been encountered.

For example, it is frequently considered desirable to construct short span bridges without a cast-in-place topping. In this case use of an allowable tensile stress of up to $6\sqrt{f_c}$ in the top fibers of prestressed precast beams is highly inappropriate, especially if deicing salts are applied to the surface. Development of criteria for limiting top fiber stress is urgently needed for these situations. As another example, it is considered unlikely that existing criteria for transverse load distribution are fully applicable to the wide range of precast beams that are potentially useful for short span bridges.

III. OBJECTIVES -

The goals of this research project should include:

A. A limited survey to evaluate problems that have been encountered in the design of short span bridges.

B. Critical review of the primary design provisions applicable to any precast box, tee, I, or other shape used in short span bridges.

C. Development of design criteria to assist transportation officials in obtaining cost effective short span bridges.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas: (unknown).

B. Suggested key words: design, short span, precast, flexure, shear, torsion, load distribution, allowable stress.

C. Related research activities: unknown

V. URGENCY - It is believed that a number of transportation agencies have encountered unexpected problems in the use of short span precast bridges. The successful completion of this project should be of assistance to these agencies, and therefore it is considered to be urgently needed.

A. General estimate of cost: $75,000.00

PROBLEM NO. 38 - COMMITTEE A2C03

I. NAME OF PROBLEM - JOINT DETAILS FOR DROP-IN PRECAST BRIDGE BEAMS

II. THE PROBLEM - In the reconstruction or rehabilitation of secondary bridges, it is sometimes desirable to use a drop-in precast member. The ends of these members may be dapped, to fit the matching construction. Current design procedures for details of the ends of dapped beams appear to be unduly conservative, and frequently lead to designs with highly congested reinforcement.

III. OBJECTIVE - The objective of this research is to develop improved design procedures applicable to dapped ends of precast bridge beams. The research is expected to include a literature review, experimental work, and development of design provisions.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas: (unknown).

B. Suggested key words: precast beams, dapped beams, design, details, testing, shear.

C. Related research activities: there is substantial previous research on beams with dapped ends as well as brackets and corbels that should be relevant to this project.

V. URGENCY - Although the subject of this research is probably of lesser importance, it is believed that its successful completion may open up new and improved applications of precast members to secondary bridges.

A. General estimate of cost: $100,000

PROBLEM NO. 39 - COMMITTEE A2C03

I. NAME OF PROBLEM - LONG-TIME FATIGUE OF STEEL REINFORCEMENT IN CONCRETE BEAMS

II. THE PROBLEM - During NCHRP Projects 4-7 and 4-7/1 entitled "Fatigue Strength of High Yield Reinforcing Bars," it was found that considerable scatter in test results existed about the mean fatigue limit at 5 million cycles. Following completion of the NCHRP test program, two preliminary fatigue tests were carried out at stress ranges 2 and 4 ksi below the mean fatigue limit at 5 million cycles. Fatigue fracture of the test bars occurred after 31 and 352 million cycles, respectively. During the life expectancy of a bridge, this number of repeated loadings could occur and bar fracture would result.

III. OBJECTIVE - To determine the long-time fatigue properties of Grade 60 reinforcing bars at stress ranges near the fatigue limit.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress area 27 has been scanned in preparing this statement.

B. Fatigue (materials) loads (forces); reinforced concrete reinforcing steels; specifications; stresses; structural design.

C. NCHRP Projects HR4-7 and HR4-7/1 "Fatigue Strength of High Yield Reinforcing Bars." Cement Research at Portland Cement Association.

V. URGENCY - A procedure to establish a practical fatigue design limit would be established. This work is required since highway bridge designers have expressed concern about recent AASHTO specifications regarding fatigue stresses in reinforcing bars.

PROBLEM NO. 40 - COMMITTEE A2C03

I. NAME OF PROBLEM - FATIGUE STRENGTH OF REINFORCING BARS AT BAR CUT OFF LOCATIONS

II. THE PROBLEM - Current highway bridge specifications limit the service load stress range to which a reinforcing bar may be subjected. Often, compliance with these requirements necessitates the extension of bar cut off locations beyond those selected to satisfy Load Factor moment capacity. This is due to the high stress range calculated in the remaining bars at the theoretical moment capacity bar cutoff location. However, each bar to be cut off would be continued a sufficient distance beyond the theoretical cut off point to allow for full development of the bar. Thus, at the theoretical bar cut off location, the actual stresses in the remaining bars are considerably lower than calculated.

III. OBJECTIVES - To determine the fatigue susceptibility of the remaining bars at a theoretical bar cut off location.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress area 27 has been scanned in preparing this statement.

B. Dynamic loads; fatigue (materials); loads (forces); reinforced concrete; reinforcing steels; specifications; structural design.

C. NCHRP Projects HR4-7 and HR4-7/1, Fatigue Strength of High Yield Reinforcing Bars.

V. URGENCY - The research findings would be implemented through recommended specifications to AASHTO. The results from this research could result in savings in steel reinforcement at bar cut off locations.

PROBLEM NO. 41 - COMMITTEE A2C04

I. NAME OF PROBLEM - LACK OF SYSTEMATIC DATA GATHERING AND RECORDING OF STRUCTURAL BEHAVIOR AND DURABILITY OF TUNNELS IN SOFT GROUND AND IN ROCK

II. THE PROBLEM - The engineering design of a tunnel normally must be based upon a number of assumptions, including the specific type of the selected tunnel lining and the lining response. The selection of the lining material and details is made to achieve maximum durability and minimum maintenance. Generally, it appears there is a lack of satisfactory historical feedback to the designer of structural behavior and the integrity of the tunnel lining so that upgrading future designs is difficult.

III. OBJECTIVES -

The objective is to develop a scope and the methodology for obtaining data on the structural and maintenance histories from tunnels (to be constructed in the future). Such a program would require the recording of geological and construction conditions, instrumentation of the tunnel linings, systematic measuring observations and recording over a number of years.

IV. CURRENT ACTIVITIES -

A. Highway research in progress - unknown.

B. Suggested key words: tunnel lining, instrumentation, geological and construction condition recording and reporting durability, maintenance.

C. Some tunnels have been instrumented with the objective of obtaining structural information. It appears difficult to obtain comprehensive data of or from such cases for a variety of reasons and there is virtually no information available on maintenance requirements.

V. URGENCY - Owing to the large numbers of tunnels likely to be constructed by the transportation industry in the fairly near future and the economic implications, it is believed this program should be implemented as soon as possible.

PROBLEM NO. 42 - COMMITTEE A2C04

I. NAME OF PROBLEM - DESIGN EFFECTIVENESS OF UNDERGROUND TRANSPORTATION STRUCTURES

II. THE PROBLEM - Ignorance of the industry in the need to educate decision-makers and designers as to the availability, effective application, and relative costs and benefits of alternative technologies; and as to the long-term performance of the alternatives in comparison to existing practices.

III. OBJECTIVES - The development of more economical designs achieved through effective consideration of construction, operational and other problems given inadequate attention in current practice, such as standardization, constructability, labor practices, flexibility to minimize changes, and operational and maintenance problems.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress Areas NA have been scanned in preparing this statement.

B. Suggested key words: design, alternatives, cost/benefit, standardization, labor, constructability.

C. There is no known research being conducted in this area.

V. URGENCY - The rapidly increasing cost of constructing urban transportation systems must be reversed if transportation needs of the U. S. are to be met in a timely manner. Lack of design effectiveness is a major part of these increased costs and must be improved.

PROBLEM NO. 43 - COMMITTEE A2C04

I. NAME OF PROBLEM - INCENTIVES FOR INNOVATIVE

DESIGNS IN UNDERGROUND TRANSPORTATION STRUCTURES

II. THE PROBLEM - Accelerating trends toward litigation, coupled with ever broadening definitions of liability and damages, are creating a deteriorating climate for innovation and for implementation of research results.

III. OBJECTIVES - To determine what can be done to provide a more favorable climate for innovation in design through the elimination of risk and development of incentives for designers of underground transportation structures.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress Areas NA have been scanned in preparing this statement.

B. Suggested key words: design, risk, liability, innovation, implementation.

C. There is no known research being done in this area.

V. URGENCY - The risk and liability involved in innovative design is perhaps the most important factor in the lack of implementation of research results and the reduction of cost of construction of transportation systems.

PROBLEM NO. 44 - COMMITTEE A2C04

I. NAME OF PROBLEM - PRE-CONTRACT PREPARATION FOR UNDERGROUND TRANSPORTATION STRUCTURES

II. THE PROBLEM - Design decisions have a tremendous impact on construction and operation costs, and contractual arrangements should assure that construction and operations thinking is strongly injected in the conceptual, preliminary, and detail design processes.

III. OBJECTIVES -

The objective is to develop techniques and practices to be applied in pre-construction phases to eliminate or minimize delays and higher costs during construction.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress Areas NA have been scanned in preparing this statement.

B. Suggested key words: design, pre-contract, cost, decision-making.

C. There is no known research being done in this area.

V. URGENCY - Research is needed to create the environment and the techniques for better decision-making at the very early stages due to the greater effect on total costs of early decisions than later decisions.

PROBLEM NO. 45 - COMMITTEE A2C04

I. NAME OF PROBLEM - DESIGN COORDINATION IN UNDERGROUND TRANSPORTATION CONSTRUCTION

II. THE PROBLEM - Current design practices do not stress the need for political and administrative considerations in selecting designers (general consultants and/or section designers), recognize the interface problems between sections done by different designers, rely on construction and operations input into the design process, evaluate productivity at the design stages, and for continuity from one project to another.

III. OBJECTIVES - To determine procedures for providing a more favorable climate for achieving closer coordination in design and for assuring recognition of needs for coordination between designers and contractors.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress Areas NA have been scanned in preparing this statement.

B. Suggested key words: design, coordination.

C. There is no known research being conducted in this area.

V. URGENCY - Significant savings in the cost of constructing transportation systems can be achieved through closer coordination of design between designer and designer and between designer and contractor, and through the continuity from project to project. No formalized procedure exists for this type of construction.

PROBLEM NO. 46 - COMMITTEE A2C04

I. NAME OF PROBLEM - A CASE HISTORY REVIEW OF THE CONSTRUCTION DESIGN OF URBAN TUNNEL PROJECTS

II. THE PROBLEM - Each major subway construction project in the United States involves significant case history information which could be used as a unique and cost-saving learning tool. However, little effort has been made to document this information, in particular, the reasons for major decisions which impact design or construction. We may know that "such and such" a method or design parameter was used, but we do not know why. Because many external constraints bear on such decisions it is well that we know the rationale for them so that they will not be improperly perpetuated as "established precedent rules." Thus far, little has been done from BART or WMATA work to build a learning curve.

It is suggested that a detailed case history review of major BART and WMATA projects be made before it is too late to find principal engineers involved in the projects. This would serve as a useful base for any engineer to use in preparing plans and designs for future projects.

III. OBJECTIVES - The objectives of the work would be -

A. Collect and document essential technical data for significant case histories for BART and WMATA.

B. Interview personnel involved in the major design and construction decisions. Establish reasons for the major decisions.

C. Formulate a concise and useful format so that the case studies can be readily used by future engineers faced with similar problems.

IV. CURRENT ACTIVITIES -

An initial step in this direction is underway in a Federal Highways sponsored contract with Delon Hampton Associates of Silver Spring, Maryland. A more extensive effort could be made, especially directed towards the BART work.

V. URGENCY - This task is urgent since the design engineers and contractors involved in the work on BART and WMATA are becoming further removed from the projects each day. Some major figures have already passed away or retired.

PROBLEM NO. 47 - COMMITTEE A2C04

I. NAME OF PROBLEM - FULL SCALE NON-DESTRUCTIVE TESTS OF SUNKEN TUBE UNITS

II. THE PROBLEM - The following areas of trench tunnel design merit research that could lead to reductions in material costs and construction time. Much of our knowledge in design in this field is based on practical experience and extrapolation of small scale laboratory tests and theoretical formulae. Of necessity, designs have been conservative.

Limited tests on full scale steel tube tunnel sections have indicated strengths far in excess of those predicted by theory. We therefore propose that provisions be made in future construction contracts for testing full scale structures in the following areas:

1. The bond stress between the interior structural concrete lining and the exterior structural steel shell plate, which for in situ conditions are assumed to act compositely.

2. In situ loading conditions on the tunnel structure due to backfill and water pressures.

3. Stresses in the concrete lining and the steel shell due to actual measured external applied loads obtained from (2).

4. Stresses in the steel shell during fabrication, launching and outfitting-with particular attention to actual buckling forces.

5. Develop a past history and collect data on future projects based on field records of strength of subgrade soils, depth of dredging, depth, type of foundation course material and gradation and method of placement.

6. Establishment of tube foundation criteria to determine the conditions for screeded or pumped soil support; pile bents or other means of support.

III. OBJECTIVES -

The objective is to develop definitive design criteria substantiated by full scale tests that would eliminate excessively conservative assumptions resulting in construction economies.

CURRENT ACTIVITIES -

A. Research in progress - None.

B. Suggested key words: sunken tube tunnels, trench construction.

C. There is no related research work in progress.

URGENCY - Moderate.

PROBLEM NO. 48 - COMMITTEE A2C04

I. NAME OF PROBLEM - CONTRIBUTION OF DAYLIGHT TO THE ILLUMINATION INSIDE THE TUNNEL PORTAL

II. THE PROBLEM - To establish by calculation and by the aid of a model the factors which influence the contribution of the daylight inside the portal of a tunnel such as: width and height of the portal, level of illumination outside the portal, clear or cloudy weather, angle of the portal with the vertical, angle of the roadway with the horizontal, orientation of the portal, the latitude, the time of the day, etc.

III. OBJECTIVES -

A. Find all causes which can influence the illumination from daylight inside the portal.

B. Evaluate analytically the influence of each of these causes.

C. Establish factors for each cause related to the daylight immediately outside the portal.

D. Verify these factors experimentally with a model.

E. Produce curves to show relation of these factors to the depth of penetration of light inside the portal.

IV. CURRENT ACTIVITIES -

A. Research in progess is unknown.

B. Suggested key words: tunnel portal illumination, illumination tunnels.

C. Related research activities are unknown.

V. URGENCY - Moderate.

PROBLEM NO. 49 - COMMITTEE A2C04

I. NAME OF PROBLEM - TUNNEL VENTILATION CAPACITY STUDY

II. THE PROBLEM - This study is made to answer the question "Have Past Vehicular Tunnel Ventilation Systems Been Overdesigned?" A recent FHWA Office of Research Study recommends including piston effect ventilation as part of the dilution ventilation required to control contaminant concentrations. A survey of use of ventilation capacity in some of the heavily used vehicular tunnels to determine if the original design, which did not allow credit

for piston effect ventilation, provides capacity in excess of actual need. Survey should also investigate other operating or special conditions in each tunnel effecting use of ventilation capacity.

III. OBJECTIVES -

This survey would provide information on actual ventilation capacity useage in tunnels that operate many hours per day at maximum traffic flow. Since all of the ventilation systems studied were originally designed on the same basis, the need for and actual use of maximum ventilation capacity should provide information as to the appropriateness of the original design capacity calculations.

IV. CURRENT ACTIVITIES -

A. FHWA Study Aerodynamics and Air Quality Management of Highway Tunnels.

B. Suggested Words-Vehicular Tunnel Ventilation use of maximum capacity.

V. URGENCY - Survey and Study should be completed by October 1978.

PROBLEM NO. 50 - COMMITTEE A2C04

I. NAME OF PROBLEM - VENTILATION REQUIREMENTS FOR SHORT TUNNELS

II. THE PROBLEM - The need for mechanical ventilation in short tunnels is determined subjectively instead of analytically especially in the preliminary design stages. The decision is determined by the designer's experience and expertise. The degree "experience and expertise" in this area is generally quite limited in the profession.

III. OBJECTIVES -

Develop parameters of factors that affect air quality in tunnels and a criteria to assist designers in making decisions as to the need of mechanical ventilation.

IV. CURRENT ACTIVITIES - Unknown.

Suggest key words: tunnels, ventilation.

V. URGENCY - Moderate.

PROBLEM NO. 51 - COMMITTEE A2C04

I. NAME OF PROBLEM - ADVANTAGES AND DISADVANTAGES OF A MONOCHROMATIC LIGHT VS OTHER TYPES OF LIGHTING SUCH AS: MERCURY, FLUORESCENT AND INCANDESCENT

II. THE PROBLEM - To find out if a monochromatic light has advantages or disadvantages over the other types of lights related to the visibility such as: definition of the objects, retention of the image, sharp image a low level of illumination and other causes and to establish ratio factors for different types of lighting at different levels of illumination.

III. OBJECTIVES -

A. Cumulate information available on the subject.

B. Incorporate, by research, other information to complete the documentation.

C. Establish ratio factors for different types of lighting at different levels of illumination.

D. Confirm these factors by laboratory experience.

IV. CURRENT ACTIVITIES -

A. Research in progress is unknown.

B. Suggested key words: tunnel lighting, monochromatic light, mercury light, fluorescent light, incandescent light.

C. Related research activities are unknown.

V. URGENCY - Moderate.

PROBLEM NO. 52 - COMMITTEE A2C04

I. NAME OF PROBLEM - TUNNEL LINER DESIGN CRITERIA

II. THE PROBLEM - Tunnel liners are presently designed by different criteria depending upon whether they are classified as flexible liners or as rigid liners. Flexible liners are usually designed for a (1) hoop force which is a function of the overburden plus (2) an additional hoop force and moment which are computed from the liner deadload as well as interior road-bed dead and live loads plus (3) an additional moment determined by an arbitrary diameter change. The arbitrary diameter change is a function of the material being tunneled through, surcharge loads and other anomalies such as adjacent tunnels, etc. Rigid liners are designed as rigid buried structures using at-rest earth pressures, actual surcharge loads, etc. The two approaches are completely different. The problem arises in the distinction between flexible and rigid liners. There is no design criteria available for transition from one type of design to the other. Also, there is no quantitative criteria for defining which linings are flexible and which are rigid.

III. OBJECTIVES -

Develop consistent tunnel liner design criteria for both flexible and rigid liners that permit a smooth and logical transition from one type of desigh to the other.

IV. CURRENT ACTIVITIES -

A. Research in progress - Unknown.

B. Suggest key words: tunnel liners, flexible liners, rigid liners, design criteria.

C. There is no related research work in progress.

V. URGENCY - Moderate. Tunnel are designed differently throughout the U.S.A. due to lack of an authoritative design criteria. Because of this, some designers are overly conservative while others may be unsafe.

PROBLEM NO. 53 - COMMITTEE A2C04

I. NAME OF PROBLEM - LACK OF ADEQUATE LOAD DATA FOR ROCK TUNNEL SUPPORTS DESIGN

II. THE PROBLEM - The magnitude of the rock load that is transmitted to a tunnel support is dependent upon the geology encountered; diameter of tunnel; excavation methods and sequence; support systems and sequence of installation. For many design projects satisfactory data on these items is not available.

III. OBJECTIVES -

The objective is to develop specific loading data to permit economic design of tunnel. Load data should include the principle rock types and geological formations likely to be penetrated by transportation tunnels and oriented to a range of tunnel diameters and support systems.

IV. CURRENT ACTIVITIES -

A. Highway research in progress - unknown.

B. Suggested key words: rock deformation, strain/stress relaxation, rockbolts, shotcrete steel sets, finite element and other analysis methods.

C. Considerable interest in this subject is being evinced in by engineers in this country and abroad. It is apparent that a certain amount of useful data covering several aspects of rock support design has been developed for specific situations.

V. URGENCY - The development of rock loading data is deemed essential for the design of economic tunnel supports.

PROBLEM NO. 54 - COMMITTEE A2C04

I. NAME OF PROBLEM - DESIGN CRITERIA - SOFT GROUND TUNNELS

II. THE PROBLEM - Design criteria for soft ground tunnels vary from design engineer and do not result in the most economical construction methods. Too often newer and more economical procedures are not used because of reluctance "to be first" or due to lack of "tunnel knowledge."

III. CURRENT ACTIVITIES -

A. Some work being done on an individual basis as well as at some universities.

B. Suggested key words: soft ground tunneling - criteria.

IV. URGENCY -

Design criteria for soft ground tunnels is necessary to standardize on design procedures, resulting in lower costs in underground construction. This would benefit transportation, utilities, and water and sewer projects.

PROBLEM NO. 55 - COMMITTEE A2C04

I. NAME OF PROBLEM - EARTH PRESSURES ON RIGID BRACED COFFERDAM WALLS

II. THE PROBLEM - While there is a reasonable amount of field measurements available for earth pressures on flexible braced cofferdam walls, there is a limited amount available for rigid braced cofferdam walls. This lack of data prevents development of simple conservative design earth pressure loading diagrams similar to the ones that exist for flexible braced cofferdam walls. At the present time, it is not known whether assumed design loading conditions are either conservative or unsafe.

III. OBJECTIVES -

Establish a program to obtain a reservoir of empirical data on values and distribution of earth pressures on rigid braced cofferdam walls. From this data develop design earth pressure loading diagrams.

IV. CURRENT ACTIVITIES -

A. Research in progress - limited data is being obtained on selected projects but there is no comprehensive program using consistent methods of measurement with uniform full coverage of wall areas.

B. Suggested key words: slurry wall, diaphragm wall, earth pressures, field measurements.

C. Related research activities are being made in the area of theoretical parameter studies and into theoretical research into constitutive models of the soil mass for use in finite element solutions to determine earth pressures.

V. URGENCY - Critical, since measurements must be made on actual projects presently being planned or in the initial stages of construction.

PROBLEM NO. 56 - COMMITTEE A2C04

I. NAME OF PROBLEM - EVALUATION OF THE BEHAVIOR OF CEMENTED SOILS

II. THE PROBLEM - Non-cemented soils and clays can present difficulties in tunneling, however, these difficulties can usually be anticipated since the behavior of these soils is well known. On the other hand, lightly cemented and slightly cohesive sands or silts pose problems which are not well defined because:

1. The performance of a tunnel in these soils is highly dependent upon type of construction procedure and water conditions. Cementation can easily be destroyed by improper tunneling or handling of ground water, thus leading to a drastic decrease in tunneling productivity.

2. The degree of cementation or cohesiveness is often variable along the

length of the tunnel as well as across its section.

3. Present testing and sampling procedures are not properly designed to evaluate cementation and, in fact, usually underestimate the degree of the effect. Existing procedures usually destroy cementation.

4. Classification techniques for soils and rocks do not address themselves to cemented soils since they are usually too strong to be called soils but too weak to be called rock.

   Large classes of soils fall into the lightly cemented soil category. Residual soils in areas such as Baltimore and Atlanta are examples as are the sands of the Los Angeles Basin.

III. OBJECTIVES -

Objectives of the research should be to achieve the following:

1. Develop a proper means of sampling or testing cemented or slightly cohesive sands or silts so as to adequately preserve cementation effects.

2. Formulate a classification system for the cemented soils directed towards the likely performance in tunneling.

3. Document the sensitivity of various cementing agents to breakdown under various tunneling conditions.

4. Document case history performance in cemented soils.

IV. CURRENT ACTIVITIES -

There is no current research activity in this area although consultants for the Baltimore subway system are addressing the special problems of cemented soil description for the Baltimore subway.

V. URGENCY - Because of a concentration of new subway construction into urban areas where large deposits of cemented soils are found (Baltimore, Atlanta, Los Angeles) the urgency of the research is high. It is a long neglected area which needs clarification for contractor and design engineer alike.

PROBLEM NO. 57 - COMMITTEE A2C04

I. NAME OF PROBLEM - STUDIES OF USE OF SMALLER SUBWAY CARS

II. THE PROBLEM - The Consulting Engineer who has been chosen to plan and design a brand new subway for small or medium sized cities must, the very first thing he does, select a subway car suitable for the projected passenger load.

The smaller the car selected the smaller the subway tubes can be, and the less they will cost the owner. Cost is now all important, particularly as a result of the over-runs on BART and WMATA. A number of American cities have recently abandoned plans for Rapid Transit Systems because of the extremely high estimates of final costs.

Both BART and WMATA have selected a subway car with a width of 10-ft 6-in. Chicago's subway cars are 9-ft 4-in. Those of PATH (the old Hudson & Manhattan) are 9-ft 2½-in wide. Montreal's cars are 8-ft 3-in wide but they are mounted on rubber tires.

The cars for BART and WMATA require a tunnel 16-ft 6-in I.D. A tunnel suitable for the Montreal car would require 14-ft 6-in I.D. By adopting this smaller car there is a savings of about 15% in excavation and about 10% in the cost of primary lining, based on a circular tunnel. This saving applies to EVERY LINEAL FOOT of tunnel built.

This same savings would apply to subways built by cut-and-cover and open-cut methods. This same savings would apply to the stations. The car requires two-foot less width and the platforms might be two-foot narrower. By adopting a narrower car the engineer is saving about 20% for the owners. Again I repeat, this applies to every lineal foot of the subway and to every station, no matter how built.

CAR DESIGN: Once the Consulting Engineer has decided on the width and height of car he should call in the sales engineer for the subway car builders, one at a time, to find out what is available. I am reasonably sure that these salesmen will tell the engineer that the savings on narrower cars would be almost nil. In fact, they might cost slightly more. But the savings to the owner will be based on every lineal foot of tunnel or box section built, and the additional cost of the smaller car will be insignificant.

The length of the subway car may vary from 50-ft to 90-ft. The length of the car governs the minimum radius, or vice-a-versa, the sharpest curve governs the car length. If the curves must be sharp, the engineer might specify "married pairs."

CAR MANUFACTURERS: The cost of a brand new subway is roughly 70% for the tunnels and stations and 30% for the cars, controls and track. The complaints that arise after a subway is completed are based almost entirely on malfunction of the cars and controls.

The builders of subway and rapid transit cars have apparently fallen on evil days. The Car Builder Cyclopedia (16th Edition: 1943) lists six manufacturers who are ready, willing and able to build rapid transit cars. The 20th Edition of this same book (1957) shows five.

Yet when BART decided to purchase their 350 cars the low bidder was a new firm from the aerospace industry. This same company later received an order from WMATA for 300 cars. In the meantime BART entered suit against the car manufacturer for $41 million because of defects and malfunction of the cars and the controls.

MARTA (Atlanta) has placed an order for 100 cars with a French manufacturer whose price was 30% lower than any American. Since no cars have yet been delivered, we don't know whether these cars and their controls are superior to the American cars.

The U.S. must maintain a healthy car building industry. It is recommended that a committee be set up to make an informal survey of all American car builders, past and present, to find out why they refuse to quote on Rapid Transit Cars. Perhaps there is feeling within the industry that specifications are too complex and that the electronic control systems are under-tested, thus opening the door to expensive lawsuits.

III. OBJECTIVES -

The objective is to determine the availability of smaller subway cars from existing manufacturers as well as the potential availability from new firms that would enter the market if the marketing conditions were favorable.

IV. CURRENT ACTIVITIES -

A. Research in progress - none

B. Suggested key words: subway cars, car builder, car manufacturer.

C. There are no related research activities in progress.

V. URGENCY - Moderate. The urgency is governed by the potential for new city systems.

PROBLEM NO. 58 - COMMITTEE A2C04

I. NAME OF PROBLEM - DEVELOP SUGGESTED STANDARDS FOR DESIGN AND CONSTRUCTION GEOLOGICAL RECORDING PROCEDURES

II. THE PROBLEM - Everyone seems to agree that better prediction of geologic conditions is one of the keys to improved tunneling, but because the problem is so complex we only talk about it. Establishing some standard methods of recording geologic facts would be a first step in this work.

III. OBJECTIVES -

Development of a standard method of recording and documenting geological conditions.

IV. CURRENT ACTIVITIES -

A. Research in progress - unknown.

B. Suggested key words: standards, geological conditions, recording methods.

C. Related research activities - unknown.

V. URGENCY - The task is urgent. The sooner a standard procedure is implemented, the better.

PROBLEM NO. 59 - COMMITTEE A2C04

I. NAME OF PROBLEM - DESIGN STANDARDS FOR ROCK BOLT REINFORCEMENT SYSTEMS

II. THE PROBLEM - Standard methods for rock bolt design should be established so that designers and contractors have some norm to which they can compare a required support system.

III. OBJECTIVES -

Development of design criteria for rock bolts.

IV. CURRENT ACTIVITIES -

A. Research in progress - unknown.

B. Suggested key words: design criteria, rock bolts, tunnel support systems.

C. Related research activities - unknown.

V. URGENCY - Moderate.

PROBLEM NO. 60 - COMMITTEE A2C04

I. NAME OF PROBLEM - ANALYSIS OF THE INFLUENCE OF IN-SITU STRESSES ON ROCK TUNNEL STABILITY

II. THE PROBLEM - The most ignored element in rock tunnel stability design analysis is the in-situ stresses. The significance of these stresses should be assessed, documented and made available for use by designers.

III. OBJECTIVES -

Development of a comprehensive reference report on rock tunnel in-situ stresses.

IV. CURRENT ACTIVITIES -

A. Research in progress - unknown.

B. Suggested key words: in-situ stresses, rock tunnel, tunnel stability.

C. Related research activities - unknown.

V. URGENCY - Moderate.

PROBLEM NO. 61 - COMMITTEE A2C04

I. NAME OF PROBLEM - GUIDES FOR GEOTECHNICAL BID DATA

II. THE PROBLEM - The question of what geotechnical data should or should not be included with bid documents has always been a problem. Some guidelines to establish consistency would be extremely helpful for engineers, contractors, owners and the courts.

III. OBJECTIVES -

Development of standard guidelines for presentation of geotechnical data to be included in bid documents.

IV. CURRENT ACTIVITIES -

A. Research in progress - unknown.

B. Suggested key words: standards, geotechnical data, bid documents.

C. Related research activities - unknown.

V. URGENCY - The task is urgent. The sooner standard procedures are implemented, the better.

PROBLEM NO. 62 - COMMITTEE A2C04

I. NAME OF PROBLEM - STUDY OF THE DETAILS OF RESIN ROCK BOLT SYSTEMS

II. THE PROBLEM - The ability of resin rock bolting systems to completely fill the hole and fully encapsulate the bolt so that the bolt is permanently protected from corrosion needs to be proven before one can have complete confidence in the permanency of the system.

III. OBJECTIVES -

Implement a comprehensive resin rock bolt test program directed towards an evaluation of the reliability of the resin as a permanent corrosion protection for the rock bolt. Report the results of the program and make recommendations on the reliability of the resin rock bolt system with respect to bolt corrosion.

IV. CURRENT ACTIVITIES _

A. Research in progress - unknown.

B. Suggested key words: rock bolts, resin, corrosion, tunnel support systems.

C. Related research activities - unknown.

V. URGENCY - The task is urgent. Resin rock bolt systems are currently in use and their reliability against corrosion should be assessed.

PROBLEM NO. 63 - COMMITTEE A2C04

I. NAME OF PROBLEM - SELECTION OF FURRED-OUT WALL PANELS IN TRENCH AND BORED TUNNELS

II. THE PROBLEM - Trench type tunnels have usually been constructed by placing conduit and surface boxes in the sidewall forms during the outfitting stage of each tube. The number and position of each box and conduit are then fixed. Future work by other contractors then may experience significant difficulties in alignment of lights, curb and wall intersections. Future conduit additions and revisions can not be made. Forming and concrete placing becomes an expensive and time consuming problem. Tube leakage becomes immediately an unsightly disclorization on ceramic wall tile. Current market reports indicate that the field of tunnel ceramic tile suppliers and-or contractors are becoming extremely narrow, to such an extent that competition (and therefore competitive pricing) is extremely restricted.

Panels furred-out from the walls, however, have the potentiality of negating many of the problems resulting from construction with ceramic wall tiles as mentioned above. Cost savings can be effected if designers and contractors could be assured of a high degree of prior research, testing and standardization of product.

III. OBJECTIVES -

A. Establish the dimensional requirements such as required space behind walls, optimum panel size, adjustments to suit grade and required thickness.

B. Study alternate panel structural systems including methods of support and attachment, means of access, accommodation of inserted facilities.

C. Study materials for panel materials, fillers, backing, paint, and finish.

D. Examine alternate methods of panel construction.

E. Determine desirable physical characteristics such as resistence to impact and fire, toxicity during a fire, ease of cleaning and durability.

F. Examine the above in relation to their compatibility with prevailing manufacturing processes and general marketability of feasible alternate types of wall units.

IV. CURRENT ACTIVITIES -

A. Some small research projects are known to have been undertaken on this subject by designers and manufacturers or fabricators but their scope has been too narrow to produce conclusive results.

B. Suggested key words: tunnels, furred-out tunnel walls, tunnel wall panels.

V. URGENCY - While the total number of tunnel construction projects are limited, from a national standpoint, the potential construction cost savings could be significant on a job-by-job basis. Furred-out wall systems have a greater potential in cost savings for trench type tunnels but could be used to a large advantage in bored tunnels. Of equal urgency is the development of such wall systems for renovating existing tunnels.

PROBLEM NO. 64 - COMMITTEE A2C05

I. NAME OF PROBLEM - LOAD HISTORY STUDIES OF RAILROAD AND RAPID TRANSIT BRIDGES

II. THE PROBLEM - There has been little field study in the United States in the past few decades to obtain strain history studies on railroad or rapid transit bridges. The large number of older bridges and the increasingly damaging effect of unit trains make the study appropriate. The extensive studies of highway bridge load histories has led to improvements in fatigue design with consequent economic savings for the structure.

III. OBJECTIVES -

A. Obtain several samples of load histories for different configurations of railroad and rapid transit bridges.

B. Develop inexpensive instrumentation that can be widely used by railroad engineers to acquire strain history data.

C. Correlate strain histories with railway loads to develop fatigue models for design and rating.

IV. CURRENT ACTIVITIES -

None in the United States.

V. URGENCY - The increasing age of most railway bridges means that fatigue failures are quite likely in the future on a number of major routes. Reported damage on a rapid transit line in Chicago indicates that not enough is known about strain history for rapid transit vehicles.

Cost: ?

PROBLEM NO. 65 - COMMITTEE A2C05

I. NAME OF PROBLEM - HIGHWAY LOAD SPECTRA FOR LOAD FACTOR DESIGN

II. THE PROBLEM - Recent strain history studies on bridges have helped to create rational load spectra for incorporation in fatigue design. A corresponding problem which has not been reported is a rational load model for use with load factor design for strength of bridge components. Loading now in the AASHTO Specification was produced several decades ago. The recent increases in truck loads and volume require an extensive study of expected extreme loads on bridge structures.

III. OBJECTIVES -

A. Study current load data to determine extreme live loads.

B. Develop a reliability or limit state oriented model to predict maximum expected highway loads during bridge lifetime for various classes and types of roadway.

C. Derive load factors to provide rational safe highway loadings.

IV. CURRENT ACTIVITIES -

No comprehensive effort in the United States.

V. URGENCY - Increase in legal allowable loads and the extensive bridge rehabilitation program being planned require that a rational approach to design loading be established.

Cost: $100,000 - 18 months.

PROBLEM NO. 66 - COMMITTEE A2D01 & A2T61

I. NAME OF PROBLEM - DEVELOPMENT OF PERFORMANCE NEEDS FOR EMULSIFIED ASPHALTS AND THEIR RESIDUES.

II. THE PROBLEM - Experience has indicated that not enough may be known about the properties of emulsified asphalts and their residues to insure optimum use under all conditions and to insure best performance.

There is a need to investigate fundamental properties of emulsified asphalts and asphalt residues, to evaluate the effectiveness of existing test methods and specifications to insure uniformity of the product. New test procedures and specifications dealing with fundamental properties of emulsified asphalts and geared towards their ultimate performance needs to be investigated.

III. OBJECTIVES -

The objective is to develop the fundamental properties of emulsified asphalts and their residues that relate to performance, i.e., mixing, optimum percent asphalt, mix handling, laydown and compaction, curing, adhesion, coating, aggregate retention. The properties desired for different applications for an emulsion may be found to be totally different.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress area 26 & 34 have been scanned in preparing this statement.

B. Suggested key words: emulsified asphalt properties, performance of emulsified asphalts, emulsified asphalt residues.

C. No related projects found.

V. URGENCY - Current specifications and testing methods are more geared to the satisfactory manufacture of an emulsion and not necessarily to their performance. Considering the national interest for saving energy and the growing use of emulsified asphalts as an energy saving material, greater effort to achieve uniformity and improved performance is felt imperative.

PROBLEM NO. 67 - COMMITTEE A2D01

I. NAME OF PROBLEM - NON-LOAD ASSOCIATED CRACKING OF BITUMINOUS PAVEMENTS CAUSED BY THERMAL AND MOISTURE INDUCED VOLUME CYCLES

II. THE PROBLEM - It has been noted that non-load associated transverse cracks occur in warm climates as well as in the cold climates. Then too such cracks are more frequent where there is little or no traffic. This suggests mechanisms in addition to the currently emphasized high tensile stresses and stiffness induced by low seasonal temperatures.

One such crack mechanism possibility is the permanent reduction in length of pavements where the volume of a pavement segment experiences changes because of reoccurring temperature and moisture cycles. This mechanism assumes the following:

A. That the pavement volume increases and decreases along with the daily temperature cycle. That with some aggregates there are also volume changes associated with moisture; that lateral restraint imposed by the quality of a pavement limits the proportional increase in the length and width of each

pavement segment that would normally occur with an increase in volume; that under these conditions the thickness of each segment would increase disproportionately; that in the volume decrease phase of the volume change cycle, the length, width and thickness decrease proportionately. (In effect the volume increase portion of the cycle is anisotropic, in the decrease portion of the cycle the contraction is isotropic); that the sum total of this imbalance produces a permanent reduction in particularly the length of the pavement segments and/or increased tensile stresses with each complete volume change cycle; that such dimensional effects are likely to occur at normal and elevated pavement temperatures where some pavement flow is likely; that the effect on a pavement's dimensions and tensile stresses due to these relatively small but frequent volume cycles is cumulative, thus contributing to non-load associated cracking at both nominal and low temperatures. (The exception could be where traffic at normal and elevated temperatures "rolls" the pavement back down to near its original dimensions.)

B. That volume cycles postulated in (A) above, are generated by (1) regular daily temperature cycles or (2) on occasion by moisture changes due to flooding or rain followed by drying or (3) by cyclic moisture-temperature changes as occur when the system goes through the dew point or when hydroenesis is operating.

In the following table an example of a 5% volume change is examined as to the extent of the changes in the length, width and thickness of a 5 x 1 x 1 pavement segment as might occur per the assumptions. Volume change and segment dimensions selected solely for convenience in demonstrating the principle.

CYCLE PHASE	VOLUME	SEGMENT DIMENSIONS		
		LENGTH	WIDTH	HEIGHT
Cycle Initiated	5	5	1	1
At Maximum Volume	5.25	5	1	1.05
Cycle Completed	5	4.92	0.984	1.034
Total Change	0	-0.08	-0.016	+0.034

Providing the basic assumptions are valid, this example demonstrates cyclic volume change does have an adverse effect on the length of the pavement and could induce tensile stresses. This could induce transverse non-load associated cracks in pavements parking lots, runways, dam facings, etc.

III. OBJECTIVES -

Establish the likelihood tensile stresses, resulting from volume changes associated with daily temperature cycles or various moisture cycles generally during the summer, contribute significantly to non-load associated transfers cracking.

IV. CURRENT ACTIVITIES -

A. Cyclic Conditions.

1. Zube - AAPT, Vol. 35, 1966 - Figure 7, pp.277, "The Development of Cracks of a 3" x 3" x 11.25" Specimen Using Absorptive Aggregate Exposed Alternatively to Moistroom and 100° F. Dry Conditions."

2. Ellis, Jones, and Littlefield, AAPT, Vol. 38, 1969, pp. 660, "Thermally Induced Densification of Asphaltic Concrete."

3. Freeze-thaw studies of Prof. R. P. Lottman, University of Idaho.

B. Seasonal Conditions

1. Haas: "A Method for Designing Asphalt Pavements to Minimize Low-Temperature Shrinkage Cracking" The Asphalt Institute Research Report 73-1, January 1973.

2. "Asphalt Pavement Cracking" - Part of Special Report 101, Highway Research Board (1969).

3. "Structural Design of Asphalt Concrete Pavements to Prevent Fatigue Cracking," Special Report 140 Highway Research Board (1973).

4. "Fatigue of Compacted Bituminous Mixtures" ASTM - STP 508 (1971).

5. "Fatigue and Dynamic Testing of Bituminous Mixtures," ASTM - STP 561 (1973).

6. Christison, Murray and Anderson, "Stress prediction and Low Temperature Fracture Susceptibility of Asphaltic Concrete Pavements, Asphalt Pavina Technology," Vol. 4. pp. 494-523 (1972).

V. URGENCY - Non-load Associated Cracking is currently of concern. Studies of principally low temperature seasonal effects have proved useful. There remains the possibility that spring-to-fall daily temperature cycles and various moisture cycles, ubiquitous and frequent as they are, influence pavement volumes which in the pavements environment could contribute to crack distress.

Information concerning this should prove timely and useful to Paving Technology. Such information will also provide added insight to the pavement environment useful in research in general.

PROBLEM NO. 68 - COMMITTEE A2D01 & A2T61

I. NAME OF PROBLEM - REINFORCING ADDITIVES FOR ASPHALT

II. THE PROBLEM - A need exists to upgrade the performance of asphalts to improve their abilities to withstand temperature and strain conditions that they are not capable of now withstanding. Previous work involving additives, such as rubber, carbon black, etc. has not led to any accepted conclusions. However, the possibility has become even more evident that additives can indeed significantly upgrade asphalt performance.

III. OBJECTIVES -

The objective would be to establish the feasibility of improving asphalt performance by study and observations of installations previously placed. If an indication of improvement is obtained, then each additives cost effectiveness needs to be established.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 26 & 34 have been scanned in preparing this statement.

B. Suggested key words: asphalt additives, asphalt modification, asphalt reinforcement.

V. URGENCY - The reduction in overlay thicknesses, early crack propagation, and overall pavement life increases, should result in an energy saving improvement. Ways need to be found to make better use of asphalt and improve its overall performance.

PROBLEM NO. 69 - COMMITTEE A2D04 & A2T61

I. NAME OF PROBLEM - PROPERTIES OF EMULSIFIED ASPHALT MIXTURES FOR HIGHWAY CONSTRUCTION AND MAINTENANCE

II. THE PROBLEM - Considerable effort has been spent in recent years in developing information on the fundamental properties of hot-mix asphalt concrete and similar mixtures. However, comparatively little has been done to determine energy trade offs and properties utilizing emulsified asphalt mixtures. There is a need to develop more information on such fundamental mixture properties as dynamic modulus (resilient modulus), fatigue characteristics, resistance to permanent deformation (creep), of both uncured and cured emulsified asphalt mixtures and on how these properties affect structural design and performance of pavements constructed with such mixtures.

III. OBJECTIVES -

1. Determine the factors which affect curing of emulsified asphalt mixtures.

2. Determine the effects of curing, stress condition, temperature, and other factors on dynamic modulus (resilient modulus), fatigue and other fundamental properties of emulsified asphalt mixtures.

3. Determine effects of water and moisture vapor on fundamental properties of cured emulsified asphalt mixtures.

4. Determine the properties in the cured state to be used for structural design.

5. Relate the fundamental properties to structural design requirements and performance.

6. Devise a plan for collecting field data to determine possible long-term changes under various conditions of environment, etc.

IV. CURRENT ACTIVITIES -

Suggested key words: Emulsified Asphalts, Emulsified Asphalt Mixtures, Structural Design, Thickness Design, Mixture Properties, Dynamic Modulus, Resilient Modulus, Fatigue Properties, Rutting, Optimization.

V. URGENCY - The study of emulsified asphalt mixtures is considered very important in view of their increased use throughout the United States.

PROBLEM NO. 70 - COMMITTEE A2E01

I. NAME OF PROBLEM - SIGNIFICANCE OF LABORATORY TESTS AS RELATED TO CONCRETE FIELD PERFORMANCE

II. THE PROBLEM - Many laboratory tests are run on concrete in an effort to predict performance of similar concrete in the field. Laboratory freezing and thawing, alkalie-aggregate reactivity, and concrete strengths are examples of such tests. Little definite research has been conducted to specifically correlate such tests, which are run under controlled laboratory conditions, with the performance of the concrete under actual field conditions.

III. OBJECTIVES -

The objectives of the proposed research can be categorized as follows:

1. Evaluation of the problem of establishing failure criteria in the field.

2. Development or selection of laboratory tests that will relate properties of concrete to concrete failure in the field.

3. Developing procedures of using test results to predict probability of failure.

What constitutes failure of concrete in a transportation related structure is most difficult to answer. It is suggested that for each service environment and each level of service, failure criteria must be established. In order to make the task manageable, the research problem should be restricted to highway concrete pavement and concrete bridge decks. Failure criteria to be established might consider factors such as micro - and macro-cracking, deflection, disintegration, abrasion, volume change, and aesthetic qualities. Scaling, D-line cracking, and popouts are typical of outward signs that should be evaluated as to how much can be tolerated before failure is reached.

Existing tests along with any new test

procedures should be selected and demonstration projects should be developed to show how the test results can be used to predict failure.

IV. CURRENT ACTIVITIES -

Many Highway Departments or Departments of Transportation in the course of daily activity are collecting information that should prove to be essential in accomplishing this project. A survey of these activities should be considered a part of this project. As an example of what is meant, several agencies use ASTM C 666, Standard Method of Test for Resistance of Concrete to Rapid Freezing and Thawing and in so doing collect a considerable amount of data (in the form of durability factor, weight change, and length change) for concrete specimens that are representative of concrete being placed in the field. An organized attempt to correlate existing and new data with field performance should be fruitful.

V. URGENCY - This problem is urgent from the standpoint that it has been an ongoing one that ultimately has probably cost the nation billions of dollars over the years.

PROBLEM NO. 71 - COMMITTEE A2E01

I. NAME OF PROBLEM - PREDICTION OF BRIDGE DECK LIFE AS INFLUENCED BY CORROSION OF STEEL REINFORCEMENT

II. THE PROBLEM - Bridge decks constructed in areas of deicing salt usage and in seawater environments have been subject to premature deterioration costing millions of dollars. Research has shown that the causes of this distress are most often chloride penetration into the concrete and the reinforcing steel corrosion which is subsequently induced. Various methods have been developed to combat this corrosion, in both new and existing structures including: thicker concrete cover over the reinforcing steel, higher quality (low water cement ratio) concrete which is properly consolidated, latex modified concrete, epoxy coated reinforcing steel, waterproof membranes with asphaltic concrete wearing surfaces, polymer impregnated and polymer concretes, and internally sealed (wax bead) concrete. Similarly, methods for studying and identifying the magnitude of the problem (delamination detection, half-cell potentials, chloride analyses and rate of corrosion probes) have been developed and are now commonly used.

Initial decisions to make many of the changes in design and construction procedures in use today were based on comparative laboratory studies which were not related to actual performance life. However, in many instances, experimental field studies have been underway for sufficient time that predictions of service life could be made if all the laboratory and field data were synthesized.

III. OBJECTIVE -

To identify and analyse all laboratory and field data on the effect of commonly used design and construction procedures for the protection of bridge decks constructed in corrosive environments; and to utilize the data to predict the extension in bridge deck life which can be expected from the use of each procedure in (1) new construction and (2) rehabilitation, when applicable.

IV. CURRENT ACTIVITIES -

A. There are many ongoing studies in the Federal Highway Administration Federally Coordinated Program (FCP) Project 4B, "Eliminate Premature Deterioration of Portland Cement Concrete." Applicable NCHRP Projects are included in the FCP and Annual Progress Reports are prepared on the FCP project.

B. Experimental bridge deck studies are being performed by the States.

V. URGENCY - There is a great need to know the actual increase in life that has been achieved by the many changes in bridge deck design and construction procedures which have occurred in recent years. Costs of the procedures vary many fold and the user must know the life of the procedures in order to choose the most cost effective means of protecting or extending the life of bridge decks.

PROBLEM NO. 72 - COMMITTEE A2E02

I. NAME OF PROBLEM - IDENTIFYING ALKALI-SILICA REACTIVE QUARTZ AND QUARTZITE IN CONCRETE AGGREGATES

II. THE PROBLEM - The highway network around the Pentagon, a naval dry dock in Charleston, South Carolina, bridges in the road system of the Georgia DOT, several dams and locks belonging to Federal Agencies, and other structures have developed alkali-silica reaction to a damaging extent, and the reacted aggregate has shown that the quartz in the aggregate has participated in the reaction. The reaction develops slowly over 20 years or more, but can be unsightly and even dangerous to the structural integrity of the structures affected.

III. OBJECTIVES -

A. Verify whether or not the quartz affected, which occurs as vein quartz and quartzite, is all highly metamorphic quartz with a high angle of undulatory extinction.

B. Verify whether or not the mica in some granite gneiss takes part in the reaction as has been alleged.

C. Set forth criteria for recognition of reactive quartz and quartzite.

D. Reproduce the reaction in the laboratory.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress has not been scanned in preparing this statement.

B. Suggested key words: Reactive quartzose rocks, mylonitization, granulation, recrystallization, undulatory extinction angle.

C. Some work has been done at the USAE Waterways Experiment Station on this topic.

V. URGENCY - Since the alkali content of cement is increasing it is desirable to find criteria for alkali-silica reactive rocks for which published criteria do not now exist so that means of controlling them may be found.

A. General estimate of cost to accomplish: $100K.

PROBLEM NO. 73 - COMMITTEE A2E02

I. NAME OF PROBLEM - CHEMICAL BEHAVIOR OF WASTE MATERIALS IN CONCRETE

II. THE PROBLEM - The chemical behavior of many waste materials when incorporated into cement and/or concrete has not been adequately determined to ensure that deleterious reactions do not develop. A variety of waste materials and industrial by-products are either being blended with cements or are being considered for use as aggregates in concrete, such as fly ash, blast furnace slag, glass cullet, residue from the combustion or municipal refuse mill tailings, waste mining rock, etc. Increasingly larger amounts of such waste materials will be incorporated into concrete because of changing patterns of supply and demand of materials and energy, economic factors and heightened concern for the quality of the environment. The research needed includes such as the determination of the possibility of deleterious chemical reactions caused by the use of recycled concrete from building demolition contaminated with gypsum plaster possibly causing disruptive sulfate reactions; investigation of the probability of fly ash having sufficiently high alkali contents that they increase the severity of deleterious reactions between cements and alkali-sensitive aggregates; investigation of the reactions possible between the components of incinerated municipal waste and the components of cement and concrete.

III. OBJECTIVES -

The objective is to develop relationships between the chemical and mineralogical composition of waste materials and their chemical performances in concrete. Emphasis is to be given to those waste materials that either are being incorporated in concrete at a high level or whose use is anticipated to rapidly increase.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress Areas 32, 34, and 35 have been scanned in preparing this statement.

B. Suggested key words: Concrete, Industrial By-Products, Waste Materials.

C. A RILEM Symposium by correspondence is currently being conducted on the "Use of Waste Materials in the Construction Industry." Many projects are being carried out to identify the sources and availability of waste materials, but little is being given to their chemical behavior in concrete.

V. URGENCY - The use of waste materials, especially fly ash, in cement and concrete is rapidly increasing. Some areas in the United States lack good quality aggregate which will soon necessitate the increased use of waste materials such as waste rock and mill tailings as aggregate. Air pollution regulations will apparently force many cement manufacturers to produce portland cements with higher alkali contents than those presently on the market. In addition, the Resource Conservation and Recovery Act of 1976 (Public Law 94-580) will for the most part require agencies using Federal funds for procurement to use construction materials that contain the highest percentage of recovered material practicable.

PROBLEM NO. 74 - COMMITTEE A2E03

I. NAME OF PROBLEM - DETERMINATION OF THICKNESS OF CONCRETE PAVEMENTS BY NON-DESTRUCTIVE TESTING METHODS

II. THE PROBLEM - Concrete pavement slabs, most of which are unreinforced, are stressed in flexure when subjected to traffic loads. Since the resistance to bending is proportional to the square of the depth of the section, the thickness of the slab is even more critical than the strength of the concrete in determining the load-carrying capacity of a pavement. As a result, specified slab thickness is an essential acceptance criterion for concrete pavement. The only reliable method for determining in-place thickness at present is to drill cores from the slab and to physically measure the core lengths. Since this procedure is costly and time-consuming, fewer determinations than desirable are made.

III. OBJECTIVES -

The objectives are to develop a technique for measuring the thickness of a body when only one surface is available to the tester and to adapt the technique to a device which can traverse a pavement slab making either continuous or closely spaced measurements of thickness. Available principles include measuring the transit times of reflected waves and measuring the resonant frequency of the slab in vertical longitudinal vibration.

IV. CURRENT ACTIVITIES - Suggested key words: Concrete; non-destructive testing; pavement; thickness.

V. URGENCY - The development of a non-destructive test will reduce costs, improve the determination of compliance, and speed up acceptance or rejection of concrete pavements. Its accomplishment would represent a significant step forward in highway engineering.

PROBLEM NO. 75 - COMMITTEE A2E03

I. NAME OF PROBLEM - RAPID ANALYSIS OF WATER/ CEMENT RATIO OF FRESH CONCRETE

II. THE PROBLEM - Mechanical strength of hardened concrete is primarily dependent upon the water/cement ratio of fresh concrete. However, there are no satisfactory methods available at present to determine this property rapidly. The rapid determination of the water/cement ratio of fresh concrete would permit immediate elimination of substandard concrete being placed in a structure. This of prime importance in certain type of structures where a very high degree of quality assurance is required e.g. nuclear containment vessel, high strength concrete columns, etc.

III. OBJECTIVES -

The objective is to develop rapid, practical and economic methods to determine the water/ cement ratio of fresh concrete. The studies could include chemical, physical, nuclear and electrical methods. Emphasis is to be placed on simplicity and the possible adoption of these methods in routine concrete operations either at the batch plant or on the field.

IV. CURRENT ACTIVITIES - Suggested key words: Mechanical strength; Fresh concrete; Water/ Cement ratio.

V. URGENCY - The development of rapid test procedures to determine the water/cement ratio of fresh concrete is considered very important to improve quality control of concrete, reduced the over design factors in general and insure quality assurance for highway pavement concrete.

PROBLEM NO. 76 - COMMITTEE A2E04 & A2E01

I. NAME OF PROBLEM - ABRASION RESISTANCE, SURFACE DURABILITY, AND SKID RESISTANCE OF CONCRETE PAVEMENTS

II. THE PROBLEM - Safe traffic operations require pavements to have adequate skid resistance. Our ability to attain and retain skid resistance will play and increasingly important role in specifications for p.c. concrete pavements and bridge decks.

Concrete pavement surfaces can be thought of as passing through three states:

Stage 1 - Initial Texture. This stage begins when the pavement is opened to traffic and continues until initial texture is worn smooth. Skid resistance, particularly at higher speeds, depends largely on the macrotexture of the initial finish.

Stage 2 - Mortar. This stage begins when the initial texture is worn smooth and continues until coarse aggregate is exposed. Skid resistance is dependent primarily on the microtexture of the mortar which is a function of the properties of the fine aggregate and cement paste.

Stage 3 - Exposed Aggregate. This stage begins when the coarse aggregate becomes exposed. Tire contact with the mortar phase is reduced and macrotexture may increase depending upon the degree to which coarse aggregate and mortar wear differentially.

The problem is to influence the abrasion resistance of pavement concrete and its components so as to prolong the time required to reach Stage 2 and to maximize skid resistance in Stages 2 and 3.

III. OBJECTIVES -

A. Identify the role of the cement paste phase as regards the initial skid resistance of conventionally textured and grooved pcc pavements and the retention of skid resistance through all three stages of the pavement's surface.

B. Identify the effects of curing compounds on the skid resistance and serviceability of roadway and bridge deck pavements (conventionally textured and grooved pavements).

C. Establish meaningful evaluative criteria for skid resistance characteristics of both fine and coarse aggregates in conventionally textured pcc pavements.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 22, 25, 26, 32 and 51 have been scanned in preparing this statement.

B. Suggested key words: concrete pavement durability, concrete properties, abrasion, skid resistance, wear resistance.

C. A partial list of related research activities which have been completed or are under way in this area follows.

1. Colley, B. E. et al., "Factors Affecting Skid Resistance and Safety of Concrete Pavements," HRB Spec. Rep. 101 (1969).

2. Chamberlin, W. P. and Amsler, D. E., "Pilot Field Study of Concrete Pavement Texturing Methods," Highway Research Board Record No. 389 (1972).

3. Weller, D. E. and Maynard, D. P., "The Influence of Materials and Mix Design on the Skid Resistance Value and Texture Depth of Concrete," RRL Report LR 334 (1970).

4. Iowa State Highway Commission, "Skid Resistance of Concrete Pavements," Project No. HR-168, (HRIS Accession No. 26 232140).

5. Virginia Highway and Transportation Research Council, "Durability of Certain Configurations for Providing Skid Resistance on Concrete Pavements," VHTRC Project No. 70 (HRIS Accession No. 104171).

6. California Department of Transportation, "Improve Portland Cement Concrete

Wearing Surfaces," Project No. 19-635293, (HRIS Accession No. 26 232162).

7. North Carolina State University, "Surface Wear and Skid Resistance Properties of Portland Cement Concrete Pavements," Project No. HPR 74-3, (HRIS Accession No. 26 233036).

8. Ledbetter, W. B. et al., "Evaluation of Full-Scale Experimental Concrete Highway Finishes," Research Report 141-4F, Texas Transportation Institute, 1974.

9. Neal, Spring, Woodstrom and Spellman, "Portland Cement Concrete Pavement Texture Quality Investigation," Interim Report, CA-DOT-TL-3126-10-75-07, January 1975.

10. Missouri State Highway Department, "An Investigation of the Durability of the Skid Resistance of Wire Combed PCC Pavement Surfaces," Study 74-5, May 1976.

V. URGENCY - A high priority is warranted because of the accelerated wear and loss of skid resistance being experienced on many concrete pavements now being built. The problem has become acute with the recent emphasis on deeper textures, many of which wear at correspondingly higher rates.

PROBLEM NO. 77 - COMMITTEE A2E04

I. NAME OF PROBLEM - THE ROLE OF SOLUBLE SALTS IN THE WATER EVAPORATING FROM FRESH CONCRETE

II. THE PROBLEM - There is evidence that alkali sulfates--as may be derived from portland cement clinker--or chloride salts, or other soluble materials may occur in variable and sometimes rather high concentrations in the solution that is formed over time from the mixing water in concrete. As this solution evaporates, after finishing of a structure, the remaining solution becomes supersaturated. There are rather ill-documented reports of scaling and perhaps other problems related to this phenomenon.

III. OBJECTIVE -

Identify the nature of the mechanisms that are involved in this phenomenon and, if necessary, to develop methods to remedy the detrimental effects.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress area 32 has been scanned in preparing this statement.

B. Suggested key words: concrete sealing, salt corrosion of concrete, abrasion resistance.

C. A partial list of related research activities underway or completed is as follows:

Fookes, Peter J. and Collis, Laurence, Aggregates and the Middle East, Concrete, November 1975, IX(II) 14-19.

Fookes, Peter J. and Collis, Laurence, Problems in the Middle East, Concrete, July 1975, IX(7) 12-17.

French, W. J., The Migration and Precipitation of Water Soluble Ions in Concrete, paper to be presented at the 4th International Symposium on Alkalis in Cement and Concrete, Purdue University, June 5-8, 1978.

Fookes, Peter J. and Collis, Laurence, Cracking and the Middle East, Concrete, February 1976, X(2) 14-19.

Fookes, Peter J., A Plain Man's Guide to Cracking in the Middle East, Concrete, September 1976, X(5) 20-22.

French, W. J. and Poole, Alan, Alkali-Aggregate Reactions and the Middle East, Concrete, January 1976, X(1) 18-20.

V. URGENCY - The need for such research is becoming progressively more urgent with the increasing probability of such soluble salts being present in larger than previously experienced amounts as derived from cements, aggregates, admixtures, and mixing water.

PROBLEM NO. 78 - COMMITTEE A2E05

I. NAME OF PROBLEM - EFFECT OF ADMIXTURES ON SLUMP LOSS OF CONCRETE

II. THE PROBLEM - Concrete mixes which do not contain admixtures sometimes suffer untimely loss of workability, described as "slump loss," and this is obviously inefficient and costly. At the present time admixtures are in widespread use. These admixtures sometimes alleviate, and sometimes aggrevate, slump loss. In the latter case, the situation can sometimes be remedied and sometimes, not. Elimination of the admixture is not always the answer, for it may be needed for other purposes. The effect of admixtures on slump loss is the subject of much speculation, but in few if any cases are all the fundamental mechanisms involved fully understood.

III. OBJECTIVES -

(i) Representative admixture types commonly used (Sections 1.1.1 through 1.1.5 of ASTM C494-77) should be evaluated under carefully controlled laboratory conditions with a variety of cements known to suffer untimely slump loss with admixtures, without admixtures, and in both cases. When the field phenomena are successfully recreated in the laboratory, the most complete analysis that is possible should be made of the total situation and all mix components, with especial emphasis on cement and admixture composition (both physical and chemical properties).

(ii) The data analysis should lead to a set of hypotheses, each of which should suggest critical experiments to confirm or deny that hypothesis.

(iii) Recommended remedial actions should evolve from confirmed hypotheses.

IV. CURRENT ACTIVITIES -

Several limited, empirical projects have been and are being conducted. Speculative theories have been evolved. However, these investigations lack the necessary depth and scope to generate convincing or widely applicable solutions to the field problems. Suggested keywords are - admixtures, slump loss, early hydration, cement composition, and test methods.

V. URGENCY - Significant time and money are being lost on a widespread scale because this problem and what to do about it are not well understood.

PROBLEM NO. 79 - COMMITTEE A2E05

I. NAME OF PROBLEM - USE OF INFRARED TO DETERMINE ADMIXTURE UNIFORMITY

II. THE PROBLEM - Many state Departments of Transportation employ Section 5.1.1 of ASTM Specification C 494-77 as one means of determining uniformity of successive lots of admixture from the same source. The criterion is that the infrared absorption patterns be "essentially similar." This is a subjective and qualitative factor which is sometimes interpreted to mean that absorption patterns of successive lots, when superimposed, must be identical. This ignores all sources of variance other than significant change in admixture composition and is not realistic. Quantitative ranges of permissible variation in parameters of infrared absorption patterns are needed to establish "essential similarity."

III. OBJECTIVES -

(i) Identify and quantify factors affecting variance in infrared absorption pattern parameters using different operators and instruments for a fixed set of reference admixture samples, and a specific technique of sample taking and sample preparation. The reference admixtures are nominally the same admixture, but vary in composition within the established quality control limitations of the manufacturer.

(ii) Analyze the resulting data to generate allowable quantitative ranges of variation for each parameter of the infrared absorption spectra that define no statistically significant difference within a predetermined confidence limit.

IV. CURRENT ACTIVITIES -

Essentially none exist. Suggested key words: admixtures, infrared, composition, and test methods.

V. URGENCY - Use of admixtures has become widespread and is steadily increasing. It is just as vital that they meet meaningful, quantitative uniformity requirements as it is for all other components of concrete mixes to do so.

PROBLEM NO. 80 - COMMITTEE A2E06

I. NAME OF PROBLEM - SULFATE RESISTANCE OF BLENDED CEMENTS

II. THE PROBLEM - In consequence of the energy shortage and the desire to reduce manufacturing costs, the production of Type IP cement (portland-pozzolan cement meeting ASTM C595) has considerably increased in the United States. IP and IS are believed to resist sulfate attack better than Type I cement. If IP's and IS's can be shown to resist sulfate comparably to Type II (moderate sulfate resistant cement) IP's and IS's may replace Type II cements. Economies gained in money go to the cement manufacturers, but it is a general advantage to the nation to use in blended cements fly ash and granulated slag, materials that already contain the energy input otherwise needed to make more portland cement clinker. Grinding blast-furnace slag and fly ash demands less energy than an equivalent amount of portland cement clinker. Some fly ashes and granulated blast-furnace slags give superior sulfate resistance to cements in which they are blended. Some fly ashes and probably some slags do not. See also problem no. 81.

III. OBJECTIVES -

To determine the factors related to portland cement that affect the sulfate resistance of concretes made from blended cements; to determine the factors related to the fly ashes and slags used in blended cements that affect the sulfate resistance of concretes containing them; to develop a cement that will tolerate high soluble sulfate levels in the aggregate or the environment, to enable use of sulfate-containing aggregates and to make it possible to produce enduring concrete structures in the most severe environments of sulfate attack.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress has not been scanned in preparing this statement.

B. Key words: Fly ash, pozzolan, slag, blended cement, tricalcium aluminate, available alumina, sulfate attack on concrete, dilution, silica content of pozzolan, portland blast-furnace slag.

C. Work is in process on this topic in the National Bureau of Standards, the University of California, the Waterways Experiment Station, and the PCA.

V. URGENCY - Type II (moderate sulfate resistant) cement is harder to find, so users who have relied on it to make concrete for moderate sulfate attack need to know whether, and which, IP and IS cements are good enough. They also need to know more about the mechanisms involved in the reactions during hydration of blended cements and about their reactions during sulfate attack.

PROBLEM NO. 81 - COMMITTEE A2E06

I. NAME OF PROBLEM - PERFORMANCE AND CHARACTERIZATION OF BLENDED CEMENTS AND OPTIMIZATION OF PORTLAND CEMENT-POZZOLAN MIXTURES

II. THE PROBLEM - In view of the national need to conserve energy, blended cements will, at least partially, be substituted for portland cements in many forms of construction. While blended cements are used extensively in many countries, their use in the United States has been low. Knowledge of the factors affecting the performance of blended cements and methods of characterization of blended cements are needed to facilitate their acceptance for use in highway and other transportation construction without compromise on quality. The interaction between hydraulic cement or lime and pozzolanic solid waste materials such as fly ash has not been thoroughly characterized even though fly ash-portland cement mixtures are widely used for construction purposes. The interaction of the pozzolanic-hydraulic cement mixture depends on the chemistry of the total system. The mixtures currently in use are not the stoichiometric optima for the chemical reactions which take place. If the composition of the fly ash-hydraulic cement blend is balanced with additions of other reaction components such as lime and gypsum so that the potential stoichiometry of the reaction is satisfied, the engineering performance of the hardened mass may be improved.

With prospects for higher coal use in the future, the use of waste material such as fly ash from coal burning will be extremely important. Before the energy crisis, it was predicted that 30 million tons of fly ash will be produced by 1980 in the U.S.A. Use of this waste resource so as to reduce energy consumption in other segments of the economy would be beneficial. When fly ash is mixed with hydraulic cement, a high quality hydraulic binder with definite benefits is produced, which also extends the production of the portland cement industry which uses much energy. The current levels of fly ash addition result in a reduction of the energy required for producing 100 lbs. of a hydraulic cement (Type IP) by about 10-15 percent. Considering the energy-critical future we face, the development of systems of optimum fly ash cement which in effect will use less energy for production of a high quality hydraulic binder is of national importance.

III. OBJECTIVES -

A. To determine the factors affecting the performance of concretes made from blended cements of the portland-pozzolan and portland-blast furnace slag types, in relation to the needs of highway construction. Performance characteristics to be considered would include rate of strength development, workability, behavior with chemical admixtures, resistance to freezing and thawing, sulfate attack, soundness, creep, alkali-aggregate reactions, corrosion of reinforcing steel, and salt scaling.

B. To develop necessary methods for the characterization of blended cements in terms of phase composition, phase distribution (including particle size and shape), and reactivity.

C. To optimize the pozzolanic (fly ash)-hydraulic cement interaction.

IV. CURRENT ACTIVITIES -

A. No HRIS scans have been made.

B. Suggest key words: concrete, blended cements, fly ash, blast furnace slag, performance, characterization, test methods.

C. Several projects on the use of fly ash and blast furnace slags in cement are under way, but there is no coordinated program.

V. URGENCY - Because relevant research activities are at a low level and are fragmented, the rate of progress is unlikely to be consistent with the national need. Since the use of blended cements in highway construction may be as readily accepted as use of portland cement-fly ash blends in construction, steps should be taken immediately to facilitate their use in response to the national need to conserve energy and resources and to prepare for possible future problems in the supply of portland cements.

PROBLEM NO. 82 - COMMITTEE A2F01

I. NAME OF PROBLEM - INVESTIGATION OF THE WEAR PERFORMANCE OF P.C. CONCRETE PAVEMENT SURFACES CONSTRUCTED USING TYPE 1P CEMENT

II. THE PROBLEM - There is considerable research and performance data on the performance of concrete made with type 1P cement or fly-ash cement used in structures. However, the performance of this type concrete in pavements has not sufficiently been evaluated under traffic for resistance to wear. Since 1P cement is gaining widespread interest throughout the U.S.A., it would be most desirable to accomplish this work.

III. OBJECTIVES -

Research proposed: Accelerated wear tests using test tracks or laboratory wheels incorporating 1P cement in the slabs are warranted. State highway agencies should also be encouraged to construct test sections along with control sections under varying traffic conditions.

IV. CURRENT ACTIVITIES -

Estimate of Problem Funding and Research Period: 3 years -- $50,000 - $150,000.

V. URGENCY - The resistance to wear of the pavement surface is most critical when texturing, such as tining, is used. Therefore, with the present emphasis on skid resistant surfaces, it is imperative that data be collected as soon as possible.

PROBLEM NO. 83 - COMMITTEE A2F01

I. NAME OF PROBLEM - OPTIMIZATION OF MACRO-TEXTURE (ROADWAY SURFACE TEXTURE) AND RIDEABILITY FOR CONCRETE PAVEMENTS

II. THE PROBLEM - The optimum road surface desired is one which will offer the best of skid resistance with the best riding quality possible. In order to accomplish this we need to establish relationships between specifications, macrotexture and rideability and develop ways of measurement for each.

III. OBJECTIVES -

A. Determine the relationship between specifications and (1) optimum macrotexture and (2) optimum rideability.

B. Refine ways of measurement for macrotexture and rideability.

IV. CURRENT ACTIVITIES -

A. As a result of the AASHO Road Test most highway engineers have adopted the psi-psr concept for measuring pavement rideability or serviceability. Some states use the BPR Roughometer as their measurement of pavement rideability. The only recent research into the relationship between Record 535 "Development of a Specification to Control Rigid Pavement Roughness," by James E. Bryden of New York DOT.

B. Rideability, roughness, surface tolerance, specifications, roadmeter.

C. No related research activities reported.

D. Texturing methods and requirements have varied considerably from State to State and many times within States. Methods such as brooms, drags, tines, vibrating grooves, etc., have been used and experimented. Due to the development of new equipment in recent years and the present emphasis on attaining durable skid resistant surfaces, it is believed that efforts toward more uniform methods are feasible and desirable. Experimental construction of transverse and longitudinal texturing in fresh concrete has resulted in a trend towards heavier macrotexturing. A synthesis of nationwide uses and recommended optimum procedures is needed.

E. This effort would be appropriate for NCHRP 20-5.

VI. URGENCY -

A. There is a wide variance in State Highway Department specifications regarding surface tolerances and methods of measurement. There is also a fairly wide range in the roughness or rideability of completed pavements. More uniform specifications and compliance with specifications would permit contractors and equipment manufacturers to respond in a more positive manner to the problem of building smooth riding pavements. Modern roadmeters are available to measure psi. Attempts should be made to determine whether current specifications on construction are really related to final riding qualities as measured by roadmeters.

B. There is an immediate need to reduce wet weather skidding accidents on concrete pavements, therefore, work should begin on this synthesis as soon as possible.

PROBLEM NO. 84 - COMMITTEE A2F01

I. NAME OF PROBLEM - UTILIZATION OF AN OPEN-GRADED STABILIZED AND FREE-DRAINING SUBBASE

II. THE PROBLEM - Research Problem Statement: Drainage layers are gaining nationwide interest. Even though there is a considerable amount of information on their performance as far as draining the water is concerned, there is very little published information on (a) stability of drainage layers using various types of aggregates under construction equipment, (b) drainage layers as part of a composite black base construction and (c) effects of stripping of the asphalt under heavy rainfall.

III. OBJECTIVES - Research Proposed: There is a lack of uniformity in the procedures used by the various states and there exists the need to develop national guidelines for using open-graded stabilized subbases. A synthesis of nationwide uses of draining subbases including selected on-site surveys is warranted at this time. The synthesis should identify reasons for the varied utilization and definite problems, if any, which need further attention. This effort would be appropriate for NCHRP Project 20-5.

IV. CURRENT ACTIVITIES -

Estimate of Problem Funding and Research Period: 2 years -- $50 - 100,000.

V. URGENCY - Pavement maintenance now exceeds 50 percent of the maintenance dollar and the effects of water cause the major repair jobs. This trend will continue unless the water can be controlled. This is an immediate problem and work should begin as soon as possible on the synthesis.

PROBLEM NO. 85 - COMMITTEE A2F03 & A2T61

I. NAME OF PROBLEM - MORE EFFICIENT UTILIZATION OF WET EARTH MATERIALS IN EMBANKMENT CONSTRUCTION

II. THE PROBLEM - The problem of drying wet soil is a major deterrent to construction progress. The traditional process is almost entirely dependent on the weather and entails many hours of aeration and manipulation to bring the embankment material to the desired moisture content. The procedure is costly in time, labor and energy. Methods, equipment and additives need to be developed to permit more efficient drying or stabilization of wet earth materials being placed in compacted embankments. Methods that heretofore were considered too costly may now merit reconsideration in the light of rising energy costs and shortages. The problem grows more acute each day. Without progressive, energy saving procedures the cost of embankment construction in money and energy may become completely prohibitive.

III. OBJECTIVES - To develop methods which will permit more efficient utilization of wet earth materials in embankment construction with resultant savings in energy and increased construction activity during weather not conducive to conventional drying.

IV. CURRENT ACTIVITIES -

Subject areas: No. 33 Construction
No. 41 Construction and Maintenance Equipment.

V. KEY WORDS - Earthwork, wet earth materials, drying, energy consumption, energy optimization.

PROBLEM NO. 86 - COMMITTEE A2F04

I. NAME OF PROBLEM - EPOXY COATING OF PRESTRESS STRAND

II. THE PROBLEM - In continuous prestressed concrete box girder structures the prestress strands are located in the top slab or the deck over the negative moment areas, thereby, becoming exposed to deicing chemicals and the corrosive condition that these chlorides induce. In normal concrete bridge decks the corrosion of deck steel does not normally effect the structural integrity of the total structure but only the deck. This is not the case with continuous box girder bridges where the principle prestress load carrying strands are placed in the concrete deck and would be subjected to active corrosion due to chloride contamination, thereby, effecting the structural integrity of the total structure.

III. OBJECTIVES - The objective is to develop the feasibility of expoxy coating prestressing strand in a manner similar to that commonly done with normal mild steel rebars used in today's concrete bridge decks.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 4, 6, 10, 12 and 18 have been scanned in preparing this statement.

B. Suggested key words: prestressed concrete, prestress strands, epoxy coating, bridge decks, deicing chemicals.

C. Epoxy coating of rebars as protection has recently proven viable following research by FHWA's Fairbanks Research Laboratory which proved its effectiveness. NCHRP Project 12-5 should be useful for this proposed project but it was complete in 1968 prior to the use of epoxy coating on rebars.

V. URGENCY - The increasing use of prestress concrete bridges in the form of long span segmental bridges increased the potential damage that an ever increasing use of deicing chemicals (chlorides) can have on a major structure. To date we have concentrated on protecting the top layer of concrete bridge deck rebars but directly beneath these rebars we currently place prestress strands in the negative moment regions of the bridge and it behooves us to start protecting the strand at the earliest possible time where any stress corrosion of the strand would be critical to the integrity of the bridge.

PROBLEM NO. 87 - COMMITTEE A2F04

I. NAME OF PROBLEM - REHABILITATION OF CONCRETE BRIDGE DECKS SUBJECTED TO PRINCIPAL LOAD CARRYING STRESSES

II. THE PROBLEM - The removal and/or rehabilitation of the normal stringer supported concrete bridge deck is today fairly routine and equally successful. However, there is much greater concern over the proper manner of replacing entire or large concrete bridge deck areas when the deck is an integral part of the total structure carrying principal stresses.

III. OBJECTIVES - The objective would be to develop limits of deck removal that would be permissible while utilizing acceptable procedures. This limit could vary depending on procedures followed. A second objective would be to identify acceptable procedures including specifications for special materials that are critical to success of each procedure or system found acceptable.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 6, 10, 12, 14 and 18 have been scanned in preparing this statement.

B. Suggested key words: Concrete Bridge Decks, Rehabilitation, Continuous Bridges.

C. Currently many projects are involved with the rehabilitation of unstressed or stringer supported decks and this data should be useful to the development of materials and procedures for similar concrete bridge decks that are subjected to principal load carrying stresses.

V. URGENCY - Rehabilitation of concrete bridge decks is today of national importance with an estimated need of 1.7 billion dollars just to rehabilitate those bridge decks on the Interstate System. Many of the decks are in poor or moderate condition (approximately 4,000) and many of these are box girder, continuous prestress or other such structures where the deck furnishes an integral segment of the overall bridge support system. These decks if not rehabilitated in the near future can cause a serious impact on our nation's highway systems if the only answer is a replacement of the entire bridge.

PROBLEM NO. 88 - COMMITTEE A2F04

I. NAME OF PROBLEM - TESTING WELD HEAT-AFFECTED-ZONE FOR FRACTURE TOUGHNESS

II. THE PROBLEM - For three decades, welding metallurgists and welding engineers have been testing weld joints for notch sensitivity. Little difficulty has been encountered in the case of deposited weld metal, but heat-affected-zone test results can be very misleading. The main problem in testing weld heat-affected-zone is the steep gradient of microstructure present.

III. OBJECTIVES - The objective of this research is to evaluate the precrack Charpy impact

composite specimen as a test of weld heat-affected-zone in bridge steels.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 4, 10 and 12 have been scanned in preparing this statement.

B. Suggested key words: weld testing, fracture mechanics, fracture toughness.

C. Background: In the mid-1950's, researchers at the Watertown Arsenal (now AMMRC) developed a test method based on the Charpy V-notch (CVN) impact test for determining:

1. the relative toughness of the weld metal and weld heat-affected-zone.

2. the microstructure causing crack initiation and

3. the transition-temperature behavior of the weld metal and weld heat-affected-zone simultaneously.

The test method utilizes a composite test specimen, usually double the standard Charpy width, containing both weld metal and weld heat-affected-zone in each test piece. Four to six test specimens are required to determine the magnitude of low-energy blow to initiate cracking in the test piece, and five to ten tests are required to determine the resistance to crack propagation in the weld joint as a function of temperature.

Thus, a method is available for getting meaningful data on both the crack-initiation and crack-propagation resistance of weld heat-affected-zone but the method has not been used on bridge steels.

V. URGENCY - In fracture critical bridge members (components whose failure could cause collapse of the bridge) there is an urgent need for data on weld heat-affected-zone (HAZ) toughness. There is no provision in the AWS/AASHTO Structural Welding Code for HAZ testing, and yet the weld region is the most likely place for crack initiation.

When fatigue cracks form at the toe of a fillet weld or at the toe of the weld reinforcement of a butt-weld splice, the crack is initially in HAZ. A method for measuring the properties of the HAZ is necessary if we are to understand the weld behavior, and if we are to realistically specify weld-joint properties.

PROBLEM NO. 89 - COMMITTEE A2F07

I. NAME OF PROBLEM - NDT BRIDGE INSPECTION GUIDELINES BASED ON FAILURE STUDIES

II. THE PROBLEM - NDT personnel generally can be trained through ASNT-TC-1A guidelines and others to know how to operate inspection equipment, but they normally do not have the inside knowledge to know where and what type of defects to look for.

On the other hand, there are those who are very familiar where fatigue cracks are likely to be based on fatigue research and testing. Much of this has been published directed toward the Bridge Design Engineers. This knowledge from research and failure studies needs to be incorporated into NDT inspection guides and specifications.

III. OBJECTIVES - To build up a pictorial reference file on where cracking problems are likely to occur, and therefore give guidance on what inspection and approach is most likely to detect the critical flaws. Most information can be obtained from literature synthesis and then reviewed and approved by selected Welding Engineers, Testing Laboratory Specialists (Research or Commercial), and from Professional Engineers responsible for existing bridge inspection programs.

IV. CURRENT ACTIVITIES -

A. The following published literature may be of help:

1. NCHRP Reports 25, 102, 147, 181.

2. NCHRP Records 253, 295, 354, 359, 400, 428, 607.

3. NCHRP Special Reports 61D, 71, 114.

B. Suggested key words: NDT, Bridge Structures, Cracking.

C. Recent studies have done much to locate the critical fracture initiation points due to fatigue loading, but these have not been integrated into NDT test sequences for both new construction and in-service inspections. One example is the need to develop a special procedure to inspect existing electro-slag welds in bridges.

V. URGENCY - The sooner that we can develop inspection techniques to detect critical flaw areas, the less chance for a total bridge failure.

PROBLEM NO. 90 - COMMITTEE A2F07

I. NAME OF PROBLEM - WELDING REPAIR PROCEDURE

II. THE PROBLEM - The area of weld repairs has suffered much abuse over the years and is in dire need of upgrading. Current codes and specifications barely address the subject except for a few generalized statements which are vague or arbitrary in themselves. Repair procedures presently being used in many shops create a greater potential for failure than the original defect would have, if left in place. This is a growing concern of many practicing engineers; that is, "the cure is worse than the illness."

III. OBJECTIVES - Research is needed to better determine the size and type of weld defects which must be removed. Once a new level of acceptance criteria has been established the research should then standardize all repair procedures. Parameters such as; type and method of excavation, preheat, size of electrode, post heat, normalizing, etc. must be spelled out.

The deleterious effect of repair welds resulting in localized areas of high residual stress must be investigated in depth as well as the advantages of normalizing such welds. The latter should be a major part of this research.

The results of this study should be to recommend to the various code writing bodies a detailed standard procedure for making stress free (or as low as possible) weld repairs to all or most weldments.

PROBLEM NO. 91 - COMMITTEE A2G01

I. NAME OF PROBLEM - APPLICABILITY OF PRESENT AGGREGATE TEST METHODS TO RECYCLED PORTLAND CEMENT CONCRETE

II. THE PROBLEM - With the shortage of natural aggregates in some areas, and also in an effort toward economy, the use of recycled PCC as aggregate in new paving mixtures is becoming more widespread. With this increase in usage the question of applicability of current aggregate test methods to this material becomes more critical. Study is needed to determine if these tests characterize recycled PCC as correctly as they do natural material. If current tests can not be applied modifications to current tests or new tests need to be developed for this material.

III. OBJECTIVES -

A. Determine the applicability of current aggregate tests to recycled PCC by comparison of test results and performance.

B. If present methods prove inadequate, develop modifications or new methods in order to make test results correlate with performance.

IV. CURRENT ACTIVITIES -

A. A synthesis report for NCHRP Project 20-5, Topic 8, "Recycling Materials for Highways," has been completed and is in NCHRP editorial and publication process. Also currently underway is NCHRP Project 1-17, "Guidelines for Recycling Pavement Materials," which is developing a process for selection of the most suitable pavement rehabilitation alternative. Most research efforts in recycling materials to this time are concerned with bituminous mixtures; now, however, as more portland cement concrete is recycled, the need for the test information will intensify.

B. Suggested key words: Recycled PC concrete aggregates, aggregate properties, aggregate characteristics, aggregate test methods, construction materials.

V. URGENCY - Information on the characteristics of crushed concrete when used as an aggregate is needed to insure the quality of the pavement and also to insure that the recycled material is employed in a mixture and environment best suited to its behavior. Proper use of this material will supplement current supplies of natural aggregate which are marginal in a number of areas.

VI. SUGGESTED PROGRAM -

A. Review existing literature for studies on the recycling of portland cement concrete, with particular emphasis on the testing carried out in conjunction with the recycling projects.

B. Determine, with the aid of an advisory panel, those tests which most need evaluation when used on recycled concrete.

C. Once the tests to be evaluated have been selected, run a series of tests on a variety of crushed concrete samples. Where possible obtain samples of concrete which has already been recycled.

D. Incorporate samples of the material tested in Task C into portland cement concrete pavement in order to monitor the field performance. For samples in Task C which had already been used in a pavement, this information should be available.

E. Compare predicted performance of Task C and actual performance in Task D and modify test methods as necessary to bring the two into agreement.

Estimated time: 3 years
Estimated cost: $250,000

PROBLEM NO. 92 - COMMITTEE A2G01

I. NAME OF PROBLEM - CHARACTERIZATION OF ACCEPTABLE AGGREGATES FOR PORTLAND CEMENT CONCRETE PAVEMENT

II. THE PROBLEM - Information on (1) the correlation between aggregate properties and their performance in PCC pavement and (2) appropriate test methods predictive of that performance need to be developed. The lack of this information prevents optimum use of currently available aggregates and also proper development of new supplies of aggregates for PCC pavement construction.

III. OBJECTIVES -

A. Determine the correlation between quantitatively different levels of aggregate properties and their performance in PCC pavements.

B. Develop suitable test methods for predicting field performance through review and modification of existing tests or development of new test procedures where existing methods are inadequate or nonexistant.

C. Develop aggregate specifications based on fundamental properties. These specifications would relate to performance criteria so that aggregate selection can be suited to the

requirements of a particular job and location.

IV. CURRENT ACTIVITIES -

A. This problem statement is a modification of Problem Statement No. 48 which was developed on NCHRP Project 4-10. The modification limits the area addressed to the characterization of aggregates used in PCC pavements. This change was required by the undertaking of NCHRP Study 10-12 (see current research, Item C).

B. Suggested key words: aggregates, aggregate properties, aggregate characteristics, physical and chemical properties, engineering characteristics construction materials, PC concrete aggregates.

C. Current related research includes the NCHRP Project 10-12 on the acceptance of aggregates used in bituminous paving mixtures. This research is addressing the problem originally raised in Problem Statement Number 48 only as it applies to bituminous mixtures. Therefore, that portion of the problem concerning PCC concrete aggregates is yet to be attacked. Other research includes studies of the wear resistance, abrasion resistance, polishing characteristics, load deformation characteristics as a function of geometric properties, toughness, and petrological characteristics of selected aggregates. In a limited number of studies, performance is being related to aggregate properties.

V. URGENCY - Information on the characteristics of aggregates that affect performance in portland cement concrete is needed to permit the design of pavements that will serve traffic throughout their design life. A high priority should be assigned to this effort to enable the development or revision of design criteria and, thereby, reduce the number of pavements that will be constructed to "improper" standards.

Estimated time: 3 years

Estimated cost: $300,000

VI. SUGGESTED PROGRAM -

A. Review of existing test methods by a steering committee composed of (a) engineers knowledgeable in highway construction, performance, and testing; (b) scientists knowledgeable in characterization of raw materials and products; and (c) geologists and plastics experts. This committee first should determine the aggregate properties and the existing test methods that correlate with performance, then recommend the aggregate properties that require further investigation and the test procedures that should be developed. The committee should meet bi-monthly, after formulation of the initial plan, to review the project performance and to determine the direction of the research.

B. Investigate in the laboratory the characterization of aggregates in accordance with the plan previously developed. It is anticipated that the characterization would evaluate the variety of aggregates that have known differences in field performance. The properties evaluated may include: strength, pore quantity, toughness, particle size distribution, pore size distribution, particle shape, abrasion resistance and hardness, wettability by different classes of cementitious agents, adhesion strength of different types of cementitious agents, drainage characteristics and water retentivity, thermal expansion, moisture expansion, surface characteristics, soundness of a composite under repeated temperature and moisture cycling (weatherability), composition, soluble salts.

C. Prepare proposed specifications for aggregate properties based on the knowledge gained from the research outlined previously. The specifications should recognize different levels of performance to assist in the characterization of aggregates for particular job localities and requirements.

PROBLEM NO. 93 - COMMITTEE A2G02

I. NAME OF PROBLEM - ECONOMICAL PRIMERS OR SUBSTRATES FOR TRAFFIC PAINTS

II. THE PROBLEM - The adhesion of traffic paints is better to asphalt than to Portland cement concrete or to some aggregates used in asphalt-type paving. The space between aggregate particles protruding above the asphalt surfaces of asphalt-type pavements are voids into which traffic paint is placed. These painted voids add little to the visibility of the markings because in dry weather the voids collect dirt and during wet weather they hold water. The effectiveness of a stripe is reduced when it is covered by dirt or water. The current trend toward skid-resistant pavements is resulting in higher protruding aggregates.

The cost of paint is increasing. Filling such voids with paint unnecessarily increases the cost of pavement markings.

III. OBJECTIVES -

1. Improved adhesion between painted pavement markings and concrete through use of a primer.

2. Develop primer-filler, more economical than paint, that can be used to fill voids between aggregate in asphalt-type pavement.

3. Provide raised base for paint stripe that will raise stripe above water on the road so that night visibility of the stripe will be improved during rain storms.

4. Develop procedures for applying acceptable systems.

IV. CURRENT ACTIVITIES -

A search of NCHRP Areas 3, 4, 5, 9 and 17 failed to show any related activity. District 16 of the Texas State Department of Highways and Public Transportation has done some preliminary work.

V. SUGGESTED WORK

1. Investigate use of asphalt-additive (such as latex) mixtures as adhesion improves.

2. Investigate asphalt-additive-filler mixtures as economical bases to fill voids and to elevate the stripe.

3. Develop and evaluate other systems that could be used as a primer or void filler.

4. Develop procedures for applying acceptable systems.

VI. URGENCY

Improving the efficiency and economics of pavement marking is a universal problem. The cost of marking materials has nearly doubled in the past five years and such costs continue to go up.

PROBLEM NO. 94 - COMMITTEE A2G03

I. NAME OF PROBLEM - MEASUREMENT AND PREDICTION OF JOINT WIDTH VARIATION IN CONCRETE PAVEMENTS

II. THE PROBLEM - Joints in concrete pavements are usually sealed without theoretical (numerical) consideration and coordination of factors such as the joint width, variation in joint width, capabilities of the sealant, and the time of year the joint is sealed. This leads to unpredictable behavior and varied effectiveness of the joint-sealant system.

III. OBJECTIVES - The main objective of this research is to come up with a method of predicting joint width variation so that proper initial joint width and a matching sealant can be used for a particular job. The research should include a Literature study, establishment of a predictive model for joint movement, field measurements on actual pavements in different locations of the country, and finalization of a practical predictive model.

IV. CURRENT ACTIVITIES -

A. Bibliography and research in progress has been scanned.

B. Suggested key words: sealants, joints, pavements.

C. There are a number of data sources on joint movements and sealants available, but a comprehensive field and theoretical study with a goal to predict joint movements for pavements is still lacking.

V. URGENCY - Since many joint sealing efforts have resulted in less-than-satisfactory results, the study appears to be timely and urgent. The knowledge gained should be useful not only for new concrete pavements but also for resealing and maintenance operations.

PROBLEM NO. 95 - COMMITTEE A2G03

I. NAME OF PROBLEM - A STUDY OF BRIDGE JOINT MOVEMENTS

II. THE PROBLEM - Bridges move. The sealing system for the bridge must respond to the bridge movement. The movement may be a straight distance change caused by temperature and moisture or it may be a racking type of distortion from the many variations of skews, horizontal, angular vertical and articulating motion patterns. There may also be impact, vibration of slab ends, or creep and plastic flow which cause permanent changes in deck length.

It is critical that bridge joints be sealed to prevent the entry of both water and incompressibles. Literally hundreds of examples can be shown of bridges with badly deteriorated pier caps, abutments and beam ends, which are caused by poorly sealed bridge joints.

III. OBJECTIVES - The main objectives of the program is to measure the amount and type of bridge joint movements. This should define the limits of the problem so that sealing systems can be designed to accommodate this movement.

Most bridges have at least some angle of skew. This may include two or more angular changes in the line of a joint, such as horizontal and vertical change, concentrated at the curb line. The joint measurements must include the curb areas because of its high vulnerability.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas, one, four, twelve and twenty-one have been scanned in preparing this statement.

B. Suggested key words: BRIDGES, JOINTS, JOINT SEALS, PAVEMENT MOVEMENT, TEMPERATURE, CREEP, SKEW.

C. Related research activities would be the AASHO ROADTEST results, the Delmar By-Pass project by NY DOT, the work done by Cook and Minkarah for Ohio DOT and FHWA, Van Breemen's work in New Jersey and other records of pavement movement such as those by Kentucky and Connecticut.

V. URGENCY - This project is considered to be critical by TRB Committee A2G03. There are standing at the moment many bridges in need of immediate repair because this problem has not been solved.

The research findings could be immediately

implemented in the form of a Guide Specification which would define the movement parameters for bridge joint seal design.

PROBLEM NO. 96 - COMMITTEE A2G03

I. NAME OF PROBLEM - RESTRAINING THE END MOVEMENTS OF RIGID JOINTED PAVEMENTS AT STRUCTURES

II. THE PROBLEM - Many bridge joints are made inoperative and, in some cases, even destroyed because rigid pavements often encroach on a structure. The lengthening of the pavement is usually caused by the infiltration of debris into the joints and cracks. Physically, what happens is that the pavement expands as a unit from the mid-length point outward as a long column, but upon contracting each slab's movements are centered upon its own mid-length point because there is no elastic restoring force to push the column back together. These open joints become filled with debris and, on the next expansion cycle, the column pushes outward a little further. Eventually, the pavement either blows up or it shoves the abutment or endwall.

As it is difficult enough to design a bridge joint for normal movements, it presently becomes doubly difficult to predict and design against encroachment. The use of expansion joints or pressure relief joints in the pavement is not the answer, as it removes the elastic restraint and the pavement lengthens more quickly. It is not unusual to see a 4 inch pressure relief joint become completely closed in 3 or 4 years. A pressure relief joint saves the structure, but ruins the integrity of the pavement. Fortunately, a pavement is not inherently an unstable column as evidenced by the existing long sections (several miles) of continuously reinforced concrete pavements which do not blow-up. Similarly behaving are the long sections of short plain slabs, such as used in California, which seldom blow-up.

Present Lug systems used on CRCP have been effective in at least halving the normal movements, from 2 to 3 inches to less than 1 inch. Technology may be such that bridge end walls could be utilized and properly designed to resist thrust, much have economically.

III. OBJECTIVES - The objective of this study is to develop an anchorage system for the terminals of jointed rigid pavements to prevent the pavement from encroaching on bridge structures. In addition to the sparsely investigated pile/lag soil anchors and subbase friction, thrust-resistant endwalls and/or tiebacks will be investigated.

IV. CURRENT ACTIVITIES -

A. NCHRP Synthesis was published on bridge approach slabs in 1969.

B. Several HPR studies have been conducted on bridge approach slabs, but most were concerned with settlement. Two HPR studies on settlement are underway.

C. TRB Committee A2B01 published SR173 in 1977 on the subject, "Design of Terminals for Rigid Pavements to Control End Movements: State of the Art."

D. Mississippi conducted an HPR study in the mid-60's on controlling pavement end movements. An excellent report, but it hardly touches the solution.

E. Numerous reports are available on blow-ups, but none attacks the problem outlined here.

V. URGENCY - This study is considered urgent because of the widespread distress which exists around the country. Expensive joints are being destroyed and major arteries are repaired under extremely hazardous conditions for drivers and workers. If FHWA is to institute "Zero Maintenance" pavement concepts, the bridges and joints at the transitions must be compatible. Similarly, new pavements are added to the growing list for rehabilitation.

PROBLEM NO. 97 - COMMITTEE A2G03

I. NAME OF PROBLEM - SILICONE SEALANTS FOR HIGHWAY RIGID PAVEMENTS

II. THE PROBLEM - The limited use of low modulus one component silicone sealants for sealing of contraction joints in rigid pavements shows that it has the capability to effectively seal out surface water if the right material is properly installed. The following questions need to be answered.

1. What physical properties should a seal have to be effective?

2. What performance can be expected?

3. Is the sealing with silicone cost effective?

4. What are the design criteria?

III. OBJECTIVES - The objective is to develop design criteria and specifications for silicone sealants and evaluate their performance.

IV. CURRENT ACTIVITIES -

A. Some successful installations have been made. Silicones have been proven as building sealants, but the disadvantage of a slow cure has precluded their use on highways.

B. Suggested key words: sealants, silicone, specifications, performance.

C. Projects are being sealed in Georgia with low modulus silicone, but very little information is available on silicones as highway contraction joint sealants.

V. URGENCY - An effective highway joint sealant has been sought with some degree of success, but the ideal sealant system has not been found. Preformed seals have the disadvantage that they require a perfect joint if the seal is to be effective and often are not watertight. Field molded polymers

undergo changes in properties with temperature. When the weather is cold and sealants are required to extend the modulus is higher and great stress is placed on bond surfaces.

Silicones are relatively temperature stable and may extend in cold weather without producing significant increases in levels of stress on contact surfaces. They can also be applied in cool weather and since they are field molded can seal a joint with small spalls and imperfections. Silicones have the potential of providing a good durable seal. This potential should be investigated immediately for applicability as a roadway joint sealant.

PROBLEM NO. 98 - COMMITTEE A2G04

I. NAME OF PROBLEM - CREEP AND STRESS-RELIEF PROPERTIES OF EPOXY ADHESIVES IN TRANSPORTATION

II. THE PROBLEM - Epoxy Resins have been in use as adhesives for over 20 years. Their use was pioneered by the aerospace industry where they are employed extensively as structural bonding agents. In this area, their long-term, time-dependent properties have been well-characterized allowing structural and mechanical engineers to apply normal design procedures established for metals to adhesive bonded segments.

It has not been possible for civil engineers to transfer this technology to highway, bridge and mass transportation construction and repair, since the majority of aerospace adhesives are formulated for performance criteria which necessitates elevated temperature cures: feasible for aircraft parts but seldom possible in transportation engineering applications due to the large size of the structures involved.

Epoxy resin adhesives, cured at ambient temperatures, are currently used in a wide variety of applications in the transportation field.

Typical areas involving potential primary structural loads where creep may be a factor are -

1. Bonding of precast elements in segmental bridge construction.
2. Grouting of metal bolts in PCC for use as stress connectors in pre-stressed and post-stressed construction.
3. Pressure injection of liquid epoxy adhesives into cracked PCC structures to restore their integrity, e.g. bridge decks, elevated freeways, and bridge support columns and beams.
4. As shear connectors for fabrication of steel/PCC composites such as bonding fresh PCC to steel T-beams.
5. Potential structural applications of epoxy admixed in PCC to improve tensile properties and resist salt degradation.
6. Rail bedding compounds for mass transportation construction.

Other applications of epoxy resins require a degree of creep or stress-relief to occur to compensate for the wide difference in thermal contraction between epoxy and PCC or steel in cold climates:

1. Bridge deck patching mortars
2. Bridge deck mortar overlays
3. Bridge deck "nosings" and joint repair.
4. General repair of PCC spalls and pop-outs.

Many companies formulate epoxies and many more compounded epoxy systems are available to the highway engineer. These compounds are usually defined by their short term mechanical, thermal, and chemical and water resistance properties as well as handling characteristics. Long-term properties such as creep and stress relaxation or relief and the inter-related effects of humidity, water, varying ambient temperatures and vibration from wind or traffic on these properties are almost never available. The raw material manufacturers have also not generated this type of data.

The availability of such information would perform two main functions:

1. Provide assurance as to the long-term durability of existing and proposed bonded structures.
2. Increase the efficiency of certain construction procedures by allowing the use of epoxy bonding through a rational consideration of the basic structural criteria of adhesives and application of such data in primary load design.

III. OBJECTIVES -

1. Survey the literature for long-term test data and test methods applicable to bonded steel and PCC relevant to structural and mechanical design in the transportation field.
2. Develop tentative performance criteria giving particular attention to the shape factor.
3. Select a representative group of proprietary formulated epoxy compounds commonly used in the transportation field by contact with State Highway Departments and perform preliminary tests on these compounds simulating various typical field conditions of load, deflection, moisture, heat and vibration. Perform short-term tests, e.g. deflection temperature and initial creep curves.
4. Extrapolate initial results and compare data with a generic chemical description of the system obtained from the manufacturer e.g. Bisphenol A-based epoxy with reactive diluent cured with plasticized aliphatic amine and containing inert filler.

5. Eliminate unpromising generic groups and expand testing on promising groups; optimize test conditions and record data for an initial period of one year.

6. Perform structural calculations and define limits of acceptance for typical adhesive applications in the transportation field for various types of joint configuration. Compare the most promising group for stress-relief and creep resistance with their short-term mechanical/thermal properties.

7. Prepare suggested specifications for epoxy compounds meeting selected generic classification and short-term mechanical tests which correlate with creep resistance and stress-relief.

OBJECTIVES - Phase II:

Continue recording results of promising systems for up to five years.

IV. CURRENT ACTIVITIES -

A. No HRIP's known.

B. Suggested key words: epoxy adhesives, epoxy mortars, epoxy grouts, epoxy sealants -

In relation to creep, stress-relaxation, stress-relief, long-term performance, time-dependent properties, stress transfer, stress properties, strain properties, thermal expansion, compatability with PCC, thermal effects, load carrying ability.

C. Selected references:

A selected review of published material revealed very few references. Johnson's work appears to be the most definitive.

Johnson, R. P., "Glue Joints for Structural Concrete," The Structural Engineer, Vol. 41, No. 10, 1963

Johnson, R. P., "Creep Tests on Glued Joints," Proc. Conf. Industrialized Building and the Structural Engineer, Inst. of Structural Engineers, London, 1967.

Johnson, R. P., "The Properties of an Epoxy Mortar and Its Use for Structural Joints," The Structural Engineer, No. 6, Vol. 48, 1970.

Kreigh, J. D., "The Use of Epoxy Resins in Reinforced Concrete--Dynamic Load Tests," Final Report No. 3 to Arizona Highway Department, Engineering Research Laboratory, University of Arizona, 1963.

Hugenschmidt, F., "Epoxy Adhesives in Pre-cast, Pre-stressed Concrete Construction," Journal of the Prestressed Concrete Institute, Vol. 19, No. 2, 1974.

Hickey, K. B., "Concrete and Epoxy Material Compared: Load Properties, Durability and Volume Change," Report No. C-1313, Concrete and Structural Branch, Division of Research, U.S. Bureau of Reclamation, 1969.

Howdyshell, P. A., "Creep Characteristics of Polyester Concrete," Report M-23, Construction Engineering Research Laboratory, Corps of Engineers, 1972.

V. URGENCY - The structural performance with time of most adhesives currently used in transportation is unknown, a situation with the potential for failure. Precast segmental bridge construction is being introduced in the U.S. from Europe. Background data on domestic adhesives for this application is largely unavailable. Epoxy adhesives are in general used for bolt grouting where creep resistance is required but criteria is unavailable. This also applies to their use as "bedding" or "chocking" compounds under, for example, rails in mass transportation. The literature contains totally conflicting criteria as to whether pressure injected epoxy adhesives, used to restore bridge decks, beams and columns, should be creep resistant to transfer load or stress-relieved to "prevent adjacent cracking."

In many other areas such as bridge deck patching compounds and overlays, a degree of stress-relief is required to prevent cracking of the PCC underlay in cold weather. Lack of criteria in this area has frequently lead to specification of materials that have subsequently failed.

ESTIMATE:

Phase I $100,000

Phase II To be determined

PROBLEM NO. 99 - COMMITTEE A2G04

I. NAME OF PROBLEM - IDENTIFICATION OF DANGEROUS CHEMICALS USED IN TRANSPORTATION ADHESIVES AND SEALANTS

II. THE PROBLEM - A greater awareness of the human health hazards of industrial chemicals has occurred over the past few years as a result of new medical findings and increased concern by both the general public, unions, industry and government. Problems of legal liability and widespread publicity have served to heighten these concerns.

Synthetic resin adhesives, grouts, mortars and sealants have been employed in a variety of applications for transportation construction and repair since the early 1950's when the ability to assess human health hazards, especially long-term hazards, was less sophisticated. The dangers of many industrial chemicals used traditionally have now been re-assessed or are undergoing reassessment.

A number of these findings have been encoded in the State and Federal regulations covering transportation, handling, and use such as CFR 29, 1910 (OSHA), CFR 16, 1500

(Federal Hazardous Substances Act), CFR 49 (DOT), CFR 21,121 (FDA) and the new EPA's "Toxic Substances Control Act" at present undergoing implementation. NIOSH summarizes existing toxicity information in their annual publication "Registry of Toxic Effects of Chemical Substances" and in NIOSH sub-file "Suspected Carcinogens".

Difficulties occur in implementing these regulations and other published findings by both Federal and State agencies and industrial formulators when developing, manufacturing and specifying synthetic resin-based compounds since interpretation requires specialized chemical knowledge and an understanding of bio-medical terminology. Compounded materials may be carcinogenic, poisonous, corrosive, irritant, sensitizing, or flammable or may present other unusual hazards, yet these may not be recognized by the formulator.

The result is that certain State Highway Departments who publish compositional-type specifications sometimes specify unusually hazardous materials unknowingly, a situation that also applies to some formulators in meeting the physical requirements of the majority of State Highway Department non-compositional, performance-type specifications.

A typical example is found in the AASHTO specifications:

M 200-73, Class I

A coal tar pitch containing high boiling coal tar distillate is generally used to meet physical specification requirements; the distillate is a known human carcinogen; formula also typically contains phenol - a poison and DTA - a corrosive.

M235-73, Class I and Class II

Specifies butyl glycidyl ether, an extreme breathing hazard and mutagen and talc without a limit on the fiber content (fibrous talc is asbestos).

M 237-73

Specifies butyl glycidyl ether and talc as in M 235 and in addition asbestos, a known human carcinogen and aminoethyl piperazine, a corrosive.

AASHTO M 234-73 provides a caution label for M 200, 235 and 237 which warns only against "severe dermatitis" and, as such, does not conform to the pre-emptive Federal regulations which require specific labels warning against specific hazards.

Fortunately only a minority of raw materials used in synthetic resin based compounds present extreme dangers such as carcinogenity and for practically all of these less hazardous alternatives are available. Therefore, the general objective of this project involves identifying the raw materials currently employed according to their specific hazards and any applicable state and Federal regulations to which they must conform during formulation, transportation, handling and use. Where potential or proven alternatives exist, these should also be identified.

This specific project is limited in scope to two-component, synthetic resin-based products that undergo chemical reaction at ambient temperatures upon addition of a catalyst, hardener, curing agent, or co-reactive resin--typically systems based on epoxies, polyesters, polyurethanes, vinyl esters, polyureas, and special acrylics and silicones.

In addition, environmental considerations of air, water, and earth polution and the effect on other life forms are excluded; the project being limited to direct human health hazards. Due to the amount of information currently available, no significant amount of biological testing is envisaged and any such testing will be limited to short-term routine testing of a select group of raw materials where published data is clearly contradictory.

It is further intended that interpretation of available biological evidence be clearly referenced as to source in order to avoid legal implications of project findings as original source data.

III. OBJECTIVES -

1. Survey the State Highway Departments, relevant departments of the Federal Government, (e.g. Corps of Engineers) and relevant associations (e.g. AASHTO, ACI) and determine the generic classes of base synthetic resins used in transportation construction and repair (e.g. epoxies, polyesters, etc.) and obtain available specifications.

2. Prepare a comprehensive listing of industrial chemicals used in formulating the various generic classes of resins that cure at room temperature, derived from the standard text books on the subject, other well-recognized publications, the specifications from Task I and by contact with the major resin, hardener, and catalyst raw material manufacturers, selected major formulators and other sources of significant expertise in the field.

3. Classify these raw materials firstly by the type of synthetic resin in which they are commonly employed and secondly by their function in the formulation (e.g. 1 epoxy resins, 1.1 hardeners, 1.2 diluents, 1.3 flexibilizers, 1.4 plasticizers, 1.5 fillers, 1.6 liquid extenders, 1.7 pigments, 1.8 thixatroping agents, etc.)

4. Survey the available sources of toxicity data relating to industrial chemicals including NIOSH, the EPA Inventory List (being established under the Toxic Substances Control Act), the various CFR's previously listed and the medical data obtained by the various raw material manufacturers used to prepare their MSDS's on specific materials. Include in this survey existing and proposed State and Federal regulations covering handling and

labeling during formula manufacture, transportation, application, and end use exposure of the various raw materials involved.

5. Classify each material according to its hazards and regulations using, as far as possible, terms easily understood by the typical formulator or specification engineer, (e.g. cancer-suspect agent, poison, corrosive for transportation, skin corrosive for handling, etc.). Terms used to describe the raw materials should not be trade names(1) or generic descriptions but the most commonly used chemical name and composition, if a mixture.

6. Review the hazard classifications for cancer-suspect agents, poisons and any other extremely dangerous materials and suggest potential or proven alternatives for these specific materials derived by contact with industry.

7. Identify any widely used raw materials where health hazard data from various sources is in clear conflict or does not exist and prepare a budget for testing these raw materials by short-time tests contained in the CFR's. Such work, if any, will form Phase II of the project after Panel approval.

8. It is intended that the results of Phase I will be circulated to State Highway Departments, Federal agencies and formulators bidding on State and Federal performance specifications as a series of separate documents according to the generic classification of the synthetic resin base involved.

IV. CURRENT ACTIVITIES -

A. No HRIP in this specific area known.

B. Suggested key words: safety, toxicity, hazardous substances, toxic substances, toxicology, health hazards, handling, allergies, precautions, personnel protection, systemic effects, carcinogens, suspected carcinogens, skin corrosives, eye corrosives, poisons, skin irritants, eye irritants, skin sensitizers, dermatitis, anitdotes, biological activity, transportation regulations, FDA approval.

In relation to - resins, synthetic resins, epoxy resins, polyurethane resins, polyester resins, silicone resins, vinyl esters, polyureas, acrylics.

V. URGENCY - There is an immediate and urgent concern as to the health hazards posed by synthetic resin compounds to State maintenance forces, to contractors to the State and Federal Government, and to plant workers manufacturing for the State and Federal Government. There is the immediate and urgent question of the burden of legal liability where the State, Federal government and such organizations as AASHTO specify dangerous raw materials without prior warning of same. There is an immediate concern regarding the supply of proprietary compounds which may contain dangerous raw materials, perhaps known or unknown to the smaller formulators, to State and Federal Government specifying the performance of materials; with incorrect or incomplete warning labels.

Although new toxicity data is still being generated, it is probably that this process will continue indefinitely, thus identification of the most dangerous raw materials, based on current knowledge would be beneficial since currently known dangerous materials are unlikely to be re-classified less dangerous, rather the reverse.

Estimate:

Phase I $50,000

Phase II To be determined

PROBLEM NO. 100 - COMMITTEE A2G05

I. NAME OF PROBLEM - THIN ELECTRICALLY CONDUCTIVE WATERPROOF LAYER FOR CATHODIC PROTECTION OF BRIDGE DECKS

II. THE PROBLEM - Many reinforced concrete bridge decks are showing distress due to the corrosion of the upper layers of reinforcing steel. The application of cathodic protection, after the decks are repaired, to prevent further corrosion requires the application of two lifts of asphaltic concrete, the first an electrically conductive layer and the second a wearing course. If the bridge is marginal in its load bearing capacity such added weight to the structure may be intolerable. Another problem with current mixes used for cathodic protection is that they are not waterproof and allow water to reach the concrete surface. If the concrete is of poor quality and does not contain entrained air freeze-thaw damage may result.

III. OBJECTIVES -

1. To develop a thin electrically conductive layer for the cathodic protection of bridge decks. Such a layer must have high electrical conductivity and be waterproof to prevent moisture from reaching the bridge deck surface.

2. To develop a method using wires or other means to distribute the electric current evenly throughout the thin conductive layer.

IV. ADVANTAGES -

Such an electrically conductive layer would permit:

1. The application of cathodic protection to all concrete bridge decks.

2. Minimize the height to which deck scuppers and expansion joints would have to be raised.

PROBLEM NO. 101 - COMMITTEE A2G05

I. NAME OF PROBLEM - PROTECTION OF REBARS FROM CORROSION IN CONTINOUSLY REINFORCED CONCRETE PAVEMENTS

II. THE PROBLEM - Many miles of continuous reinforced concrete pavements (C.R.C.P.) have been laid in the United States. Deicing salts are now penetrating through the concrete to the reinforcing steel and causing corrosion of the steel. This corrosion is causing the pavements to crack and spall thus opening them to further damage. This damage is similar to that which has now been experienced for several years on concrete bridge decks.

III. OBJECTIVES -

To find a means of preventing further corrosion and repairing C.R.C.P. pavements.

The application of cathodic protection (CP) to such pavements using the technique developed for bridge decks would be too costly for such long stretches of road. This would involve a powered system with an electrically conductive asphaltic concrete lift covered with an asphaltic concrete wearing course. Some other method of applying cathodic protection should be sought. Since these pavements lay on ground which will vary in conductivity from one area to another it is possible that cathodic protection could be applied in a manner similar to that used for pipe lines. This technique should be investigated. Another method of repair could be to repair the current damage then overlay the pavement with a 2 inch layer of dense, low slump concrete or with a latex modified concrete. This method would rely on the tensile strength of the added concrete to prevent further corrosion by preventing further build up of corrosion.

IV. ADVANTAGES -

Such research could save large sums of money being spent to replace these pavements which are now showing distress.

Prevent further distress in such pavements.

PROBLEM NO. 102 - COMMITTEE A2H01

I. NAME OF PROBLEM - NUCLEAR DETERMINATION OF PORTLAND CEMENT CONCRETE DENSITY

II. THE PROBLEM - The attainment of adequate consolidation in layers of freshly placed portland cement concrete is a crucial step in the construction of bridge deck and pavement structures. Consolidation removes volumes of entrapped air which reduces strength and increases permeability of the concrete. Additionally, in the case of bonded concretes, adequate consolidation provides the essential contact between layers for the development of good bond.

The potential in-place density, or unit weight, of concrete can be determined by measuring the standard unit weight of fresh concrete after mixing in accordance with ASTM C138. The problem which remains is to determine the in-place density of the concrete for comparison to the standard unit weight. A quantitative approach is to measure the density of hardened cores drilled from the placements. A qualitative method is to measure microscopically the voids greater than 1 mm in size, which are assumed to result from inadequate consolidation, in the hardened concrete. The drawbacks to these procedures are that they are destructive and they take place long after the time in which corrective reconsolidation could be applied.

The majority of highway agencies use nuclear systems for specification control of moisture and density of soils and aggregates and the density of bituminous concrete. However, very little work has been reported on the use of nuclear techniques for determining the density of portland cement concrete.

Three specific areas of investigation are needed. The first deals with two-course construction of bridge decks and the influence of the underlying concrete on the density reading obtained on the top. The second area concerns methods of eliminating the steel influence in paving concrete. The third area concerns the method for determination of density goals: should rodded or vibrated unit weight be used to establish the density standard and should a standard unit weight measure or another mold shape be used?

III. OBJECTIVES -

To determine methods whereby the nuclear gauges can be used as a quality control tool in determining the density of two course bridge construction and reinforced concrete pavements.

Estimate of Funds Needed: $100,000

Estimate of Time Needed: 15 months

PROBLEM NO. 103 - COMMITTEE A2H02

I. NAME OF PROBLEM - QUALITY ASSURANCE AS RELATED TO PERFORMANCE FEEDBACK SYSTEM

II. THE PROBLEM - A quality assurance program within a transportation agency involves, besides material sampling, testing and inspection, a review and update of these procedures based on performance of the finished product. Conceptually, it is a feedback system and emphasizes the interrelations among various disciplines within the agency. Typically, a highway or transportation agency collects large volumes of data on a pavement system such as PSI, PSR deflection, friction value, accident information, etc. However, most of this is fragmented and, therefore, not fully geared to providing answers desired concerning planning, design, construction and maintenance needs. An organized method of collection, storage, retrieval and analysis of the volume of data is needed to provide all disciplines a tool for their functional activity. In addition, we need to identify the material characteristics that could be related to pavement performance. Likewise, relevant performance criteria need to be defined in order to relate them to specifications and back to construction quality criteria.

III. OBJECTIVES -

To develop this type of integrated quality assurance system, the following specific objectives must be accomplished:

1. Define various subsystems relevant to quality assurance feedback system.

2. Identify, within each subsystem, various attributes that may have a bearing on the overall performance and decision making process.

3. Define a method of collecting and automating a data handling system for storage and retrieval for the overall system.

4. Develop guidelines for relating performance data to material characterization and specifications.

IV. CURRENT ACTIVITIES -

Quality assurance has always been projected as a full circle type of feedback system and a few states, notably Texas, California, Colorado, Illinois, and Louisiana, have developed or are developing a computerized system for some or all of the subsystems considered to be a part of the overall system. The FHWA is preparing a report on the Construction Data Retrieval System which should be forthcoming soon. Very little information is available on material characteristics and pavement performance relationships, mainly due to lack of efficient and practical data base.

V. URGENCY - The soundness of a quality assurance system within an agency can only be judged when it can be related to the performance of the finished product. Present practices do not come anywhere close to providing information relative to the interrelation between design, construction, maintenance and performance. The problem of finding a solution is obviously a multidiscipline one and may involve pavement and maintenance committees. However, regardless of where the origin lies, it is an urgent one.

PROBLEM NO. 104 - COMMITTEE A2J01 & A2T61

I. NAME OF PROBLEM - IMPROVED MOISTURE-DENSITY REQUIREMENTS

II. THE PROBLEM - Compaction of soil and rock materials is one of the most effective means for improving the engineering properties of those materials for use in highway embankments and pavements. Compaction requirements, usually based upon AASHTO T-99 or AASHTO T-180, have been used by many agencies for years. The efforts to achieve the required moisture content and density significantly affect construction costs and associated energy consumption. Excessive compaction requirements are wasteful and of no significant benefit.

Compaction requirements would clearly be most cost-effective if related to the required engineering properties of the embankment or roadbed. The engineering properties, in turn, depend upon the location of the soil and rock material within the structure and the imposed loads during construction and during the life of the structure. Should the embankment and the subbase be divided into zones with different compaction requirements for each?

III. OBJECTIVES -

A. To determine the required engineering characteristics (which should include but not be limited to; volume stability and bearing capacity) for different zones in embankments and pavement bases.

B. To determine the practical advantages (which should include but not be limited to; economics and rate of construction) of varying the moisture-density requirements from one zone to another.

C. To develop recommendations for improved moisture-density requirements for highway embankments and pavement bases.

IV. CURRENT ACTIVITIES -

Items from the Transportation Research Information Service were reviewed in preparing this statement. The study "Improving Embankment Design and Performance," being conducted at Purdue University, is more closely related to the subject study than any of the others listed.

V. URGENCY -

Embankment construction is typically the largest single item in highway construction. Any reduction in unit cost will result in significant savings in overall construction costs.

VI. ESTIMATED COST -

A. $150,000 if laboratory and field tests on one construction project are included.

B. $400,000 if a wide variety of soil materials and construction equipment are included.

PROBLEM NO. 105 - COMMITTEE A2J01 & A2T61

I. NAME OF PROBLEM - IMPROVED TECHNIQUES FOR MEASURING THE ACCEPTABILITY OF COMPACTED SOIL

II. THE PROBLEM - Soils used in earthwork construction are normally compacted to improve their strength and reduce settlement. During construction the normal existing field control, to meet these objectives, is by indirect means using moisture and soil density criteria developed in the laboratory. Indirect control weakens the feedback process from construction engineer to designer. This increases the probability that changed field conditions (from that assumed in design) will not be recognized and/or won't be recycled through the design process: this often results in either under design or over design. Under design

normally results in failure to meet service objectives and is accompanied by higher maintenance costs and premature reconstruction: both of these factors are accompanied by higher energy demands. Over design usually results in higher than necessary construction costs accompanied by higher energy usage.

Field control via methods that tie directly to materials characterization used in design would have the following advantages:

1. Value engineering principles could be more readily used to take advantage of new techniques, or field conditions not anticipated during design.

2. It would be possible to directly address the problem that laboratory processing of materials sometimes does not accurately predict performance characterization (or acceptability) of field processed soil.

3. It is much easier for construction engineers to feedback critical information to designers to insure the original service objectives will be met. This is especially important where materials performance properties within the project change significantly, and where frequent materials changes can be expected.

III. OBJECTIVES AND GOALS:

The goal for research in this area would be to develop new methods or validate existing procedures that enable more optimal usage (minimize costs and energy consumption) of soil materials.

New technology would: (1) Develop methods of measuring properties of field processed soils that insure original design requirements are met. (2) Reduce construction costs and construction energy demand through more optimal usage of soil materials. (3) Open opportunities for contractors to use value engineering in earthwork construction.

IV. CURRENT ACTIVITIES -

A. Highway research in Areas 32, 61, and 62 have been scanned in preparing this statement.

B. Suggested key words: Compaction, Soil Properties, Stability, Embankments, Quality Control, Energy, Value Engineering.

C. Although some work has been done in this area very little recognition was given to possible benefits in energy conservation and possible application of value engineering to the problems.

V. URGENCY - The problem of determining the acceptability of field processed soils has long been recognized as a major problem in earthwork construction. Task Force A2T61 recommended this subject for further research because of the opportunity for significant energy savings by more optimal use of soil materials.

PROBLEM NO. 106 - COMMITTEE A2J03

I. NAME OF PROBLEM - LIME AND LIME FLY ASH STABILIZATION

II. THE PROBLEM - Lime and lime-fly ash stabilization procedures are widely utilized. Although there are several mixture design procedures being utilized to establish the required lime or lime plus fly ash contents required for stabilization, there are no procedures that have gained widescale acceptance. In most instances, the mixture design procedures are not sufficiently flexible for broad scale application to achieve various lime treatment objectives (modification, swell control, strengthening) or accommodate special situations encountered in lime-fly ash stabilization (fine aggregate sources, by-product aggregates, late season construction conditions, etc.). Quality criteria (strength, durability, volume stability, etc.) for lime and lime-fly ash treated materials have not been well defined. The criteria generally do not account for the wide diversity of applications and range of service conditions (traffic, environmental factors, etc.) encountered in practice.

Most lime-fly ash construction is of the "plant mix" type while "mixed in place" procedures are normally used in soil-lime construction. The major quality control items of interest are - 1) lime and fly ash quality, 2) soil or aggregate properties, 3) lime and fly ash quantities and distribution, 4) mixing, 5) pulverization, 6) compaction, and 7) curing. All aspects of the construction process must be carefully controlled. The degree of control varies depending on the stabilization objective. Satisfactory quality control tests, procedures, and appropriate quality criteria are essential to achieving adequate quality control. Although many aspects of lime and lime-fly ash quality control are considered in current specifications, additional effort is needed to refine and expand the present practices and develop supplemental procedures where appropriate.

Priority research topics are listed below:

Priority	Subject
1.	Lime and fly ash quality effects on stabilization.
2.	Cut-off data considerations in lime and lime fly ash construction.
3.	Quick lime utilization in soil-lime stabilization.
4.	Soil type (pedologic classification, mineralogy, etc.) and aggregate characteristic effects on stabilization.

III. OBJECTIVES -

The general objectives are to establish

component material (lime fly ash, soil, aggregates) quality guidelines and criteria and to develop comprehensive mixture design procedures with associated quality criteria and construction quality control procedures for lime and lime-fly ash stabilization. Mix design procedures and quality criteria must be adaptable to the entire spectrum of stabilization objectives and applications. The quality control procedures would: a) include appropriate field testing procedures, b) consider sampling and testing frequency, c) establish quality criteria, d) consider tolerances and allowable variability, e) provide rational methods for determining curing requirements and cut-off dates if applicable, f) provide a method of construction acceptance, and g) provide for post-construction surveillance.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress Area 62 and 64 have been scanned in preparing this statement.

B. Suggested key words for this problem are lime, soil-lime, lime stabilization, soil stabilization, fly ash, lime-fly ash, mixture design, test procedures, quality control, construction, quality criteria.

C. Several ongoing lime and lime-fly ash stabilization research projects were noted. None of the projects specifically addressed the topics listed in the priority ratings for this research needs statement.

V. URGENCY - There is an increased utilization of lime and lime fly ash stabilization in transportation construction. The energy and materials savings potential associated with stabilization will engender even greater utilization. Based upon the current state of the art and the judgment of currently active researchers this project area is classified as "urgently needed."

PROBLEM NO. 107 - COMMITTEE A2J06

I. NAME OF PROBLEM - OPTIMIZATION OF SOIL CHEMICAL STABILIZING AGENTS AND METHODS

II. THE PROBLEM - Soil chemical stabilizing agents and methods are many times applied to transportation subgrades without full consideration of all possible alternatives. The agents and methods utilized tend to be those which are in general use in a localized geographical area rather the most efficient and economical. Investigations are needed into the real efficiency and optimization of all feasible agents and methods, including chemical waste products, that improve chemical, mineralogical and physical properties of soils in each localized area.

III. OBJECTIVES -

The research needed should include testing of all problem clay soils which occur in each geographical area so as to provide a reference base for localized application of results. Measurements made should be before and after treatment chemical, mineralogical and physical properties of each soil. The efficiencies of each treatment in achieving desired property changes could then be determined for the localized area. This information could then be utilized along with known chemical, mineralogical and physical properties of a given clay soil to optimize its stabilization with chemical agents and methods.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress, areas 61, 62, 63 and 64 have been scanned in preparing this statement.

B. Suggested key words: Soil Stabilization, Chemical Stabilization, Subgrades.

C. Many research efforts have been directed toward the use of single chemical stabilization agents or combinations of agents and their improvement of engineering properties, but little study has been or is being made into optimization of agents and methods, especially utilizing effeciency of all property changes for the diverse clay soils of localized geographical areas.

V. URGENCY - The study of optimization in soil chemical stabilization is considered very important to the efficient use of materials and to construction of the most economical transportation structures. The information made available by such studies could be used to assist in the selection of optimal chemical stabilization agents for soils in projects or localized areas. These studies could be combined into information useable state wide or nationally.

PROBLEM NO. 108 - COMMITTEE A2J06

I. NAME OF PROBLEM - IN-SITU CHEMICAL STABILIZATION OF SATURATED SOILS

II. THE PROBLEM - Many instances exist in which the need arises to stabilize a soil layer or formation that has become saturated in order to ameliorate its engineering properties, e.g., saturated subgrades, bases and subbases, etc. The major problems encountered in these situations are mainly finding a chemical that can be easily pumped into the soil that can react under high degrees of saturation (i.e., water-compatible).

III. OBJECTIVES -

To search the commercial market and/or develop chemical stabilizers having low viscosities and good reactivity under very high degrees of saturation. Study should involve stabilization of saturated fine grained soils of low and high plasticity.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress, areas 62, 63, 64 have been scanned in preparing this statement.

B. Suggested key words: Soil Stabilization, Chemical Stabilization, Saturated Soils.

C. Some work has been previously done on ameliorating properties of saturated soil during construction using chemical stabilizers ranging from acids to polymeric resins. No systematic research effort has been directed towards stabilizing such soils in-situ, without having to rework the soil in the field.

V. URGENCY - Many subgrades, bases and subbases that may even have been improperly treated initially do become saturated after construction and cause severe instability and ultimate failure of the pavement. Currently, such problems are generally corrected through removal, treatment, remixing and reconstruction, at very high cost and great inconvenience to the users. In-situ treatment, if possible, may correct this situation.

PROBLEM NO. 109 - COMMITTEE A2K02

I. NAME OF PROBLEM - DEEP IN-SITU STABILIZATION FOR THE CORRECTION OF SETTLEMENT AND STABILITY PROBLEMS

II. THE PROBLEM - Many of the new deep stabilization techniques developed during the past 20 years are becoming more attractive and feasible each day. Methods such as stone columns, dynamic consolidation and deep chemical stabilization have provided solutions where conventional treatments were unfeasible. Designers of these systems presently rely on past experience and empirical approaches to develop adequate treatment procedures.

III. OBJECTIVES -

A. To develop cost effective, rational design guidelines for the above mentioned techniques. Theoretical analysis, laboratory and field testing and documented case studies will be required.

B. To encourage the acceptance and implementation of these and other new techniques at appropriate locations.

C. To encourage the development of new and improved methods of deep in-situ stabilization.

IV. CURRENT ACTIVITIES -

A. Suggested key words: settlement, stabilization, stone columns, chemical stabilization, dynamic consolidation.

B. Most States have had little or no experience with these techniques.

V. URGENCY - The unique problems which were the catalysis in development of these methods are no longer extraordinary. Restrictions of right-of-way, environmental constraints, maintenance of traffic and time have all become equally important to economics in design of facilities. Many of our conventional treatment measures are no longer considered acceptable at some locations and it appears that future developments will further limit our available tools.

PROBLEM NO. 110 - COMMITTEE A2K02

I. NAME OF PROBLEM - THE EFFECT OF CONSTRUCTION TECHNIQUES ON THE PERFORMANCE OF VERTICAL SAND DRAINS

II. THE PROBLEM - The different methods of installation of vertical sand drains have a direct effect on the engineering characteristics of the soil in which the drains are installed. The major characteristic which appears to be subject to alteration is the coefficient of permeability. The difficulties attendant to accurate predictions of the time required for settlement have created severe construction scheduling problems and costly delays.

A rational design procedure is needed to permit the engineer to accurately predict the rate of settlement which accompanies the various methods of sand drain installation.

III. OBJECTIVES -

To develop a rational design procedure for the rate of settlement by investigation which includes laboratory tests, field tests and observations of vertical sand drains installed by current methods in a variety of soil types.

IV. CURRENT ACTIVITIES -

A. Suggested key words: permeability, natural drainage paths, remolding, smearing, sand drain diameters.

B. Although several projects have been constructed where different sand drain installation techniques were evaluated via test sections, no formal research has been conducted and no design procedures are available for accurate predictions of rate of settlement.

V. URGENCY - Millions of linear feet of sand drains have been installed in the United States. Many projects are being designed which traverse soft ground acres where settlement is a major design consideration. A rational design procedure for sand drains is imperative to allow an economical evaluation of sand drain construction techniques and to avoid costly construction delays.

PROBLEM NO. 111 - COMMITTEE A2K02

I. NAME OF PROBLEM - SECONDARY COMPRESSION CHARACTERISTICS OF ORGANIC DEPOSITS

II. THE PROBLEM - Embankments constructed over organic foundation soils are subject to long term post construction settlements that are often detrimental to the subsequent performance. A large portion of this settlement is attributed to the secondary consolidation characteristics of the organic soil. Currently, there is no design method available which produces accurate predictions of the amount of or the rate of secondary consolidation.

III. OBJECTIVES - Basic information on the consolidation properties of organic soils is required in order to develop economical and satisfactory methods of stabilizing

such deposits. The objectives of the research are -

A. By means of laboratory investigations, determine the consolidation characteristics of various types of organic soils, including the limitations of applying the present "primary" and "secondary" consolidation concepts to these soils. New test procedures and equipment may be required.

B. Develop rational design procedures which include predictions of rate and magnitude of secondary consolidation with reasonable accuracy.

C. Compare the results of observations and measurements of long term settlement of embankments constructed over organic deposits with laboratory test data and design assumptions.

IV. CURRENT ACTIVITIES -

A. Suggested key words: primary consolidation, secondary consolidation, organic content, amount of settlement, rate of settlement, test methods.

B. Many small research projects have been undertaken on this subject, but their scope has been too narrow to fulfill the necessary objectives which will lead to rational design procedures.

V. URGENCY - In some parts of the United States, especially in urban areas, the only land areas remaining for location of new transportation facilities are swamps and marshes. This is particularly true of coastal areas. Removal of the organic soil requires disposal areas and substantial quantities of suitable borrow material. Such areas are becoming less advisable due to associated ecology problems and economic considerations. Thus the utilization of the organic deposit as a foundation material has become imperative in many sections of the country. Successful completion of this research will result in substantial savings in the transportation field.

PROBLEM NO. 112 - COMMITTEE A2K02

I. NAME OF PROBLEM - LONG TERM STABILITY OF CUT SLOPES

II. THE PROBLEM - Many cut slopes that were built 8-10 years ago are now starting to fail without showing any previous signs of instability. This, in part, is due to the long term effects on the stability of the cut slopes that were not recognized when making the original design.

A rational procedure is needed to permit the engineer to determine which cut slopes will fail due to long term effects, and how to adequately design for them.

III. OBJECTIVES -

A. To develop an investigational procedure that will determine which cut areas may need to be designed for long term stability.

B. To develop a design procedure for the long term effects.

C. To develop stabilization methods to use in the correction of existing failures, in areas of potential failure and for new construction.

IV. CURRENT ACTIVITIES -

A. Suggested key words: creep, long term stability, drained and undrained conditions, stabilization.

B. A few states have made some progress in this area, but most states are still designing without any special considerations. Corrections are then made after failures occur.

V. URGENCY - Many cut slopes that are now 8-10 years old are failing due to the inadequate design for long term effects. Unless new techniques are developed to spot these potential failure areas before they fail, we will continue to have a problem that will cost thousands of dollars a year.

PROBLEM NO. 113 - COMMITTEE A2K03

I. NAME OF PROBLEM - EVALUATION OF BITUMINOUS AND OTHER COATINGS TO REDUCE PILE DRAG

II. THE PROBLEM - Pile drag can be compensated for in a rational pile design in several ways. Bituminous coatings have been proved effective in reducing pile drag, however not enough research has been undertaken which can establish reliable design parameters for the design engineer. Research is needed to evaluate the various types and thicknesses of bituminous and possibly coatings of other types of materials under varying installation and soil conditions and more importantly, to follow up with design data which can be employed by the engineer. Different coatings should be tested on different pile types for varying soil conditions. The piles must be thoroughly instrumented and monitored during pile driving and for a considerable period thereafter.

III. OBJECTIVES - The research should culminate in a useful (to the design engineer) comparison and evaluation of the coatings and other variables in the experiment. The effectiveness of each coating should be stated in terms that can be translated by the designer into design parameters and specifications.

IV. CURRENT ACTIVITIES -

A. No substantial activities. Just a limited literature search.

B. Suggested key words: pile drag, bituminous coating, negative skin friction, pile design.

C. Not enough background to answer this

question on related research activities.

V. URGENCY - This research is badly needed to give the Engineer a reliable tool so that effective and economic pile designs which are subject to drag conditions may be progressed.

PROBLEM NO. 114 - COMMITTEE A2K03

I. NAME OF PROBLEM - THE BEARING CAPACITY OF COMPACTED EARTH BRIDGE APPROACH EMBANKMENTS

II. THE PROBLEM - The height of the usual bridge approach fills ranges from 18 feet to 35 feet. The material used for such embankments, typically comes from local sources. Local materials may be glacial tills, fresh water, or marine deposits. While the in-situ shear strength characteristics of such materials are well known the performance and suitability of these as a load-bearing structure in their remoulded and compacted state, should be further investigated.

In the past, the bearing capacity of these compacted fills was estimated rather than computed or evaluated on the basis of parameters, or small or full-scale test results. As a rule, such estimates were believed to be very conservative - consequently, the bridge designer shied away from placing spread footings within the fill and instead, utilized pile support or other deep foundations for the abutments.

Evidently, the latter design - in many cases - might not have been the most economical solution.

III. OBJECTIVES -

A. To develop methods for the evaluation of the suitability of compacted fills, to carry bridge abutment loads constructed of - (a) granular, (b) heterogeneous, and (c) various cohesive materials.

B. To study the stress distribution under spread footings, constructed within above approach fills.

To determine the best geometry of approach fills for the suitability of supporting abutment loads on spread footings.

IV. CURRENT ACTIVITIES -

No independent activity scanned.

V. URGENCY - The economics possible offer great economic benefits, particularly as timber piles become scarce and shells for CIP piles may become short in supply.

PROBLEM NO. 115 COMMITTEE A2K03

I. NAME OF PROBLEM - FULL SCALE FIELD LOAD TESTS ON PILE GROUPS

II. THE PROBLEM - Over the years a considerable number full scale field load tests have been conducted on single piles, but very few full scale field load tests have been conducted on pile groups. Of course, there are no foundations constructed on single piles and pile foundation design must include consideration of group action. Both bearing capacity and settlement of the group must be considered. Design for bearing capacity normally involves the use of a "Group Efficiency Factor" and the factors currently used were established primarily from model studies. For pile groups in clay, the possibility of a "block failure" must be considered. There is no established design criteria for settlement of pile groups.

III. OBJECTIVES - The broad objective is to develop design criteria for pile groups by conducting full scale field load tests on groups founded in both cohesive and cohesionless soils. Specific objectives are as follows:

A. To instrument the group so that the action of individual piles can be determined.

B. To develop group efficiency factors for different pile spacings and for different pile shapes.

C. To investigate the development of block failures in cohesive soils, and

D. To relate the settlement of the pile group to that of a single pile in the group.

IV. CURRENT ACTIVITIES -

A. No Highway Research in Progress areas have been scanned in preparing this statement.

B. Suggested key words: pile groups, field load tests, bearing capacity, settlement.

C. Related research would include any research currently being done on single piles and any model studies on pile groups or field performance studies of in service pile group foundations.

V. URGENCY - The proposed research would be a long term effort to develop reliable design criteria for foundations on pile groups which in turn would reduce foundation costs. Currently used design criteria are based primarily on model studies and have not been verified by full scale field performance tests.

The cost of this research would be high, probably $500,000 or more and should probably be at least a 5-year study. The cost could be reduced by testing actual foundations under actual loading conditions.

PROBLEM NO. 116 - COMMITTEE A2K03

I. NAME OF PROBLEM - EFFECTS OF DIFFERENTIAL SETTLEMENT ON STRUCTURES

II. THE PROBLEM - A great deal of money is often expended on the special treatments for the support of structural foundations in order to eliminate settlement, so as to avoid the

possibility of the occurrence of differential settlement across as well as between structural elements. Steel frame structures may be able to withstand greater foundation deflections than the more rigid reinforced concrete structures, and therefore the foundation support for these two types of structures may differ even where the loadings are the same. Simply supported deck slabs of bridges may permit greater movements across and between substructure elements that would be acceptable for continuous span bridge decks. A thorough evaluation of the literature, and a survey and compilation of experience should be made to ascertain applicable safe limits (or angular deflections) for differential settlement for various types of structures and framing systems.

III. OBJECTIVES - The objective of this research would be to establish the degree of differential settlement that can be introduced into the design of specific types of structures and support systems without adversely affecting the utility and safety of the structure. The goal would be to establish a set of criteria, which if exceeded, would require special foundation treatment to limit differential settlement.

IV. CURRENT ACTIVITIES - Work has been reported in matters related to the effects of differential settlements on building frames and exteriors by L. Bjerrum, and the results of others have been presented in various textbooks; however, I have no idea of the Highway Research in Progress, HRIP, work.

Suggested key words: differential settlement, structural distortion, stress redistribution. I have no idea of related research activities in HRIP.

V. URGENCY - This would be urgently required with regard to the effects of open cut excavation and tunnelling operations, on adjacent structures, as is commonly a problem in subway construction. Today, considerable money may be involved in the support of structures, which might be reduced if the data were available on how the foundations of such structures, and the structures themselves, would react to induced differential movements.

It is estimated that the required research could be accomplished and the results compiled by one man in one year's time, allowing adequate funds for travel and communication, as well as special measurements. A budget of $50,000 would be ample.

PROBLEM NO. 117 - COMMITTEE A2K03

I. NAME OF PROBLEM - SOIL: PILE LOAD TRANSFER IN PILE GROUPS

II. THE PROBLEM - Field tests on single test piles have shown that the transfer of load from a pile to the soil or vice versa can be predicted using the effective stress approach. Very few, if any, field tests have been performed on groups of test piles. Since most engineering structures that use pile foundations are supported on groups of piles, a field test program is urgently required in order to find correlation between the behavior of pile groups and single piles. Such correlations would provide improved design methods and consequently more economical pile foundations.

III. OBJECTIVES - To carry out a field testing program on various groups of piles in different soils to study the stress transfer in positive and in negative skin friction.

IV. CURRENT ACTIVITIES -

A. Research on single piles or pile groups is currently under way in Canada, England and Sweden.

B. Suggested key words: piles, pile groups, effective stress, positive friction, negative skin friction or downdrag, pile tests.

V. URGENCY - Much information on the behavior of single test piles is available and has been published. This knowledge cannot be applied directly to the design of pile foundations because it has never been correlated with the behavior of pile groups. Unless this is done soon, the present experience will remain academic. The profession needs this correlation now to improve the design of pile groups.

Cost estimate: $150,000 - $200,000

PROBLEM NO. 118 - COMMITTEE A2K03

I. NAME OF PROBLEM - DESIGN OF ANCHORED BULKHEADS IN OVERCONSOLIDATED PLEISTOCENE CLAYS

II. THE PROBLEM - There is a high incidence of anchored bulkhead failures in the Houston area. These bulkheads are constructed primarily in the Beaumont Clay Formation. There is reason to believe that conventional analysis techniques lead to unconservative design. In order to validate design procedures for anchored bulkheads in the Beaumont Clay Formation it is necessary to understand the details of previous failures. Unfortunately, these details are unavailable because of litigation arising from the failures.

III. OBJECTIVES -

A. To identify and document case histories of bulkhead failures in the Beaumont Clay Formation.

B. To develop design procedures for anchored bulkheads in the Beaumont Clay Formation.

IV. CURRENT ACTIVITIES -

A. Suggested key words: anchored bulkhead, overconsolidated clay, Beaumont Clay Formation, active pressure, drained strength, undrained strength, Houston Ship Channel.

B. Designers are presently using standard design procedures using either drained or undrained strength parameters.

V. URGENCY - Lack of understanding of the

behavior of overconsolidated clays results in either unsafe or overconservative design for anchored bulkheads. The Houston Ship Channel cuts into the Beaumont Clay Formation in many areas; the industrial development along the channel will require construction of many bulkheads. Good design procedures would avoid costly failures or unnecessarily expensive structures.

PROBLEM NO. 119 - COMMITTEE A2K05

I. NAME OF PROBLEM - FRACTURE ANALYSIS OF PAVEMENT SYSTEMS

II. THE PROBLEM - Pavement failures are related to the development of cracks and/or excessive deformations due to repetitive loads or environmental conditions. The analysis and prediction of failure would be aided by the development of procedures for explaining the initiation, propagation and accumulation of cracks.

III. OBJECTIVES - The objective is to develop theoretical information on the development of cracking in pavements on the basis of fracture-mechanics principles. Specific objectives include the development of theoretical procedures for predicting the initiation and propagation of cracks and the influence of cracks on stresses and displacements throughout the layered system.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 25, 26, 62 and 63 have been scanned in preparing this statement.

B. Suggested key words: fracture mechanics, pavements, cracking.

C. Many projects are monitoring the development of cracking patterns in the field, and laboratory studies of fatigue cracking are being conducted, but little study is being made of theoretical failure analysis.

V. URGENCY - The study of fracture mechanics is considered highly important to the development of methods for predicting pavement performance and thus to the design of pavement systems. It was one of ten research needs identified at the Workshop on Structural Design of Asphalt Concrete Pavement System at Austin, Texas, December 1970.

PROBLEM NO. 120 - COMMITTEE A2K05

I. NAME OF PROBLEM - STOCHASTIC ANALYSES OF PAVEMENT SYSTEMS

II. THE PROBLEM - The reliability of a pavement system may be evaluated better by procedures that take into account the statistical variations of load, environment, pavement geometry and material properties. Information is required on the statistical variation of the preceding parameters so that stochastic techniques can be used for the solution of appropriate boundary value problems. Also, information is required on relevant construction, maintenance, and failure costs so that probabilistic approaches can be used to obtain optimum economic designs.

III. OBJECTIVES - The primary objective is to obtain solutions for the probability of occurrence of various stress-strain-displacement responses of pavement systems. Secondary objectives are to assemble statistical data on loads, geometry, environment, material properties and costs.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 25, 26 and 63 were scanned in preparing this statement.

B. Suggested key words: pavement systems, stochastic processes, construction maintenance.

C. Limited work at Illinois, Ohio State, Purdue, Texas and MIT has begun to apply stochastic concepts to the analysis of pavement systems. This work was discussed in a symposium at the 1975 TRB Annual Meeting.

V. URGENCY - Because of the natural variability of the various factors influencing pavement design and performance, it is considered very important that statistical data on variability be gathered and stochastic methodology be applied to the analysis of pavement design.

PROBLEM NO. 121 - COMMITTEE A2K05

I. NAME OF PROBLEM - STRESS-DEFORMATION ANALYSIS OF TRACK BEDS

II. THE PROBLEM - For improved designs and maintenance it is important to understand how the load is transferred in various components and junctions or interfaces of track beds.

III. OBJECTIVES - To develop

A. Better understanding of the material behavior and interfaces subjected to different loading modes.

B. Improved techniques for prediction of load-deformation behavior.

C. Verify predictions with field observations.

D. Analyze effect of various factors such as physical and environmental on track behavior.

IV. CURRENT ACTIVITIES -

A. Triaxial behavior of ballast and other materials under repeated loading and two-dimensional finite element analysis at University of Illinois (Marshall Thompson).

B. Prototype behavior of track beds, Queen's University Canada (G. P. Raymond).

C. Field measurements in track beds, SUNY, Buffalo, N. Y. (E. Selig).

D. Behavior of interface under repetitive loads in direct shear device, of materials in multiaxial testing and three-dimensional finite element analysis at Virginia Polytech. Institute and State University (C.S. Desai).

E. Others.

V. URGENCY - Because of the need to maintain track beds in reliable conditions and for rational understanding of track behavior for improved design for future transportation needs, investigation of this topic should be urgent.

PROBLEM NO. 122 - COMMITTEE A2K06

I. NAME OF PROBLEM - EFFECTIVENESS OF DAYLIGHTED SUBBASES

II. THE PROBLEM - Wide shoulders and low back slope gradients on high type roadways have greatly increased (a) the length of drainage path, (b) the quantities of drainage layer aggregates required and (c) the size of the exposed face of the daylighted layers over those of most pavements built 15 or more years ago. Also, current specifications for drainable aggregates often permit very slow draining materials (1 ft/day or less) to be used in daylighted layers. As a result, the new geometrics and low permeability materials are causing water to be retained in pavement structural sections for times long enough to cause premature deterioration under traffic loads. In addition to the use of slow draining materials, there have been frequent reports of blockage of the outlet faces of daylighted subbases by landscaping topsoil. There is a need to determine ways to increase the effectiveness of daylighted subbases.

III. OBJECTIVES - To develop improved criteria for the use of daylighted subbases, with special attention to geometries, the hydraulics of drainage layers, and relative construction and maintenance practices that can affect their performance.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas on drainage of pavements have been reviewed in preparing this statement.

B. Suggested key words: drainage blankets, drainage systems, drainage practices, daylighting, subdrains, subsurface drains, subbase materials, permeability, landscaping.

C. Related research activities are concerned with open-graded drainage blankets, permeability of base course materials, relative permeability of adjacent pavement layers, shoulder drainage, and the opening and closing of longitudinal cracks between concrete pavement slabs and the shoulder.

V. URGENCY - Research studies to date indicate that, probably, millions of dollars are being ineffectively expended anually on daylighted pavement sections. Improved design criteria and construction practices are urgently needed to use these expenditures more wisely and prolong the life of highway pavements.

Estimated cost - $150,000

PROBLEM NO. 123 - COMMITTEE A2K06

I. NAME OF PROBLEM - PERFORMANCE OF PAVEMENT SUBDRAINS IN A FREEZE-THAW ENVIRONMENT

II. THE PROBLEM - An important factor affecting pavement performance and life is the presence of water in the pavement system. In the northern United States deterioration of asphalt-concrete pavements is the greatest in the late winter and spring when repeated freeze-thaw cycles occur. The excess water in the pavement materials, subbase and subgrade contributes to rapid structural damage to the pavement under traffic loads. Subdrains and/or drainage layers in the pavement are the only, available methods for removing this water in a timely and efficient manner. However, often the subdrain system is frozen and may be inoperative. The operating effectiveness of subdrain systems under freeze-thaw conditions has never been thoroughly investigated.

III. OBJECTIVES - The over-all objective of this research is to determine the performance of pavement subdrain systems constructed under current practice in a freezing environment. This will involve field instrumentation and monitoring of the freeze-thaw behavior of the pavement, subdrains, and the conduit system to the outlet.

If deficiencies are determined to present installations a research plan should be developed for improved designs.

IV. CURRENT ACTIVITIES - Highway Research in Progress areas have been scanned and no known studies are currently under way.

V. URGENCY - The Federal Highway Administration's "Guidelines for the Design of Subsurface Drainage Systems for Highway Structural Sections" and the Federal Highway Administration's "Water in Pavement" Workshops presented throughout the United States demonstrated the need for drainage in pavements. In northern states the efficiency of pavement underdrain systems may be seriously impaired in the pavement section and at the outlet during the critical freeze-thaw period when a significant amount of pavement distress occurs.

PROBLEM NO. 124 - COMMITTEE A2K06

I. NAME OF PROBLEM - PREDICTING PERMEABILITY OF HIGHWAY MATERIALS FROM PHYSICAL AND CHEMICAL CHARACTERISTICS

II. THE PROBLEM - A major factor contributing to the rapid development of pavement distress is excessive moisture in the pavement structural section. Water is the principal factor causing loss of strength and resiliency in the subgrade and structural section of pavement system.

In order to decrease the effects of water on pavement system considerable effort is now

being directed toward the design and construction of subsurface drainage systems. However, in the design of these drainage systems, satisfactory effort has not been made to define the permeability characteristics of the existing pavement materials or the drainage materials themselves. Because of the importance of the permeability or hydraulic conductivity properties in effective subdrainage design, it is necessary to develop a quick, efficient, and economical procedure for measuring this property both in the field and in the laboratory.

III. OBJECTIVES - The general objective of this project is to develop a procedure for determining the hydraulic conductivity (permeability) of highway materials from physical and chemical characteristics. The specific objectives are -

1. Determine the physical and chemical properties which directly affect material permeability.

2. Establish a predictive permeability model based on physical and chemical parameters.

3. Validate the permeability model by use of controlled laboratory or field tests.

IV. CURRENT ACTIVITIES -

A. HPR studies in Illinois, New Jersey and Ohio.

B. FHWA RFP for in-situ field permeability test method.

C. FHWA Workshop - Water in Pavements.

D. Organization for Economic Cooperation and Development - Water in Roads.

V. URGENCY - The effects of moisture on pavement systems have been widely documented. In order to design effective pavement subdrainage systems the material hydraulic conductivity properties must be known. Because of the broad range of structural materials and drainage materials used in pavements, a quick and accurate procedure which can be used to predict material hydraulic conductivity based on physical and chemical properties is needed. This need is especially evident where the hydraulic conductivity must be determined on in-situ materials in the field. The benefits that may be derived from the proposed research are primarily economical. The study is foreseen as an important step leading to the goal of designing subsurface drainage systems based on well defined hydraulic parameters.

PROBLEM NO. 125 - COMMITTEE A2K06

I. NAME OF PROBLEM - FILTER CLOTHS AND FABRICS

II. THE PROBLEM - Filter cloths and fabrics made of artificial fibers are being used extensively in Europe and to a lesser extent, in the United States, for earth reinforcement is chiefly to provide support over local soft, wet deposits of soil and humus. In drainage systems, they are being used instead of some of the aggregate in graded filters. However, there are as yet, no established criteria for the use of filter cloths and fabrics and no standard tests for evaluation of their engineering properties. Some qualities which probably affect their suitability for specific applications but for which there are no standard tests include: tensile strength, resistance to chemical and physical deterioration, equivalent opening size, permeability or percent open area, burst strength, long term response to repeated loads, and absorption.

III. OBJECTIVES - The objectives of this study are to establish engineering criteria for the use of filter cloths and fabrics and to develop laboratory test methods for the evaluation of their engineering properties. The use criteria should be in a handbook form suitable for the designer.

IV. CURRENT ACTIVITIES -

A. There are no current research projects in this area.

B. Suggested key words: filter cloths, subsurface drainage, earth reinforcement.

C. Current related research activities include a FHWA contract effort on "Improved Subsurface Drainage and Shoulders," NCHRP Study 4-11, "Buried Plastics Pipe," and "Development of a Subsurface Drainage Manual for FHWA".

V. URGENCY - Silting and clogging requires replacement of millions of dollars worth of subsurface drainage systems each year. There is an immediate need to improve graded filter systems to reduce current and future maintenance costs of both subsurface drainage systems and of pavements, slopes and other highway structures they are designed to protect.

Estimated Cost to Accomplish - $150,000

PROBLEM NO. 126 - COMMITTEE A2L01

I. NAME OF PROBLEM - PHYSICAL PROPERTIES OF SOILS RELATED TO GEOPHYSICAL SUBSURFACE EXPLORATION

II. THE PROBLEM - The physical properties of conductivity, density and velocity of soils and bedrock are measured by geophysical techniques. The correlation of the measured physical properties with soil types and/or bedrock is one of the major components of the interpretation of geophysical data. The correlation between physical properties of soils and/or bedrock may vary from area to area; however, broad ranges of physical properties can be correlated with soil types and bedrock. Correlation data are available in numerous textbooks and articles, but a comprehensive study or library search of such data is not available.

III. OBJECTIVES - The physical properties of soils are affected by numerous factors and may vary from area to area. The proposed study, which may take the form of a library search, would present the data in a systematic way.

The data may be grouped as relating to differing climatic and geographical regions, i.e., tropical, temperate, arctic, foothills, plains, etc. The objective of this study is to further the understanding and behaviour of the physical properties of soils and bedrock under varying climatic and geologic conditions, which would lead to improved interpretation of the geophysical data.

IV. CURRENT ACTIVITIES -

A. The TRIS data base for key words "geophysical exploration" and "soil physical properties" was scanned in preparation of this statement.

B. Suggested key words for this problem: geophysical explorations, geophysical measurements, soil physical properties, correlation, subsurface exploration.

C. No research program was found which would meet the objectives; however, it is expected that many State Departments of Highways and FHWA have in-house files containing useful and related data.

V. URGENCY - The need for a systematic study of physical properties is a long-standing one. The availability of a set of data resulting from the proposed study would enhance many fold the value of geophysical surveys, thus improving their cost effectiveness. It is considered that the problem is urgent.

PROBLEM NO. 127 - COMMITTEE A2L01

I. NAME OF PROBLEM - EVALUATION OF GEOPHYSICAL METHODS AND INSTRUMENTS AS APPLIED TO SUBSURFACE EXPLORATION FOR TRANSPORTATION CORRIDORS

II. THE PROBLEM - There have been numerous developments in geophysical instrumentation and interpretation techniques in recent years. Some techniques and instruments have been tested in detail over a variety of geologic conditions. Others have had a minimum of field testing to establish their potential usefulness and/or limitations in subsurface exploration.

The problem may be subdivided as follows:

A. Analysis and comparison of geophysical methods and instrumentation as applicable to subsurface exploration.

B. Analysis and comparison of interpretive techniques with special emphasis on transportation applications.

III. OBJECTIVES -

Specific objectives are as follows:

A. Determination of those geophysical methods most appropriate for transportation applications.

B. Evaluation of modern geophysical instruments in regard to their applications and limitations.

C. Examination of new interpretive techniques and comparison with established procedures.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 21, 35, 61, 62 and 63 have been scanned in preparing this statement.

B. Suggested key words: geophysics, subsurface exploration, depth to bedrock, physical properties.

C. Although some research is presently being undertaken on minor aspects of this proposed problem statement, no studies meeting its overall objectives were discovered.

V. URGENCY - The use of geophysics for subsurface exploration is increasing. Knowledge of appropriate methods, equipment, applications, and interpretation will help the practicing engineer select the appropriate geophysical technique for the problem at hand. The problem is considered to be of continuing interest in transportation engineering.

PROBLEM NO. 128 - COMMITTEE A2L01

I. NAME OF PROBLEM - EVALUATION OF EQUIPMENT AND PROCEDURES FOR SAMPLING SAND AND GRAVEL DEPOSITS

II. THE PROBLEM - The difficulties encountered in attempting to obtain representative samples of cohesionless or nearly cohesionless sands and gravels have been recognized for many years by those responsible for locating natural sources of these materials. These difficulties may be subdivided as follows:

A. Gradation changes caused by faulty sampling equipment and techniques.

B. Contamination by overburden materials as sample is brought to the surface.

C. Mixing and loss of identity of materials from different subsurface units.

D. Inability of equipment to bring samples to the surface. This occurs most frequently when the bed lies below the water table.

III. OBJECTIVES -

A. Determine the ability of presently available equipment to obtain representative samples of sands and gravels above and below the water table.

B. Develop, if possible, new equipment and techniques capable of obtaining representative samples of sand and gravel under all conditions.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 31, 32, 33, 34, 35, 61, 62 and 64 have been scanned in preparing this statement.

B. Suggested key words: subsurface exploration, borings, sampling, soils, soil gradation, sand, gravel, aggregates.

C. No studies meeting the overall objectives of the proposed problem statement were discovered. However, related research titled "Evaluation of International Literature on the Sampling of Aggregates" is currently being conducted at Darmstadt Technical University, Germany. At present the Darmstadt study is confined to review of literature, but studies of actual technical and statistical problems encountered in sampling natural aggregates are contemplated.

V. URGENCY - This problem is considered to be of continuing urgency in the area of soil and aggregate exploration.

PROBLEM NO. 129 - COMMITTEE A2L04 & A2T61

I. NAME OF PROBLEM - CHANGES IN SOIL STIFFNESS AND STRENGTH INDUCED BY FROST ACTION

II. THE PROBLEM - Moisture changes and other affects induced by freeze-thaw cyles significantly alter the strength and stiffness properties of soil, and thereby affect the performance of the pavement. Current pavement design methods do not adequately account for reduced subgrade support conditions caused by these frost induced changes. Reduction factors are estimated on the basis of judgment and limited field performance studies rather than test procedures. Recently developed mechanistic pavement design methods which are based on calculated stresses and strains and make use of cumulative damage principles require an accurate assessment of the seasonal variations in strength and stiffness. The use of a resilient modulus test appears to be the best procedure for characterizing the response of subgrade and base materials under freeze-thaw conditions; however, other parameters should also be examined. The development of laboratory test procedures will need to be verified by comparing predicted theoretical pavement response to measured deflections in the field.

III. OBJECTIVES - The general objective of this research is to determine the methods for characterizing the effects of frost action on the strength and stiffness of subgrade soils and granular unbound base course materials. The specific objectives are -

1. Evaluate pavement response and performance models currently in use or being developed to determine which strength or stiffness parameters of soil and unbound base courses affected by freeze-thaw serve as the most useful and important input parameters to the preferred models.

2. Determine laboratory and field procedures for evaluating the selected strength and stiffness parameters.

3. Develop predictive models of the selected strength and stiffness parameters in terms of readily measured soil properties.

4. Validate the strength and stiffness models by means of controlled laboratory and field tests.

5. Couple the strength and stiffness models with pavement response and performance models for use in design and evaluation of pavements affected by frost action.

IV. CURRENT ACTIVITIES -

A. Frost Research in Progress.

1. The development of laboratory techniques and procedures for characterizing the stress-strain response of subgrade soils in the frozen, thawing, and thawed states is underway at the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL).

2. The development of laboratory techniques and procedures for determining an order ranking of frost susceptibility of subgrade soils is underway or completed at several research agencies such as FHWA, CRREL, Purdue University, Massachusetts DPW, Pennsylvania DOT, New Hampshire DOT and several foreign countries.

3. Mathematical modeling projects are currently underway at CRREL and the University of Illinois.

4. Full-scale field testing of frost heave and thaw weakening are currently underway at several sites in Pennsylvania and Massachusetts.

B. Suggested key words: frost action, freeze-thaw, thaw weakening, resilient modulus, pavement damage accumulator, materials characterization, soil strength, soil stiffness, and pavement response.

V. URGENCY - There is no fundamental way, currently available, to accurately account for the significant reduction in strength and stiffness due to frost action on pavement systems. There is a critical need for a broad data base of actual values of resilient modulus and other suitable parameters of a wide variety of subgrade soils and base course materials, measured throughout the year including periods of freezing, thawing and recovery. These actual field measurements are necessary to verify analytical and laboratory predictive techniques which are in turn urgently needed to improve pavement design in seasonal frost areas.

PROBLEM NO. 130 - COMMITTEE A2L05

I. NAME OF PROBLEM - DESIGN OF HORIZONTAL DRAINS IN SOIL OR ROCK

II. THE PROBLEM - Recent equipment developments have caused a rapid expansion in the use of horizontal drains in all types of soil and rock. At present, there is no proven way of determining where and to what length and slope such drains should be drilled for optimum effect except where the geology is well enough known to permit seeking specific joints, faults, or strata.

There is no general way of predicting the shape or extent of the zone of influence of the drains. Drilled drains are expensive and can be useless or even detrimental if poorly located. Present placement methods may provide more drainage than is necessary. It is desirable to know the service life and have a better understanding of the behavior of these drains during the service life.

The design and construction of collector systems affects the ultimate performance of the entire drain installation. Types of materials and methods of handling the collected water need study.

III. OBJECTIVES -

The objectives of this research are to answer the following questions:

1. With respect to soil and rock conditions:
   a) What is the optimum location, spacing, slope and casing type for drains?
   b) What is the zone of influence around the drains?
   c) How should pipe size and slot size be determined?
2. How should performance be monitored?
3. How can the need for individual pipe or system maintenance be determined?
4. How can maintenance best be accomplished?
5. What are the characteristics and performance of various collector system designs?
6. What service life can be expected?

IV. CURRENT ACTIVITIES -

A. The TRIS data base was surveyed using the key words "horizontal" and "drains."

B. Suggested key words: drain, subsurface drainage, horizontal drains, drain performance, drawdown.

C. The only research currently active is a project in California jointly sponsored by the Federal Highway Administration and the California Department of Transportation. The study, titled "The Effectiveness of Horizontal Drains," is a survey of existing installations to determine how well they have performed. A study of design methods is not included. This project is estimated for completion in June 1979.

The TRIS data base also lists a Federal Highway Administration pilot project on horizontal drain maintenance reported in 1964 in "Special Reports on the Use of Equipment and Methods of Maintenance." No other recent or current research related to the key words was found.

V. URGENCY - A large amount of horizontal drain work is being done, especially in the control of landslides. Criteria leading to successful installations and accurate estimates of bid quantities would be valuable to designers and construction engineers.

PROBLEM NO. 131 - COMMITTEE A2L05

I. NAME OF PROBLEM - CONSTRUCTION METHODS FOR HORIZONTAL DRAINS

II. THE PROBLEM - Over the past several years, numerous techniques for drilling and installing horizontal drains have been developed by contractors; however, little information has been published or made available on the effectiveness of these techniques. Designers may not be aware of the extent of current technology and have difficulty preparing proper specifications.

III. OBJECTIVES -

1. Prepare a state of the art summary covering -
   a) Equipment capabilities,
   b) Drilling methods and techniques,
   c) Borehole guidance procedures and capabilities,
   d) Hole stabilization techniques.
2. Review existing installations to determine the geologic conditions, drilling techniques used, production rate achieved, costs, and problems encountered.
3. Survey requirements and needs for environmental controls.
4. Develop a demonstration project to evaluate newer techniques and equipment available and determine opportunities and limitations with respect to geologic materials and conditions.

IV. CURRENT ACTIVITIES -

A. The TRIS data base was surveyed for the key words "drilling equipment" and "horizontal drains."

B. Suggested key words: drilling equipment, drilling methods, drilling machines, horizontal drains, subsurface drainage, and drainage practices.

C. No research covering this area was found in the literature survey. A study jointly sponsored by the California

Department of Transportation and the Federal Highway Administration titled "The Effectiveness of Horizontal Drains" is a survey of existing installations. This survey may gather historical data on installation methods used.

V. URGENCY - The use of horizontal drains is increasing, especially in the eastern half of the United States. Many new contractors are entering the field using methods and techniques which have not been available recently. Designers in preparing specifications for bid purposes are having difficulty properly specifying approaches and techniques to achieve the desired effect resulting in construction difficulties, improperly constructed drains, and in some cases, legal action by contractors.

PROBLEM NO. 132 - COMMITTEE A2L06

I. NAME OF PROBLEM - MOISTURE INDUCED STRENGTH VARIATIONS IN PAVEMENT SYSTEMS AFTER CONSTRUCTION

II. THE PROBLEM - Moisture is a fundamental variable in all problems of soil stability. It has special significance in pavement systems since subgrades are generally constructed in the surface soil which is usually subjected to large moisture content variations and strongly influenced by surrounding climatic conditions. It is for this reason that the problems of moisture movement in soils, moisture accumulations under pavement surfaces, and subgrade-moisture control are of prime importance relative to pavement construction, design, behavior, and performance.

The importance of including moisture effects in pavement design is indicated by the fact that more than 50 per cent of the flexible pavement failures at the AASHO Road Test occurred during the spring when moisture accumulations in the pavement system were the greatest. Numerous research studies in the field and laboratory have also shown that moisture content can have a pronounced effect on strength and deformation properties of pavement soils and materials.

The engineering problems associated with the behavior of pavement soils and materials responsive to moisture changes indicate that further study is required in reference to strength variations in pavement systems after construction.

III. OBJECTIVES - The general objective of this project is to develop a procedure for determining moisture induced strength variations in pavement systems after construction. Specific objectives are -

1. Determine the magnitude of moisture induced strength variations which can occur in various pavement soils and materials for a known set of conditions.

2. Develop procedures for predicting the magnitude of strength variation which can be expected to occur in the field based on intrinsic pavement conditions, material properties, climatic conditions, etc.

3. Develop procedures for utilizing the study findings in pavement design.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progesss at the University of Illinois entitled, IHR-604 - Moisture Movement and Moisture Equilibria in Pavement Systems, and IHR-605 - Subgrade Stability.

B. Transportation Research Studies Conducted at Texas A and M University.

C. "Seasonal Strength of Pavements," George W. Ring.

D. "Water in Roads" Organization for Economic Cooperation and Development.

V. URGENCY - Numerous researchers have concluded that meaningful evaluation of the engineering properties of pavement soils and materials requires that the moisture properties be specified.

The benefits that may be derived from the proposed research are primarily economical. The study is foreseen as an important step leading towards the ultimate goal of including moisture in the design of pavement systems. With improved procedures for evaluating strength variations caused by moisture, pavement design techniques can be refined and pavement performance predictions can be improved. These improvements and refinements may result in financial savings in the initial design phase as well as minimizing moisture induced failures of in-service pavement systems.

The research could lead to an optimized design of the pavement system in relationship with its moisture environment; therefore, reducing the detrimental effects of moisture.

PROBLEM NO. 133 - COMMITTEE A2L06

I. NAME OF PROBLEM - EVALUATION AND CORRELATION OF THE INFLUENCE OF CLIMATE ON SUBGRADE MOISTURE CONDITIONS USING SOIL SUCTION DATA

II. THE PROBLEM - The design, construction, and performance of pavements (rigid or flexible) is determined by the strength and volume change characteristics of the subgrade soil. Since the strength and volume change properties of nearly all soils are influenced by variations in subgrade moisture conditions, it follows that pavement performance is largely influenced by subgrade moisture conditions. In many cohesive soils, increased moisture contents result in significant strength decreases and volume increases (expansive soils). Efforts to quantify the variations of moisture conditions for various soil types have met with limited success and essentially nothing is known about the influence of climate. As an illustration of the problem, consider a pavement placed on a relatively active clay. Sufficient samples are taken during early spring when most subgrade moisture conditions are at their maximum value; however, the pavement is not constructed until late summer when most subgrade moisture conditions

are at their minimum value. The pavement is designed based on high moisture content conditions, which is conservative from a strength standpoint and desirable from a volume change standpoint; however, the pavement is built during low moisture content conditions, which is more conservative from a strength standpoint but extremely nonconservative from a volume change standpoint. Following construction, the subgrade moisture content increases, the volume increases, the strength decreases, and pavement damage occurs. This simple analogy points out the need to quantify the influence of climate on subgrade moisture conditions for various soils. If these relationships were better understood, then perhaps the in-service condition could have been predicted and appropriate design alternatives selected. The major reason for the lack of success in establishing these relationships is the dependence on soil moisture content alone to quantify the subgrade conditions. With the acceptance of the soil suction concept, a more sensitive and reliable parameter is available for quantifying subgrade moisture characteristics.

III. OBJECTIVES - The major objective of this project is to determine the influence of climate on subgrade moisture conditions and establish relationships between the two variables so that the adverse effects of moisture variations can be accounted for in the design process. Specific objectives include:

A. For selected sites representing various soil and climatic conditions, the depth, amount, and extremes of variations of subgrade soil suction and moisture content will be determined.

B. Using U. S. Weather Bureau data, classify the climates of the various site locations using accepted climatic classifications.

C. Correlate the measured soil suction and moisture content data with climatic classification parameters and established procedures on a regional (climate) basis to adjust design conditions for anticipated construction or long-term conditions.

IV. CURRENT ACTIVITIES - Though no current research is active in this particular area several current projects could provide technical input into the effort.

A. Research studies at the U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, on expansive clays.

B. Transportation research studies at Texas A&M University.

C. Moisture movement studies at the University of Illinois.

D. Research studies at the Civil Engineering Research Facility, University of New Mexico on expansive clays.

E. "Towards New Methods in Highway Engineering," C.S.I.R.O., Division of Applied Geomechanics Lecture Series No. 31, Australia, 1976.

V. URGENCY - With the cost of building new highways and maintaining existing highways continually increasing, the need to assure maximum performance of a pavement throughout its design life is essential. An extremely important factor in optimizing pavement performance involves minimization of the adverse effects of subgrade moisture variations. Minimization of the moisture related problems requires an understanding of the factors causing the variation. The soil suction concept and the development of procedures to measure soil suction as well as recent work with moisture sensors now provide the means to establish the quantitative relationship. With the relationships available, the economic benefits of a pavement design which accounts for variations in the moisture conditions and reduces the detrimental effects of the variations can be realized.

PROBLEM NO. 134 - COMMITTEE A2L06

I. NAME OF PROBLEM - A CONTINUING MONITORING AND ANALYSES OF THE EFFECTIVENESS OF VARIOUS MODES OF CONTROLLING EXPANSIVE SOILS ON CONSTRUCTION PROJECTS

II. THE PROBLEM - Expansive soils can be estimated as causing four billion dollars worth of damages in the United States in the last year. The problem is world wide where dry and then wetting climatic conditions and clay soils result in expansive movements. It affects a wide variety of transportation facilities including airports, heavy rail systems, highways and canals. A great deal of work has been done by many engineers around the world, at the universities, laboratories, agencies and in construction. Many solutions have been taken from the laboratory and are being applied on construction problems throughout the United States. An orderly analysis, at regular intervals, of their effectiveness is needed to provide a measure of true economy of the various methods as well as a cost saving procedure of significance.

III. OBJECTIVES - The ability to evaluate effectiveness, economy and practical choice of options in the reduction of costs of the expansive soil movement is a general goal. The specific objectives are -

1. Determine what type of control measures are being currently tested under construction conditions.

2. To analyze their effectiveness and examine the ways this effectiveness is being measured.

3. To continually bring forward more effective modes of controlling the expansive soil problem and to permit less effective methods to be equally well recognized.

IV. CURRENT ACTIVITIES -

A. Highway research on the moisture and expansive soil problem is being conducted at the University of Illinois.

B. Transportation research studies are being conducted at Texas A&M University.

C. The comprehensive examination of the expansive soils problem by the Waterways Experiment Station.

D. Research at the Sandia Corporation, the U. S. Air Force and University of New Mexico.

E. Testing by the Mississippi State Highway Department.

F. Testing by the South Dakota Department of Transportation.

G. Testing by the Colorado Department of Transportation.

H. Testing by the Arizona State Highway Department.

I. Testing by the Texas State Department of Highways and Public Transportation.

V. URGENCY - This problem becomes more expensive with the passing of time. As man develops more sophisticated structures, pavements, more intensively uses the land, the destruction caused by the expansive soil becomes more and more expensive. Man has faced with the problem of using his resources with ever increasing wisdom and economy. Engineers are required to meet these needs or face the loss of the public acceptance as a profession that is attempting to solve significant world wide problems. This research could form an effective bridge between the university laboratory, governmental agencies, private and public construction in solving a problem of international significance.

PROBLEM NO. 135 - COMMITTEE A2M01

I. NAME OF PROBLEM - TRACK SYSTEM OPTIMIZATION

II. THE PROBLEM - With the many track configurations, variations in maintenance operations and cycles and types of train operations (vehicle type and speed), there exists no definitive method to select an optimum track rehabilitation (upgrading and maintenance program.

Increases in axle load, train length and speed and deferred track maintenance, have in different ways lead to more and more track with slow orders and permanently reduced speed limits. With continuing increases in the cost of materials and labor the railroad engineer is faced with the complex problem of resource allocation.

The availability of track geometry data has provided but one tool to aid the engineer in this difficult decision process. Details of actual track conditions coupled with predictive tools that require system and component life cycles, which vary with the many track and load conditions, are needed to adequately restore and maintain the railroad system as a national resource.

III. OBJECTIVES - Development of a general predictive methodology which will provide the railroad Chief Engineer and staff the means to optimize resource allocations. Sub-objectives include; (1) an understanding of the life cycle of the track both as a system and as components under varying conditions, (2) means of non-destructively determining the existing conditions of the railroad network and (3) data base which is an inventory of both the track system (components and geometry) and rolling stock loads (magnitude, frequency and yearly totals).

IV. CURRENT ACTIVITIES - Presently the railroad industry and the Federal Government are conducting research covering the railroad system. The industry has research by individual railroads and suppliers and jointly funded activities through the Association of American Railroads, American Railway Engineering Association, Railway Progress Institute and other groups including transit authorities. Also the Track Train Dynamics Program, a joint industry/Government research program, is actively conducting and sponsoring projects. The Government has the major portion of R&D funds and has a wide range of on-going projects.

V. URGENCY - The railroads spend huge sums each year on the operations and maintenance of the railroad network. While past experience does provide a tool to allocate resources, it is general knowledge that a better method could save millions of dollars. With the continuing inflation and energy situations, combined with the need to maintain a viable railroad network, it is imperative that research of this type be given the highest priority.

PROBLEM NO. 136 - COMMITTEE A2M01

I. NAME OF PROBLEM - VIBRATION OF TRACK AND SUPPORT

II. THE PROBLEM - The advent of recent energy price increases have reaffirmed the importance of railways as a mode of transport for the movement of bulk commodities. To meet the challenge, track design, construction and particularly maintenance practice are being improved to satisfy the needs of changing load patterns, however the rate of progress is slow and the availability of documented design procedures is limited. For instance, the governing document for track specification in North America is the Manual of Recommended Practive of the American Railway Engineering Association (AREA) which does not contain a procedure of design and leaves such matters as the determination of ballast depth to the individual operators who rely on their own experiences.

The dynamic response of vehicles to track

irregularities and elastic parameters has been recognized with high speed services. Computer similations supported by confirmatory service operations and testing have led to more stringent tolerances on alignment and track maintenance. For high speed passenger traffic with light wheel loads and speeds exceeding 200 km/h (120 mph) continuous raft foundations of concrete or bituminous material are gaining favour over the conventional ballast system. Resilient pads are being introduced between rails and sleepers or raft to minimize dynamic loads.

At the other end of the loading spectrum where axle loads reach 360 kN (41 tons) with maximum speeds of 100 km/h (50 mph) modifications in track parameters are receiving less attention. Heavy axle load unit train operations running at generally reduced speeds adopt basically the same philosophies of track design that have been developed for faster passenger operations. Whilst this may be adequate for 'static' track response in terms of bearing pressures and maintenance of alignment it is clearly apparent that the dynamic response is not as accommodating. Frequent reports of rail-head corrugation on lines used with unit train rolling stock clearly indicate an excitation of the track into its fundamental resonant mode leading to periodic rail overloading and track deformation. In addition slab track design has shown very poor performance under heavy loads as demonstrated by the breakup of the slab section of the Kansas test track in less than six months of service justifying, for the present at least, the continued use of conventional track for heavy freight service.

Conventional ballasted track is a comparatively loose assembly of rails, fastenings, ties and ballast designed to transmit the dynamic forces from a moving vehicle to the underlying road bed. It depends for its vertical alignment upon the ability of the ballast and road bed to sustain the repeated applications of contact stress due to the passage of each wheel over the hard spots caused by each tie. The ballast layer itself is characterized by a high angle of internal friction, a high modulus of elasticity effective over an extended period and as a result of its angular shape a high resistance to displacement of its particles under dynamic action.

Nevertheless, when subjected to the action of dynamic repeated loads the ballast layer undergoes cumulative irreversible (plastic) deformation which is recognized as ballast subsidence or voiding. The typical relation between load repetition, frequency, and ballast settlement is complex and not clearly understood. Even less understood is the correlation between the rate of tie settlement and ballast contact pressure and ballast acceleration. A further complication arises when the load is distributed by the flexible rail to adjoining and subsequent ties.

III. OBJECTIVES - The overall objective is the improvement of railway track support through better understanding of the use of ballast material and the sizing and spacing of rail ties.

This objective implies the need to increase the resistance of the track structure to the development of irregularities due to vibrations and repeated loading from traffic and due to the effects of the weather. The program should be mainly concerned with the optimization to vibration and repeated loading -

(a) of ballast, subballast and subgrade materials

(b) design of the ballasted track structure including tie sizing and spacing and the selection of rail.

IV. CURRENT ACTIVITIES -

Some work on track resonance is being done in Europe and Japan related to lighter axle loads. Little or none is related to heavy axle loads.

V. URGENCY - The Maintenance of Way budget represents about one-third of the expenses of railway operation with about one-third of these expenses going to the replacement and upkeep of track. Thus the urgency for this project should be amongst those given top priority.

PROBLEM NO. 137 - COMMITTEE A2M01

I. NAME OF PROBLEM - EVALUATE CONCEPTS TO UPGRADE EXISTING TRACK TO ACCOMMODATE INCREASED AXLE LOADS OR INCREASED SPEEDS

II. THE PROBLEM - Railroad track in the U. S. has deteriorated in overall quality during the past two decades. Increased axle loads are responsible for a great portion of this situation. (Closely Related to Problem No. 3).

III. OBJECTIVES - Tabulate and evaluate all known concepts for possible upgrading of track to meet current loads.

IV. CURRENT ACTIVITIES -

1. FAST track.

2. AAR TTD studies.

V. URGENCY - All Railroads are actively engaged in their individual methods. Overall advice on evaluation of all techniques would be of help.

PROBLEM NO. 138 - COMMITTEE A2M01

I. NAME OF PROBLEM - ESTABLISH A UNIFORM STANDARD OF ACCEPTABLE TRACK STIFFNESS FROM A TRAIN RESPONSE VIEW

II. THE PROBLEM - The classification of track standards is currently measured by the many individual components of the track. This method does not provide a safe level of operational measurement by which to judge a track.

III. OBJECTIVES - Using track "stiffness" as a single measurement of relative operational

safety, develop a method of measuring track "stiffness" which can be used as a minimum safe level, a design specification, or load determinant.

IV. CURRENT ACTIVITIES -

1. Some activity by D.O.T.

2. Dr. Arnold Kerr, Princeton University.

V. URGENCY - Present evaluation methods are not meeting needs of the evaluation in American and Canadian Railroads.

PROBLEM NO. 139 - COMMITTEE A2M01

I. NAME OF PROBLEM - INVESTIGATE THE MERITS OF HEAT-TREATED RAIL VS. ALLOY STEEL RAIL

II. THE PROBLEM - With higher wheel loads on track than ever before, the need for an improved rail steel is increased.

III. OBJECTIVES - Test new types of heat treating and alloy combinations to develop the best for a rail including economic considerations. The welding (pressure-butt and thermit) should be included in the testing.

IV. CURRENT ACTIVITIES - FAST TRACK - testing only, no research.

V. URGENCY - Increased axle loads require urgent work to improve rail steel.

PROBLEM NO. 140 - COMMITTEE A2M01

I. NAME OF PROBLEM - INVESTIGATE THE TRADE OFF BETWEEN REDUCING AXLE LOADINGS OR IMPROVING TRACK

II. THE PROBLEM - In the U.S.A. rail axle loadings have been increasing steadily over the past two decades due to large volume cars being designed and built. These increased axle loads have caused deterioration to track structure which is an economic loss to the railroads, off setting the gain made by increased car loadings.

III. OBJECTIVES - Determine the true dollar value of increased axle loadings after deducting track deterioration.

IV. CURRENT ACTIVITIES - Some past activities such as analysis of economics of the 125 ton coal hopper cars. Some activity in studies of wheel loadings on rail.

V. URGENCY - Most of the damage has been done or is irreversibly continuous. The study could help in future axle load design.

PROBLEM NO. 141 - COMMITTEE A2M01

I. NAME OF PROBLEM - LONGITUDINAL STRESS MEASUREMENT OF RAIL UNDER OPERATING CONDITIONS

II. THE PROBLEM - Continuous welded rail exists in nearly 70,000 miles of U. S. and Canadian Railroads. This rail is restrained from expanding and contracting, and therefore builds up longitudinal stresses either compression or tension at the rate of about 200 psi for each degree of temperature change, fahrenheit. Dynamic stresses introduced by rail vehicles add to the thermal stress to create the possibility of buckling or breaking of track.

III. OBJECTIVES - Develop a device which will measure the longitudinal internal stress in rail and determine whether this stress is tensile or compressive. The device must be capable of measurement and recording stresses while moving along the track at any speed between 10 MPH and 80 MPH. The device would be used on a variety of existing track testing vehicles.

IV. CURRENT ACTIVITIES

1. Some activity in DOT R&D.

2. British Rail has developed a non-destructive method of detecting longitudinal forces in CWR. (This device must be fixed to the rail, and therefore, is not practical for repeated testing of many miles).

V. URGENCY - Railroads urgently need such a device with which to make periodic checks of CWR to locate potentially dangerous locations at which a build-up of stresses might cause buckling or break and possibly result in a derailment.

PROBLEM NO. 142 - COMMITTEE A2M01

I. NAME OF PROBLEM - TRACK RAIL LUBRICATION EVALUATION

II. THE PROBLEM - Most transit systems use rolling stock with fixed axles and wheels. In negotiating curved track, the wheel flanges and rails make sustained contact causing accelerated wheel and rail wear and annoying noises we call squealing.

III. OBJECTIVES - A lubrication evaluation program combining field and laboratory measurements is recommended to determine the criteria needed for a lubrication system.

IV. CURRENT ACTIVITIES - Current practice is the use of rail lubricators of the Mechanical or High Pressure type. Both systems are automatically actuated by a passing train. Typical problems occur with over and under lubrication from location to location.

V. URGENCY - Little research has been expended over the years toward developing new and evaluating existing track lubrication systems.

It is estimated that a significant noise reduction can be achieved with the use of a lubrication system. In addition, these installations have the added benefit of increasing the useful life of wheel and rail components.

PROBLEM NO. 143 - COMMITTEE A2M01

I. NAME OF PROBLEM - EVALUATION AND DEVELOPMENT OF STANDARDS FOR GUARD RAIL ON CURVES

II. THE PROBLEM - The criteria for the use of guard rail on curves varies from one transit

system to another. It is evident that the criteria for the use of guard rail on curves of transit systems has not been established.

III. OBJECTIVES - To study, develop and evaluate basic standards for transit operation for guard rail and its applications.

IV. CURRENT ACTIVITIES - Many transit properties rely on past practices and cut-and-dry definitions to determine if guarding of curve is required.

V. URGENCY - Because of the added cost of guarding curves and the reliance on standardization of track construction, there is a need to clearly define the use of guard rail criteria.

PROBLEM NO. 144 - COMMITTEE A2M01

I. NAME OF PROBLEM - INVESTIGATE TIE-PLATE CANT FOR TRANSIT

II. THE PROBLEM - Most Transit Systems use the Standard Cant of 1:40. This may not be the most efficient cant in relation to wheel and rail wear in transit applications.

III. OBJECTIVES - An evaluation program should be undertaken for rapid transit operations using the "worn wheel contour," standard AAR tapered wheel tread and the conic wheel design with the various canted plates, to determine if a different tie plate cant would be more advantageous.

IV. CURRENT ACTIVITIES - Recently, the Union Pacific Railroad installed four test sections utilizing 1:40, 1:30, 1:20 and 1:14 canted tie plates. The 1:40 cant resulted in the wheel load on the gauge side of the rail head; the 1:20 cant resulted in the wheel load on the field side of the rail head; the 1:14 cant resulted in the wheel load on the field side of the rail head; the 1:30 cant resulted in the wheel load on approximately the center of the rail head.

V. URGENCY - There has been no determination of optimum rail cant for rapid transit operations.

PROBLEM NO. 145 - COMMITTEE A2M01

I. NAME OF PROBLEM - COMPARISON OF BONDED JOINTS TO WELDED JOINTS FOR TRANSIT

II. THE PROBLEM - One of the most critical components of rail construction is the rail joint. The rail joint is designed to unite rail sections into one continuous rail. The rail joint also serves to hold the rail ends accurately, evenly and firmly in place to assure even rail surface and rail alignment.

III. OBJECTIVES - An evaluation program should be undertaken to compare the bonded joints as an alternate to the welded joint.

IV. CURRENT ACTIVITIES - Most Transit Properties use welded rail joints.

V. URGENCY - Since present Transit Properties are continually rehabilitating existing trackage and new properties are under construction or are being planned; an evaluation of these two types of joints would be most advantageous.

PROBLEM NO. 146 - COMMITTEE A2M01

I. NAME OF PROBLEM - EVALUATE NEW TRACK SYSTEMS FOR NOISE AND VIBRATION REDUCTION FOR TRANSIT

II. THE PROBLEM - It has become increasingly evident that transit noise and vibration has become a major problem in metropolitan areas.

III. OBJECTIVES - Noise and vibration attenuation has become an important consideration in all facets of rapid transit operations. Rail, rail joints, fasteners and track bed are contributing factors in transmitting noise and vibrations to adjacent property. There may be locations along the route of new subways that are suitable for more attenuation than welded rail with resilient fasteners can offer, but may not warrant the greater degree and more costly attenuation provided by the floating slab track. To satisfy that condition, other systems would be necessary.

Such systems as STEDEF ballastless track and Slab Track Should be tested and evaluated for the amount of attenuation such a system could offer. Other sound reducing track components should also be looked into at this time.

IV. CURRENT ACTIVITIES - Not applicable

V. URGENCY - This is probably the most urgent transit need at the present time with the news media reporting major public concern with this problem.

PROBLEM NO. 147 - COMMITTEE A2M02

I. NAME OF PROBLEM - COST REDUCTION OF SIGNAL AND COMMUNICATIONS MODIFICATIONS AS A RESULT OF RAILROAD ELECTRIFICATION, WITH SPECIAL EMPHASIS ON EMI

II. THE PROBLEM - The capital cost of electrifying a railroad is significantly influenced by the modifications which are required to the existing signal and communications system of the railroad and commercial communications system. A major area of capital cost addition comes from measures taken to reduce the effects of electromagnetic interference (EMI) which can seriously disturb these signal and communications systems (S&CS).

The principal sources of EMI are magnetic induction which introduces noise in the S&CS having lines parallel to the railroad; electrostatic induction, which causes high voltage to appear on the S&CS components, causing potential hazards and equipment damages; ground conduction, which causes current flows in conductors in ground contact near the railroad causing corrosion effects and potential hazards and radio frequency interference caused by pantograph bounce (arcing) and propulsion and power supply options.

A further cause for concern is the possible proliferation of interference in the local power distribution network necessitating inductive coordination extending beyond

the railroad right-of-way. The severity of the problem will depend on the extent to which locomotive rectifier harmonics flow back into the AC network where communications and power lines are together on joint use utility poles or in common trenches.

III. OBJECTIVES - To characterize the electromagnetic environment in the vicinity of 60 hz, 25 or 50 KV railroad electrification systems which utilize thyristor-controlled locomotives, to estimate the effect of the environment on signaling and tele-communication systems, and to recommend mitigative measures which insure compatible operation.

Conduct theoretical studies and field tests in the following areas:

1. Influence - Determine the amplitude and frequency characteristics of the traction system current at the source (power feed point and locomotive) and along the catenary system.

2. Coupling - Determine the coupling of the electromagnetic field generated by the source and estimate the induced voltage per unit length in the disturbed circuits, i.e., on signal and tele-communication cables or wires. Perturbations of the influence by shield wires or track circuits should be taken into account.

3. Susceptibility - Examine the susceptibility characteristics of affected systems for both the 60 Hz fundamental frequency and the harmonic frequency components. Establish susceptibility thresholds with regard to operational or interference margins and personnel safety problems which may result from induced voltages.

4. Mitigation - Study the feasibility and effectiveness of mitigative measures which can be applied to the electrification system. Examples are filtering and auto - or booster transformers. Consider alternatives such as the redesign or relocation of affected signaling or telecommunication systems. Compare alternative approaches on a cost-effectiveness basis.

IV. PROPOSED TEST PROGRAM -

1. Approach

Identify two or more typical CTC mainline signal system that are using DC double rail track circuits. Average length of track circuit should exceed 5000 feet; inter-lockings to include short track circuits with multiple routes. Controls and indications are to be transmitted via supervisory control system, relay or electronic via open line circuits or cables

2. Subsystems

Separate the various subsystems of the signal system that could be affected by an electrified operation.

Such as -

a) Long track circuits
b) Short track circuits
c) Wayside equipment
d) Cable circuits
e) Pole line circuits
f) Supervisory system

3. Interference

Classify the potential interference that could be encountered in the various subsystems. For example:

a) Interference that renders the signal system inoperative (unsafe for train operation).

b) Interference that will present intermittent failures.

c) Interference that is of nuances level.

d) Interference that creates personnel danger.

4. Selection

Establish which subsystems are affected and by what class of interference rank by importance and replacement cost.

5. Program

Prepare program of providing mitigation for the various subsystems.

6. Method

Develop method of providing minimum replacement of existing components without destroying signal system integrity. If necessary prove approach by actual field modifications and subsequent tests and experiments.

V. FINAL PRODUCT - Develop a set of standards which can be applied to future railroad electrification. This development of standards should not neglect the experience of overseas standards which are already in existence, but make every effort to include the experience of Japanese National Railway, French National Railway, British Rail, German Federal Railways and South African Railways under their electrification to high voltage (25-50 KV), commercial frequency (50-60 Hz).

PROBLEM NO. 148 - COMMITTEE A2M02

I. NAME OF PROBLEM - ELECTRIC TRACTION

II. THE PROBLEM - The return on investment in railroad electrification is enhanced by both the reduction of life cycle costs and the increase in operational performance achieved upon implementation of the electrification.

Life cycle costs, which include capital investment as well as operating cost, are influenced by the traction equipment selected for the motive power.

The major areas are -

1. Procurement costs of the traction equipment.

2. Cost of minimizing or eliminating interference effects on the power distribution, signalling and communications systems of the railroad and commercial power transmission and communications.

3. Maintenance cost.

4. Energy costs, which include energy and demand charges, power factor penalties and other penalties which arise from generation of harmonic frequencies which are fed back to the utility supplying power.

III. OBJECTIVES - Selection of traction equipment influences the operational performance of the electric railroad including schedule speed, trailing tons which can be hauled by a single unit and service dependability which results from maintainability and reliability of the equipment itself.

The research for electric traction should be directed toward the reduction of the life cycle cost of electrification and the enhancement of operational performance. The research needs are summarized as follows:

Review of Foreign Experience

Review both domestic and foreign experience in electric traction equipment for electrified railroads to ascertain -

1. Special problems encountered.

2. Solution proposed and tried.

3. Ensuing results.

Thyristor Controlled Equipment

Thyristor control (controlled rectifiers) in motive power for electrified railroads produces signal and communications interference which may be more difficult to correct as the power level of the propulsion unit increases. Minimization or elimination of its disruptive effects should be investigated. Costs associated with implementation of methods to accomplish these goals should be determined and tabulated.

Alternative Traction Equipment

Power conditioning and propulsion equipment which provide an alternative to thyristor controlled DC series motor units have been produced or tested in prototype or production quantities both here and abroad. Among these alternatives include commutated, controlled rectifier controls using DC motors and variable voltage and frequency inverter control using three phase AC induction and synchronous motors. In addition, thyristor controlled units which utilize separately excited DC rather than series DC motors are being produced. These alternatives have life cycle cost and performance capabilities which are determined by improved energy consumption, maintenance, power factor, harmonic generation suppression, adhesion levels and procurement and development cost reduction. One such development might be the use of linear induction motors in heavy grade areas and improved slip/slide control. These alternatives should be investigated to determine their effect on life cycle cost and operational performance of the electrified railroad.

Regenerative Braking

Because of the impending energy shortage and national policy toward energy conservation, there has been a renewed interest in feeding electrical power developed by equipment dynamic braking to other motive power or to the electric utility system. Only electrified railroads with dense passenger commuter traffic or dense freight traffic with large elevation changes would benefit from regeneration at reasonable cost. These rail routes should be identified and the cost-benefit of adding regeneration determined.

Computer Technology

The advent of low cost microprocessor and computer technology can lead to the development of totally new areas of electrified railroad operations such as energy consumption reduction, troubleshooting and maintenance aids, optimization of train handling, automatic train control, automatic train operation, and electric power demand control. In terms of the present, near and far term developments in this field, cost-benefits of such implementation of computer technology should be investigated.

Energy Storage Motive Power

Electrification of main line railroads may leave branch lines unelectrified. Motive power with energy storage capability (battery or flywheels), which may run on the main lines and branch lines, may prove cost effective. An investigation to determine under what circumstances such equipment might prove beneficial should be undertaken.

Solid State Electrical Switches

The development of solid state switching as opposed to mechanical devices could represent a reduction of maintenance cost when the state of the art reaches the point that initial cost can be justified by reduction of maintenance expense.

PROBLEM NO. 149 - COMMITTEE A2T59

I. NAME OF PROBLEM - EVALUATION OF AASHO ROAD TEST SATELLITE AND ENVIRONMENT STUDIES TO IMPROVE PAVEMENT PERFORMANCE PREDICTION EQUATIONS

II. THE PROBLEM - Statement of Problem: The AASHO Road Test ended in 1962 and provided the basis for improved pavement design as set forth in the AASHTO Interim Guides for the design of pavement structures first distributed in 1969 and published in 1970.

As pointed out in the AASHO Road Test's final reports and in the original draft guides no information was available at the Road Test with respect to the effect of environment nor the effect of sub-grade soil since these did not vary at the Road Test. Furthermore, the effect of long-term cyclical weather was not thoroughly evaluated since the Road Test traffic was applied in two years. In 1970 the revised AASHTO Interim Guides included a great deal of information taken from pilot studies in many states. As pointed out in that report nevertheless, the weaknesses with regard to the influence of environment and subgrade soil still exists.

After the Road Test ended there was a significant effort by NCHRP to begin a series of small studies in each state which were termed "Road Test Satellite Studies." The effort to conduct these studies in an organized manner was unsuccessful because of lack of support. Nevertheless, many states did begin studies on existing or newly constructed pavements. These observations of in-service pavements have now been underway for a period of 10-15 years. In almost every case, observations on such pavements are more detailed than those available on any other pavements in a particular state. Furthermore, in most cases they include some observation of pavement serviceability-performance.

In many cases the individual states have been unable to synthesize significant amounts of information because their individual satellite studies are relatively small and the variation of environment over the range of the individual study is narrow. However, if this information could be combined with information from other states so that the overall inference space for environment becomes considerably larger, then it should be possible to make more definitive statements about the effect of environment on pavement behavior.

At the Road Test a series of pavements was constructed on the so-called Loop 1. These pavements were not subjected to traffic during the Road Test nor have they been subjected to traffic since that time, thus they have been in existence subjected only to environmental forces for a total of twenty years. It is highly desirable that someone take this opportunity to look at these pavements and evaluate these environmental effects for updating the AASHTO Interim Guide. Studies should also be made of old Road Test Sections now on the Interstate System.

This is the type of study which is almost impossible for a single state to do and can only be done by a joint state action or by the AASHTO through NCHRP.

III. OBJECTIVES - The objective of this research is to pull together information from Satellite Road Tests in many states and the information available on Test Sections which still exist at the Road Test Site. This information is to be used to better determine the effects of time, subgrade soils, and environmental pavement performance.

IV. CURRENT ACTIVITIES - Benefits of the Research: The proposed research would have significant benefits to all participating states and to all AAHTO Guide users. The significant costs associated with this information have already been spent, that is, the cost of the AASHO Road Test, the cost of construction and observation of the existing pavements.

The marginal or additional cost of pulling the existing information together in a uniform method and analyzing it in a reasonable or rational way will be small when compared to the cost expended to date. The benefits will be large, thus the cost benefits will be quite large.

Perhaps more importantly, this research would pull together more information than can be obtained in no other way in such a short length of time for such a low cost. It is obvious that there is no guarantee as to the outcome of this project but it must be pointed out that this approach offers the best possibility we have to obtain better data on long term (10 years plus) performance observations.

V. TIME FRAME AND COST OF PROJECT - The research should begin as soon as possible with a pilot or feasibility study of 6-9 months duration. The full study, if conducted, would require 24 months to complete. Estimated cost for carrying out the entire study is about $200,000. A significant portion of this cost would be associated with meetings with individual states, collecting information, rechecking and sorting it on a realistic basis for subsequent analyses. The output for the research project could take the form of improved equations or coefficients related to environment and subgrade strength for integration into the AASHTO Interim Design Guides. The data collected should be filtered, processed, sorted and published in a codified form for subsequent use and analysis by any state desiring to do so.

PROBLEM NO. 150 - COMMITTEE A2T61

I. NAME OF PROBLEM - ENERGY UTILIZATION MODEL FOR HIGHWAY CONSTRUCTION QUALITY STANDARDS

II. THE PROBLEM - Determine the amount of energy consumed to meet various levels of quality in construction of highway facilities.

Many of the construction quality standards in use today were developed without consideration of the amount of energy consumed to meet the standard selected. Because energy is used to perform work and is common to all activities, there is a need to quantify the energy expended to meet various levels of quality.

There is an average amount to total energy use associated with each increment of quality specified in any construction process. The cost of this total energy must be considered in future evaluations of quality standards. "First energy" like "first cost" is not the only factor to be considered. Rather it is the total energy consumed over a lifetime of useful service of the facility which must be related to

the standard of quality selected. The level of total energy cost should be correlated with the benefit of each level of quality above a minimum acceptable standard. The quality benefit may be in terms of lower life cycle cost, increased reliability, decreased maintenance, longer life or better environmental quality. Once determined the quality benefit could then be assessed against the total energy (cost) to arrive at a quality benefit/energy (cost) ratio. This ratio could aid the highway engineer in his determination of the optimum quality level.

III. OBJECTIVES - To develop an energy utilization model which will provide the highway engineer with a method for determining how much energy will be consumed for each additional increment of quality produced assuming a minimum standard for safety and reliability. The model must indicate the quality level which provides the optimum use of limited energy resources to produce the most effective result. The model should consider geographic, climatic, resource availability and other pertinent factors which may affect quality standards. Labor and equipment are considered to be resources as well as fuels and other materials.

It is anticipated that the research will include at least the following tasks:

Task 1. Assessment of the existing usage evaluation criteria, including measures of effectiveness currently in use and others which might be used.

Task 2. Establishment of minimum quality standards for selected processes.

Task 3. Development of an application manual which describes the theories, tools, procedures and data sources necessary to apply the energy utilization model to highway construction standards.

Task 4. Compilation of a handbook of relevant energy usage data for highway construction standards with sources identified.

Examples of the processes which may be selected for study include:

1. reduction of mixing temperatures for asphalt mixtures
2. use of drum drier.
3. plain vs. reinforced concrete.
4. density specifications.
5. establishment of gradation bands.
6. selection of aggregate blends to ensure less volume/unit weight of material.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 15, 22, 25, 26, 27, 31, 32, 33, 34, 35, 40, 41, 51, 62, 63, 84 and 90 were scanned in preparing this statement, and no research in progress was found.

B. Suggested key words for this problem:

Energy
Energy utilization
Mathematical model
Models
Quality
Quality control
Quality standards
Standards

C. No direct research on this problem appears to be in progress. Some related studies have been made on energy conservation, particularly in connection with the consumption of fuel in construction equipment and various construction processes. TRB, Asphalt Institute, and the Texas State Department of Highways and Public Transportation have published reports in these areas.

V. URGENCY - This project is considered to be of the highest priority. No studies of the sort posed in this problem have been found so the approach developed herein will be unique.

Research findings may be implemented by making them available to transportation agencies throughout the nation. Studies of life cycle energy costs could be made a mandatory prerequisite to release of highway funds.

PROBLEM NO. 151 - COMMITTEE A2T61

I. NAME OF PROBLEM - QUALITY STANDARDS THAT OPTIMIZE THE USE OF MATERIALS AND ENERGY IN CONSTRUCTION

II. THE PROBLEM - The majority of Quality Standards currently being utilized in construction are empirically founded and relate to actual performance only in an indirect way. In addition, these Quality Standards rarely encompass the aspects of optimizing the use of materials and energy or the matter of life cycle costs. In view of our current national situation with regard to materials shortages, the energy crisis, and limited monetary funding numerous Quality Standards must be reevaluated. It is imperative that these Quality Standards be reassessed with respect to their direct effect on performance, their impact on life cycle costs, and their drain on energy resources. An integral part of this problem is to assess the sensitivity of these Quality Standards as they affect actual performance, total life cycle costs, and total energy consumption. Alternative Quality Standards must also be rapidly and accurately analysed for purposes of optimization.

III. OBJECTIVES - In view of the above stated problem there is a dire need to develop a well defined systematic methodology for assessing the criticality of Quality Standards in light of performance, life cycle

costs, and energy consumption. The development of such a methodology will provide the tools by which crucial decisions can be made with respect to wise allocation and the use of the resources of money, materials, and energy.

IV. CURRENT ACTIVITIES -

Highway Research in Progress areas Pavement Performance, Bituminous Materials and Mixes, Cement and Concrete, Construction, General Materials, Minerals Aggregates, and Maintenance have been scanned in preparing this statement.

Suggested key works for the problem: performance, skid resistance, riding quality, roughness, serviceability, deflection, faulting, deterioration, texture, loading effects, crack detectors, measurement systems, profiling systems, sensitivity analysis pavement evaluation, zero maintenance pavement, pavement life, pavement condition, pavement evaluation and rehabilitation, pavement serviceability standards, road smoothness, rideability, rutting, quality evaluations, probabilitation methods, improved pavement, fatigue, impulse index, rehabilitation forecasting, premium pavement, durability, reflection cracking, moisture effects, qualities of sand, predicting performance, service behavior, permeability, process control, quality control, rational, nuclear testing methods, wear properties, compaction, aging, rapid test methods, statistical specifications, uniformity, evaluation models, nondestructive testing, statistical evaluation, corrosion, delamination detector, sampling, materials test data systems, statistical quality control, simulation of uncertainty, density standards, acceptance sampling and testing, waste materials, new construction materials, precision of test methods, sampling techniques, accelerated tests, inspection, computer simulation, products evaluation, Quality Assurance, graduation control, maintenance rating techniques, energy saving methods, pavement maintenance, resurfacing priorities, maintenance costs, maintenance strategies. There are many related research activities currently in progress which if appropriately synthesized and integrated would yield the inputs, components, and techniques for developing the systematic methodology outlined above.

V. URGENCY - Since the transportation industry is one of the primary users of energy and materials, it is essential that the research outlined in this problem statement be addressed. Quality standards not only impact on materials usage but also affect the efficiency of high energy consumptive modes of transportation; automobiles, trucks, buses, etc. The proposed methodology could be implemented by incorporating it into current workshops relating to pavement design, maintenance management, quality assurance and the like.

Research and development costs for this work are estimated to cost $500,000.

PROBLEM NO. 152 - COMMITTEE A2T61

I. NAME OF PROBLEM - THE USE OF ASPHALT PAVEMENTS AS SOLAR ENERGY COLLECTORS

II. THE PROBLEM - Practically everyone recognizes the heat gathering capacity of asphalt pavements. One generally learned this as a child during a hot summer day when trying to cross a street or driveway in bare feet. Perhaps on a sunny, but cold winter day, one could lie down on an asphalt driveway or playground and keep comfortably warm. Little did anyone know that such energy was to become such a scarce and valuable commodity that it is now attractive and perhaps necessary to attempt to collect what was once taken for granted. Approximately 93 percent of all the paved highways in the United States are asphalt-type surfaces accounting for about one percent of the land surface of the United States. These thousands of miles of existing highway pavements plus driveways and parking lots may provide a ready means to collect solar energy. Most pavements are exposed to solar radiation each day at least part of the time. This energy collected during the daytime is returned to the environment at night or during bad weather until it is exhausted. If the necessary technology was available, this energy might be used as a heat supplement for a variety of applications.

The potential energy which could be obtained from asphalt pavements is dependent on the temperature differential between it and the environment and the heat capacity of the pavement itself. Factors influencing the temperature differential include: inclination of sun on pavement (function of season and latitude), weather conditions (function of cloud cover, wind, etc.), and blackness of pavement surface (function of pavement age, degree of aggregate exposure, etc.). Factors influencing the heat capacity of the pavement would include: material composition, and pavement density.

III. OBJECTIVES - The principal goal would be to develop techniques to utilize existing and new pavement surfaces as solar energy collectors. Factors to be investigated would include: (1) asphalt mix composition variables, such as aggregate type to maximize performance (black aggregate or steel scrap might be beneficial), (2) asphalt mixture type such as dense-graded or open-graded, (3) type and design of heat collection system, and (4) determining the potential benefits to be derived from use of pavements as energy collectors.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 11, 31, 33, 40, 82, 83, and 84 have been scanned in preparing this statement for this problem.

B. Suggested key words: Pavement heat, solar cells, solar radiation, heat capacity, heat conductivity, heat emission, heat pump, heat exchange, solar heat, black body.

C. Although there is a great deal of

interest and research involving solar cells, no attempts have been made to investigate the use of asphalt pavements for such a purpose.

V. URGENCY - All energy-related activities are of utmost importance to the National Security. As recently as the winter of 1976-1977, a number of areas of the United States had experienced a critical shortage of fuels (energy) with which to provide heat to residential and commercial buildings. This shortage might have been alleviated to some degree if the subject technology had been available and had been implemented.

PROBLEM NO. 153 - COMMITTEE A2T61

I. NAME OF PROBLEM - DEVELOPMENT OF A NEW LOW ENERGY BINDER SYSTEM FOR USE IN PAVEMENT STRUCTURES

II. THE PROBLEM - Historically, binder systems for flexible and rigid pavements have been those materials most readily available at an economical price and capable of adequate performance. Little thought was given to the energy requirements necessary to produce the systems just as little consideration was given to the latent energy potential of the binder system itself. The recent development of a drastic shortage of commonly used energy materials plus the continuing rising cost spiral for all forms of energy has abruptly brought about the need to re-evaluate the requirements for these historic binder systems versus possible alternates.

All present forecast indicators predict there will be a continuing and expanding need for pavement systems to carry wheeled loads well into the 21st century. The use of the automobile and truck is not just a way of life, it is an economic necessity at this time, one which will require many years to de-emphasize or replace. This necessity coupled with the prevalent energy situation has created the need to depart from the historic materials and develop instead a new low energy binder system capable of being used with both natural and synthetic aggregates. The pavement structures thus created must provide smooth, safe and durable riding surfaces which are distortion free, relatively inelastic, water resistant and adaptable to grade adjustments. This new system should be adaptable to maintenance activities and capable of minimizing traffic delays which are another form of high energy loss.

III. OBJECTIVES - The purpose of this research is to develop and prove a new pavement binder material that contains a minimum of latent energy and requires low amounts of energy for production. The material may be synthetic or natural, or may be a combination of the two, and must be compatible with the aggregate, sands and soils normally utilized in the construction of pavement structures. In addition, it must be a material that adapts easily to maintenance requirements that develop during the course of the pavement life and preferably, will be a material that can be used in that maintenance in such a manner to curtail costly restrictions to traffic flow.

It is anticipated that these objectives will be achieved by including at least the following tasks:

Task 1: Identification of current and potentially available methods, materials and concepts that hold promise for a pavement binder system. This task will be based upon a review of the literature, research in progress and other appropriate sources.

Task 2: Preliminary analysis of the information developed under Task 1.

Task 3: Laboratory development and evaluation of potential systems for the purpose of establishing feasibility based upon the desired characteristics outlined.

Task 4: Field evaluation of selected systems. Installations shall be located so as to provide an adequate history of service under most conditions.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 25, 26, 31, 32, 33, and 34 have been scanned in preparing this statement.

B. Suggested key works for this problem: binder, pavement binder, low energy binder, cement, pavement design, pavement material, sulfur, sulfur-asphalt, fly ash-portland cement, lignins.

C. Related research activities include the research efforts underway by the FHWA and several states the use of sulfur as a binding agent, both with asphalt and by itself, 2) the use of fly ash, especially the high lime fly ashes, as a potential portland cement replacer, and 3) the use of modified woodlignins as potential binders.

V. URGENCY - The energy intensive binders in use today--notably portland cement and asphalt--are rapidly becoming too expensive and scarce to meet the demands. Thus, research is needed now in order to find lower energy binders for the future requirements in construction, rehabilitation, and maintenance of our nations highways.

PROBLEM NO. 154 - COMMITTEE A2T61

I. NAME OF PROBLEM - EFFECTS OF PAVEMENT CHARACTERISTICS, ESPECIALLY ROUGHNESS ON HIGHWAY VEHICLE FUEL CONSUMPTION

II. THE PROBLEM - Limited research by Paul Claffey (NCHRP Report No. 111) indicates that pavement characteristics have a substantial effect on energy consumption of passenger cars, pickups, and trucks. Correction factors showing the ratio of fuel consumption on different types of roadways relative to high-type concrete or asphalt are shown in Table 1.

The "correction factors" for different vehicles indicate, for example, that fuel

consumption is from 16 percent to 50 percent higher on badly patched and broken asphalt than on high-type concrete or asphalt. The correction factors are even higher for gravel and sand. Table 2 presents similar information for tire wear, another product affecting overall energy consumption, both directly and indirectly. (These summary tables are based on the work of Claffey as summarized in W. F. McFarland's Benefit Analysis for Pavement Design System, Research Report 123-13, Texas Transportation Institute, College Station, Texas, April, 1972; McFarland's report also summarizes other studies, in the U. S. and other countries, that have dealt with this problem).

There is a need to extend Claffey's work to other types of vehicles and to also cover different degrees of pavement roughness between the extremes covered by Claffey. Fuel consumption and tire wear need to be related to measures of pavement roughness that can be used by decision-makers in determining the point at which it is economical to improve rough pavements.

III. OBJECTIVES - To provide decision-makers with data on the interactive effects of energy consumption and tire wear for different types of vehicles with different loads on pavements with different characteristics.

It is anticipated that the research will include tasks such as -

Task 1: Review relevant literature to determine state-of-the-art and develop experimental procedures.

Task 2: Determine the types of information needed by decision-makers.

Task 3: Plan and execute controlled experiments to develop data.

Task 4: Develop better methods of presenting and using this data.

Task 5: Write report documenting findings.

IV. CURRENT ACTIVITIES -

A. Reports by Claffey and McFarland previously mentioned provide a fairly good summary of research to date.

B. No research in progress has been located.

V. URGENCY - This research could provide the basis for considerable energy savings in highway transportation.

VI. COST - Experimental studies for several types of vehicles on several types of pavement probably would cost at least $200,000. (It might be possible to supplement field studies with computer simulation and produce more results for a given budget, and this possibility should be explored, also).

TABLE I

Correction Factors for Adjusting Vehicle Fuel Consumption

Vehicle Type and Uniform Speed (mph)	Correction Factors by Road Surface: High-Type Concrete or Asphalt	Badly Broken and Patched Asphalt	Dry Well-Packed Gravel	Loose Sand
Passenger Cars:				
10	1.00	1.01	1.09	1.23
20	1.00	1.05	1.13	1.28
30	1.00	1.20	1.26	1.40
40	1.00	1.34	1.56	1.73
50	1.00	1.50	1.70	2.00
Pickups:				
10	1.00	1.00	1.07	1.33
20	1.00	1.00	1.09	1.49
30	1.00	1.01	1.16	1.67
40	1.00	1.06	1.27	2.02
50	1.00	1.16	1.34	--
Two-Axle, Six-Tire Trucks:				
10	1.00	1.03	1.24	1.46
20	1.00	1.06	1.28	1.62
30	1.00	1.07	1.45	2.16
40	1.00	1.08	1.58	2.46
50	1.00	1.20	1.69	--
Tractor Semi Trailers:				
10	1.00	--	1.07	--
20	1.00	--	1.27	--
30	1.00	--	1.59	--
40	1.00	--	1.75	--

TABLE 2

Correction Factors, Relative to High Type Asphalt, For Tire Costs

Vehicle Type and Uniform Speed (mph)	Correction Factors by Road Surface: High Type Concrete	High-Type Asphalt	Dry Well Packed Gravel
Passenger Car:			
20	0.33	1.00	3.81
30	0.53	1.00	2.92
40	0.67	1.00	2.49
50	0.71	1.00	2.44
60	0.67	1.00	--
70	0.68	1.00	--
80	0.63	1.00	--
Pickup:			
20	0.31	1.00	3.81
30	0.52	1.00	2.95
40	0.67	1.00	2.47
50	0.72	1.00	2.45

ADDENDUM

PROBLEM NO. 15 - COMMITTEE A2A05

NAME OF PROBLEM: ESTABLISHMENT OF MARSHES AS A MITIGATIVE TECHNIQUE

V. URGENCY - Because of the mandates to protect wetlands highway agencies need an effective method of mitigating impacts on wetlands. Wetland construction is one alternative.

PROBLEM NO. 19 - COMMITTEE A2B02

NAME OF PROBLEM: FLEXIBLE PAVEMENT STRUCTURAL DESIGN REQUIREMENTS FOR LOW-VOLUME ROADS

IV. CURRENT ACTIVITIES - A variety of research activities are on-going in the area of flexible pavement design but are not specifically addressing the needs of low-volume roads relative to the structural aspect. Those pertaining to low-volume roads are mostly directed toward geometric design and safety standards. The need for this type of work is expressed in the announcement and call for papers for the Second International Conference on Low-Volume Roads to be held August 20-23, 1979, at Ames, Iowa.

Suggested Key Words - Flexible pavement, structural design, low-volume roads, surface distress, structural maintenance, pavement service level, performance, terminal Serviceability Index.

V. URGENCY - The problem is of high priority among local agencies, and the results will be of immediate value in the refinement of flexible pavement design procedure to respond to the specific needs of low-volume roads.

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A2B03	Pavement Rehabilitation Design	M. W. Witczak
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A2C04	Design of Underground Transportation Structures	D. A. Linger
A2C05	Dynamics and Field Testing of Bridges	C. P. Heins, Jr.
A2D01	Characteristics of Bituminous Materials	J. Claine Peterson
A2D04	Characteristics of Bituminous Paving Mixtures to Meet Structural Requirement	B. F. Kallas
A2E01	Performance of Concrete-Physical Aspects	D. Stark
A2E02	Performance of Concrete - Chemical Aspects	B. Erlin
A2E03	Mechanical Properties of Concrete	V. M. Malhotra
A2E04	Batching, Mixing, Placing and Curing of Concrete	R. E. Hay
A2E05	Chemical Additions and Admixtures for Concrete	R. E. Berger
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A2F03	Earthwork Construction	R. P. Turner
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A2G03	Sealants and Fillers for Cracks and Joints	W. T. Burt III
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A2G05	Corrosion	H. J. Fromm
A2H01	Instrumentation Principles and Applications	T. M. Mitchell
A2H02	Quality Assurance and Acceptance Procedures	G. W. Steele
A2J01	Compaction	C. M. Higgins
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A2K02	Embankments and Earth Slopes	R. A. Forsyth
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A2K05	Mechanics of Earth Masses and Layered Systems	H. E. Whals
A2K06	Subsurface Drainage	G. W. Ring III
A2L01	Exploration and Classification of Earth Materials	R. B. Johnson
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A2L05	Engineering Geology	R. L. Schuster
A2L06	Environmental Factors Except Frost	B. J. Dempsey
A2M01	Track Structure System Design	M. E. Harr
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A2T61	Optimizing the Use of Materials and Energy in Construction	W. B. Ledbetter