236


# TRANSPORTATION RESEARCH CIRCULAR

Number 236, December 1981
ISSN 0097-8515

Transportation Research Board, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington, DC 20418


# OPERATION AND MAINTENANCE OF TRANSPORTATION FACILITIES


modes
1 highway transportation
2 public transit

subject areas
23 environmental design
25 structures design and performance
40 maintenance
51 transportation safety
52 human factors




OPERATION AND MAINTENANCE OF TRANSPORTATION FACILITIES


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## 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 government agencies, research institutions, industry, the academic community and others in allocating scarce funds and manpower to the solution of transportation problems.

The problem statements in this circular represent efforts by six committees in the maintenance section during the past few years to identify, within the scope of the committees, current and significant problems. Most of the committees, in different ways, established priorities among the problem statements of the committees but no attempt was made to establish priorities among the problem statements developed by different committees.

In a separate but related effort for the Federal Highway Administration, the Transportation Research Board developed a recommended national program of maintenance research and development needs. This recommended program can be found in "Highway Maintenance Research Needs - 1980." Problem statements contained therein were useful to the individuals responsible for developing the national program. Most committee chairmen and committee members participated in national program activities.

COMMITTEE A3C01 - MAINTENANCE AND OPERATIONS MANAGEMENT

Problem No. 1 - Contractor Assistance in Highway Maintenance

Contractor assistance is the utilization of private contractor forces and/or equipment to perform some or all maintenance tasks on a roadway system. This includes any contractor help from renting a piece of equipment with an operator to having a formal contract with a contractor to perform all of the maintenance tasks on a roadway system.

The most recent undertaking on a national level to determine the significance of contractor assistance in highway maintenance was performed by the American Association of State Highway and Transportation officials in 1973. The AASHTO reports (1,2) indicated that contract maintenance accounted for 14% of the maintenance budget in 1972. This percentage was up from 7% recorded in 1959. Since that time, however, there has been a significant increase in the percentage of the total highway funds spent on highway maintenance and there has also been a gradual reduction in the number of highway employee positions in many states. These two factors combined could make contractor assistance not only an important part of the highway maintenance activities but also a significant part of the total highway program.

The objective of a research project in this area would be to identify the maintenance activities where contractor assistance is being utilized and the expenditures associated with this assistance. This information could then be compared with the highway maintenance and total highway program expenditures to determine the significance of contractor assistance. The analysis of this information over several years could identify the growth rate of contractor assistance in highway maintenance. In addition to the above, the research project should develop general guidelines to aid the field engineer in determining whether or not a specific maintenance task should be performed by state forces or by contractor assistance or by a combination of the two.

References:

1. "Summary of Contract Maintenance as Currently Practiced by Member Organizations," American Association of State Highway & Transportation Officials, Washington, D.C., 1973

2. "Typical Contract Maintenance Projects Showing Scope of Work and Unit Costs," American Association of State Highway & Transportation Officials, Washington, D.C., 1973

Problem No. 2 - Developing and Evaluating Contracts for Maintenance Services

Background:

The vast majority of highway, street and other public-facility maintenance has traditionally been performed by public employees. Some agencies have contracted with private firms or individuals to mow rights-of-way or to service roadside parks; many have asphalt sealing and other major jobs performed by contract. But the lion's share of the work has been done by state and local-government employees.

Today, we are seeing what appears to be the start of a trend toward retaining private contractors to perform a wide variety of maintenance. Project reports, generally published in trade magazines, usually provide some indication of the costs and benefits of a particular contract. But the articles typically do not provide the information needed for an objective assessment of the contract. Most provide only part of the picture. (For example, a recent article on contract street sweeping failed to mention a number of factors associated with the switch from public to private performance, including the disposition of people and equipment formerly doing the work, and the basic features of the contract.) Other sources of information relative to maintenance contracting are nearly as sketchy: reports from taxpayers associations, for example, typically favor private enterprise, without providing the details that might be useful in developing and evaluating specific contracts.

Problem:

Highway and transportation engineers and managers lack the information needed to develop and evaluate contracts for maintenance services. There is need to (1) develop a series of model contracts for various maintenance services or at least general guidelines relative to contract provisions for various maintenance services, (2) establish criteria by which contractor performance can be measured and evaluated, and, (3) make the information available to highway and transportation engineers and managers.

Problem No. 3 - Development of a Method to Determine Quantity Standards

Background:

A quantity standard may be defined as the annual quantity of maintenance work per unit of inventory necessary to maintain a highway system at a desired level of condition. In the past, at least in New York State, quantity standards have been set by the consensus of a panel of "experts" in the particular maintenance area such as pavements.

For the most part these experts were the best available and their judgments were based on many years of observations. However, with the advent of a number of years of tight public budgets, highway and transportation departments have had trouble convincing top administrators that these quantity standards represent true needs. Often, maintenance gets deferred to the long term economic detriment of the state.

It has become painfully obvious that what's needed is a way of making a direct numerical calculation of a quantity standard using data on system condition, rate of deterioration and the effect of the application of the various maintenance tasks and techniques. It must include the economic optimization of long term system ownership. With this, the highway and transportation departments can provide a numerical basis for sound maintenance budgets.

Problem:

The determination of standards for crew performance lends itself to direct analysis from work accomplishment data. This is not true of quantity standards. Their numerical determination depends upon elaborate system condition and maintenance data and the application of operations research. Although some attempts have been made, the effort seems to have lacked either sufficient data or the right techniques. Most seriously, there has been a lack of a coordinated effort to solve the problem.

At the present time New York State has undertaken significant work toward this end. All the available resources are being used; however, it is anticipated that this effort will take several years.

Proposal:

The following three tasks should be addressed:

1. A study of existing data systems should be made. This should include all fifty states and as many other jurisdictions as possible. Both condition and maintenance history data systems should be reviewed. A complete compendium of these should be published.
2. A review and evaluation of all operations research on quantity standards should be made. The evaluation should include ease of data acquisition, theoretical operations model and the applicability of results. Summaries should be published.
3. Using either whole systems or pieces of systems together with new techniques, a general method for computing quantity standards should be synthesized. It should have general applicability for use by individual states in developing their own quantity standards. Due to the variation in conditions from state to state no attempt should be made to develop nationwide quantity standards themselves.

COMMITTEE A3C06 - STRUCTURES MAINTENANCE

Problem No. 1 - Training in Bridge Maintenance

Problem:

The condition of our Nation's bridges is worsening each year. Inadequate highway maintenance funds have forced bridge maintenance managers to concentrate their efforts on emergency and major repairs and defer preventive or minor maintenance. Structures that could be restored to a good condition by performing minor maintenance are left to continue to deteriorate.

It is imperative that state and local highway agencies set up a program that will effectively deal with this problem. In order to carry out such a program, proper training in bridge maintenance is required for the field crews.

Objective:

1. Identify areas in bridge maintenance requiring proper training.
2. Develop training courses to depict proper maintenance procedures for bridges.
3. Prepare training manual. The benefits that would occur are:
a. Maintenance personnel will become more knowledgeable in proper maintenance procedures for structures.
b. Improved quality in the state's and local agency's bridge maintenance program.
c. Reduced costs as a result of longer lasting, safer and aesthetically acceptable structures.

Key Words:

Bridge maintenance training; maintenance procedures for structures; proper maintenance techniques; bridge maintenance program; cost benefits.

Related Work:

AASHTO Guide for Bridge Maintenance Management 1980
Florida DOT Bridge Repair Manual
NCHRP Rehabilitation of Bridges on Low Volume Roads
Bridge Deck Repair Training (Missouri) AASHTO

Urgency/Priority:

The project should be completed in two (2) years maximum in order for anticipated results to be useful.

Cost:

The proposed research is estimated to cost $250,000.

Implementation:

The Federal Highway Administration, state and local agencies would be responsible for implementing the results of this study. The results would be implemented in the form of maintenance practice. A 90 percent probability of implementing the anticipated results is likely with the only problem being funding.

Problem No. 2 - Type and Frequency of Bridge Inspections

Problem:

Bridge owners are becoming increasingly concerned about the cost of bridge inspections. The proposed research will provide, for the first time, objective requirements for all types of bridge inspection and a measure of the labor and equipment cost for the work. In turn, this information can be used for planning and budgeting the bridge inspections and for establishing quality assurance standards. This will result in more effective use of bridge inspection funds and allow limited funds to be used to produce the most effective inspection program.

Objective:

To define types of bridge inspections, and identify optimum inspection cycles. The research will:
1. Identify all types of bridge inspections.
2. Define the scope of work to be performed in doing each type of inspection, and recommend personnel and equipment requirements. Personnel recommendations shall include numbers and qualifications necessary for each, and the number of man days required for unit size of bridge type.
3. Establish optimum inspection frequency for each type of inspection.
4. Establish recommended report format for each type of inspection.

To classify bridges in terms of age, type, material, degree of redundancy, condition, load capacity, loading, traffic volume and mix, importance to transportation system served, anticipated life expectancy, and any other parameters which may affect the type and frequency of bridge inspection.

Key Words:

Bridge inspection; quality assurance standards; type of bridge inspection; scope of inspection work; optimum inspection.

Related Work:

Current Bridge Inspector's Training Manual, Federal Highway Administration.
Manual for Maintenance Inspection of Bridges - 1978, AASHTO

Urgency/Priority:

This should receive the highest priority since major sums of money are being directed to inspection and extreme care must be taken to ensure that the quickest benefit is derived from these expenditures.

Cost:

The proposed research is estimated to cost $100,000.

Implementation:

The results of this research should be published for general use, and be formatted as a recommended Section 2 to the AASHTO Manual for Maintenance Inspection of Bridges, 1978. It would be highly desirable to have the results adopted by the AASHTO Subcommittee on Bridges and Structures.

Problem No. 3 - Cracks in Rigid Concrete Overlays

Problem:

Rigid concrete overlays are a widely accepted method of bridge deck protection, with over 20 years of exposure. Cracks occasionally occur in these overlays, in varying frequency and pattern. The cause of these cracks and their effect on the long-term performance of the rigid concrete overlays, is presently unknown. Since these overlays continue to be placed on bridge decks, this information must be determined as soon as possible so that corrective action, if any is needed, can be taken.

Objective:

The objectives of this research are:
1. Evaluate effect of cracks on performance of overlay and deck.
2. Determine causes of cracks and how to prevent them.
3. Evaluate most effective methods of repair.

Since it has been assumed that cracks will shorten the life of a rigid concrete overlay, their prevention and repair will increase the structure's life, and decrease total costs for the funding agency.

Key Words:

Rigid concrete overlays; bridge deck protection; cracks; low slump concrete; latex; modified concrete.

Related Work:

1. NCHRP Synthesis (Project 20-5) on traffic induced cracks, by Dr. Dave Manning, Ministry of Transportation, Ontario, Canada.
2. "Investigation of Cracks in Latex Modified Portland Cement Concrete Bridge Deck Overlays, Phase I: Field Investigations," R. K. Smutzer, Indiana State Highway Commission.
3. "Latex Modified Concrete Bridge Deck Overlays-Field Performance Analysis," Professor A. Bishara, Ohio State University, Report No. FHWA/OH/79/004.

Urgency/Priority:

This project should be completed as soon as possible in order for the anticipated results to be useful.

Cost:

$150,000.

Implementation:

If the results of this research are implemented, probably both design and construction practices will be effected. One problem which may affect the implementation of these results is the resistance to spend "today's" money for tomorrow's results.

Problem No. 4 - Cost Effective Bridge Repair Details and Procedures

Problem:

The FHWA's "Eighth Annual Report to Congress on the Special Bridge Replacement Program" (1979) showed a total of 242,000 bridges on the federal-aid system and, of these, 40,700 were classified as deficient, i.e., either structurally deficient or functionally obsolete. Other FHWA statistics report there are more than 331,000 bridges on county, secondary, municipal and rural roads outside of the federal-aid system. It has been estimated that about one-half of these federal-aid bridges are in need of repairs and improvements. There are a number of other sets of statistics from different sources which provide slightly different figures. Regardless of what sets of statistics are considered the most reliable, it is clear that highway bridges in the United States are in serious need of attention.

Replacement of these deteriorated bridges would be extremely costly and is not a practical solution for the near future. The alternative is to develop cost effective repair procedures together with accompanying recommended materials and design details.

Objective:

The purpose of the research is to identify some common deficiencies and corrective measures applied in the various types of highway bridges on and off the federal-aid system. County and municipal bridges should be included in the study as well as bridges under the jurisdiction of state highway departments. A well organized systematic effort should be made to evaluate the procedures to determine those that are cost effective. Cost effective procedures should include but not be limited to:

1. Extension of the service life of the bridge for a reasonable number of years or increasing its capacity with regard to either axle loads or clearances.
2. Planning the cost of repair to bear a rational relationship to the extension of the service life.
3. Not requiring unusual personnel skills or scarce equipment. Normally, required equipment and personnel should be reasonably available.

In identifying these cost effective procedures, the experience record of a procedure used by an agency should be documented together with that agency's recommendations of how the procedure might be improved by using different materials, modifying the design or changing the procedure.

The study should also give special attention to repair procedures that have not proven cost effective and their reasons for not having been considered successful.

Key Words:

Bridges; structural deficiencies; retrofit; rehabilitation; restoration.

Related Work:

The following reports have recently been published

relating to highway bridge repair and rehabilitation.
1. "Extending the Service Life of Existing Bridges by Increasing Their Load Carrying Capacity," by R. H. Berger. Federal Highway Administration, Report No. FHWA-RD-78-133 (1978) 152 pp.
2. "Bridges on Secondary Highways and Local Roads: Rehabilitation and Replacement," by H. L. Kinnier, F. W. Barton and W. T. McKeel, Jr. NCHRP Report 222 (1980) 132 pp.
3. "Durability of Concrete Bridge Decks." NCHRP Synthesis of Highway Practice 57 (1979) 61 pp.

Urgency/Priority:

The dire physical conditions of existing highway bridges in itself justifies a high priority of studies relating to bridge repair. In addition, however, the Surface Transportation Assistance Act of 1978 makes available $4.2 billion for a highway bridge improvement program for four years ending in fiscal 1982. Since this appropriation only begins to respond to the needs, federal funding is likely to continue.

Cost:

$250,000.

Implementation:

The results of this research would be immediately usable by the 50 state bridge offices as well as the hundreds of county and municipal jurisdictions.

Effectiveness:

There is a never ending search for proven cost effective bridge repairs and a presentation of such repair procedures would be highly effective in improving the efficiency of the use of the federal, state and local tax dollar.

Problem No. 5 - Levels of Maintenance for Bridges Related to Service Life and Cost

Problem:

Many bridges constructed prior to 1940 and many early Interstate bridges from the 1950s now require replacement. While most of the pre-1940 bridges were constructed in underdeveloped settings, this is no longer the case for the construction of the replacement bridge. Generally, an extensive maintenance of traffic effort is required, social and environmental impact is tremendous, and cost of having to remove the existing structure, as well as the replacement cost of the new structure, is extremely expensive. A recent comparison between 5200 state maintained bridges and approximately 4000 county and city maintained bridges indicate that county and city bridges require replacement years earlier than the state maintained bridges. Interstate bridges in many states are affected due to original construction details which did not protect the reinforcing steel from the corrosive action of deicing chemicals. This life span difference can be attributed to different design standards, quality of materials used and maintenance effort provided for the structure. With the replacement problems and cost reaching a prohibitive level, preservation would allow many bridges to merely be widened as the need for greater lane capacity develops rather than require complete replacement. Design standards, as well as materials, have been studied and received extensive development over the years, but the effect of various levels of maintenance effort has had little attention. With the rising cost and problems with the reconstruction of bridges, there is a need to have cost-effective bridge maintenance programs that can be implemented for those bridges which have not reached the point where replacement or extensive rehabilitation is necessary. There exists a need for research that will identify maintenance programs with different levels of effort which can give predictable results in terms of service.

Objective:

The objective of this research is to identify and evaluate bridge maintenance programs with respect to service life and to develop cost-effective programs that give predictable service life.

The benefits that are expected to accrue from this research are:
1. Identification of maintenance activities that contribute significantly to service life.
2. Optimum schedule for performing these maintenance activities for the different highway systems or usage.
3. Cost-effective maintenance of existing bridge structures in terms of service life.

Key Words:

Maintenance management; maintenance schedules; maintenance activities; cost effectiveness; evaluation of maintenance; optimized maintenance; value engineering; predictable service life.

Related Work:

NCHRP 223, "Maintenance Levels-of-Service Guidelines"
NCHRP 58, Synthesis, "Consequences of Deferred Maintenance"
AASHTO, "Guide for Bridge Maintenance Management - 1980"
FHWA-RD-79-121, "Coating and Corrosion Costs of Highway Structural Steel"
FHWA-RD-78-133, "Extending the Service Life of Existing Bridges by Increasing their Load Carrying Capacity"
FLA DOT, "Bridge Maintenance Manual - Planning and Repair Methods"
NCHRP 222, "Bridges on Secondary Highways and Local Roads - Rehabilitation and Replacement"

Urgency/Priority:

Many states are expressing concern about the lack of their ability to meet current bridge maintenance needs while in many instances they are already faced with a backlog. Recently, the State of New York stated that at their current rate of funding, the deterioration of New York's structures will be essentially complete by 2010. Bridge needs were recently evaluated in Florida and identified an annual need of $95 million. Current funding is in the range of $50 to $60 million. These trends are expected to continue until programs are developed to better preserve existing bridges. With the National Bridge Replacement and Rehabilitation Program well underway, there is an immediate need to design cost-effective bridge maintenance programs which can be implemented to preserve the new structure and extend the service life of those already existing.

Cost:

The proposed research is estimated to cost $200,000.

Implementation:

The results of this research would be immediately useable by the 50 state bridge offices as well as the hundreds of county and municipal jurisdictions. The primary organizations that communicate regularly with these government jurisdictions, e.g., AASHTO, NACO, APWA, would be used to promote adoption of the cost-effective maintenance programs.

Effectiveness:

Short Range - The implementation will give decision makers a proper balance of maintenance costs and service life expectations. Maintenance effort can be immediately directed to the most cost-effective maintenance activities.

Long Range - Will provide life cycle cost for new structures. May result in having a scheduled life time maintenance sequence designed as a part of original constructions plans.

Problem No. 6 - Bridge Approach Slabs Design and Maintenance

Problem:

The design, maintenance, repair and rehabilitation of bridge approach slabs have a tendency to be neglected because of the overwhelming problems of the bridge structure itself. These slabs are important members of the structure and require periodic inspection to evaluate condition, in addition to the other components of the bridge structure. Corrective steps, taken as required, can minimize future more extensive repair costs or accidents.

Proper design of the approach slab of the bridge structure is extremely important and the construction should be done under strict surveillance. The maximum compaction of underlying fill during construction is a major consideration to minimize the formation of voids under the slab during the service life of the bridge.

The maintaining of sufficient approach slab support fill is an area of importance since it minimizes slab cracking and pumping, in addition to an uneven hazardous roadway surface. The end result of insufficient support is often complete replacement of slab.

Improvement in the design of approach slab seating onto the structure, improving the compaction during construction and the maintaining of the support of underlying fill during the service life of the bridge structure are important areas of consideration for research. The method of seating also includes associated joint configuration consideration and should be part of the investigation which should include the obtaining of service performance information of existing structures.

Objective:

Objectives of the research effort are threefold.
1. Review state of the art, including performance, cost, and constructability.
2. Identify those details and specifications that have produced the most efficient structure.
3. Develop composite details for constructing and maintaining approach slab structures.

Key Words:

Approach slabs, design and maintenance; support fill; slab cracking and pumping.

Related Work:

None Identified

Urgency/Priority:

This research is needed immediately. Many of our deficient structures will be rehabilitated or reconstructed during the next decade and details for functional approach slabs are needed so that they can be included in this effort.

Cost:

$150,000.

Implementation:

The results could be used immediately in the bridge replacement rehabilitation program.

Problem No. 7 - Orthotropic Decks

Problem:

Orthotropic steel bridges and decks are a relatively new design concept with the steel plate decks serving as the top flange of the bridge beams subject to compressive and tensile stresses. The earliest known major bridges of this type in the United States were opened to traffic in the late 1960s. The serviceability of these bridges depends on the composite interaction of the deck plates with other superstructure elements.

Objective:

1. To review the performance of current pavement wearing course systems used with orthotropic decks including corrosion control.
2. Evaluate those pavement systems presently considered to be effective from a cost benefit analysis.
3. Review current maintenance activities.
4. Identify future maintenance needs and develop techniques for protection and repair procedures.

Key Words:

Design; serviceability; deck protection; skid-resistant wearing surface.

Related Work:

None identified.

Urgency/Priority:

Research into this area would provide information useful to the design of new structures and provide guidelines where reconstruction or maintenance is required. Extending the service life of these decks and possibly reducing the dead load would result in significant savings. Since reduction of structural steel in these bridges is a design objective and because some originally constructed decks are showing distress, research in this area is urgently needed.

Cost:

$200,000. This research will take approximately 24 months.

COMMITTEE A3C07 - ROADSIDE MAINTENANCE

Problem No. 1 - Chemical Mowing: A Survey to Determine Needs and Requirements

Problem:

With the decreasing availability of fossil fuels and the increasing cost of fuels, labor and equipment, mechanical mowing is becoming more and more prohibitive as a routine practice in roadside maintenance. The potential exists to reduce or replace this costly practice through the use of plant growth retardants. There are several growth retardants currently on the market and more are expected in the near future. Some may already be cost competitive with mechanical mowing.

In order to evaluate new materials, for use in a chemical mowing program, it is necessary to describe the need for and the requirements of these products, in the context of current vegetation management policy.

Objective:

Determine the minimum requirements for a cost-effective chemical mowing program, that would provide a practical alternative to present mechanical mowing practices.

Define the requirements that a plant growth retardant would have to satisfy in order to be considered acceptable for roadside maintenance.

Key Words:

Chemical mowing; mechanical mowing; growth retardants; roadside maintenance.

Related Work:

The Joint Highway Project, Purdue University, has a research project "Chemical Mowing: A New Maintenance Concept for Indiana Roadsides" directed by Professor D. James Morre and started August 1977. The project is scheduled for completion in 1982. The principal objectives of this project involve evaluation of growth retardant materials available commercially or soon to be commercialized as candidates for inclusion in roadside maintenance programs. This project and related efforts elsewhere would benefit greatly from an evaluation of needs and requirements for chemical mowing treatments. Most states have policy and procedure guidelines for roadside mowing; e.g., "Guide for the Determination of Mowing Limits. New York State Department of Transportation, May 1971." However, no information is available concerning performance requirements for chemical mowing.

Urgency/Priority:

As mowing costs increase and more growth retardant materials become available maintenance engineers will find themselves under increasing pressure to attempt chemical mowing. Potential users and manufacturers, as well as researchers responsible for evaluation of new materials, would benefit from an estimate of what the requirements might be for chemical retardants over the next 10 years and what performance standards these materials or practices should meet.

Because the potential for cost savings is dependent on the early availability of an appropriate criteria, the research should be considered urgent.

Cost:

The cost of the proposed project, including preparation and duplication of reports should not exceed $20,000 per year for a three year study.

Implementation:

The findings of the study will be made available to highway, research and industry personnel involved in the use and development of retardant materials for vegetation control on roadsides. A set of standards will be developed including the minimum requirements that a retardant material must meet in order to be cost-effective in a program of roadside maintenance. These standards will be be utilized in the evaluation of retardant materials and as the basis for future recommendations at the State and National level.

Effectiveness:

Safety would be implemented, since tractors mowing roadsides constitute a hazard both to the operator and to the motorist. The ultimate goal would be a single spring time application of a growth retardant material that would give full season control of growth of grass and weeds and eliminate the need for the bulk of the mechanical mowing along the Nation's roadsides.

Problem No. 2 - Litter Control Methods

Problem:

Collection of litter is becoming more and more expensive each year for Departments of Transportation. While litter control is a low priority item, it is often stated litter breeds litter. For this reason and due to pressure from various public groups, Departments of Transportation are forced to spend millions of dollars per year on this activity.

Objective:

Determine the most effective means of litter control used throughout the world. As an example, examine:

1. Various laws on litter control.
2. How are they enforced?
3. Are fines or other penalties effective?
4. In some states, large litter containers are provided by local governmental agencies along the highways for deposit of litter by local residents. Do these in any way discourage littering the highway? If so, perhaps financial cooperation between governmental agencies could reduce the highway litter problem.
5. Effectiveness of advertisement against littering.

Key Words:

Laws; enforcement; litter containers.

Related Work:

A great deal of research has gone into equipment for removal of litter; however, methods of removal should not be a part of this research.

Urgency/Priority:

According to a survey by Rural and Urban Roads, $60.7 million was spent on litter removal or control in the United States in 1978.

Cost:

Less than $50,000.

Problem No. 3 - Preservation of On Right-of-Way Vegetation versus Visibility of Outdoor Advertising Devices

Problem:

On right-of-way roadside landscape features are being destroyed to improve the motorists' view of off right-of-way commercial activity.

The highway landscape is conceived, acquired, designed, constructed and maintained with the use and enjoyment of the highway user as the primary objective. The next objective or consideration is the impact the highway facility has on the region, both environmentally and aesthetically.

The acquisition of rights-of-way, which are aesthetically vegetated or which will support and accommodate landscape plantings, is an acquisition consideration and expense. Roadside landscape design incorporates the preservation of desirable landscape features with the treatment of earthen areas to provide function, utility and beauty. Controlled construction activities further preserve and implement these objectives as does subsequent vegetative management practices.

The roadway was never intended, or the roadside designed to display, accentuate or otherwise accommodate outdoor advertising devices. Therefore, the cutting, removal, or other damage to vegetation on the highway right-of-way, for the purpose of enhancing the motorists' view of billboards or adjacent commercial activity is logically and legally contrary to the highway program.

Objective:

Establish the legal precedence for which the national highway program is established and define the intrusions from which this program must be protected.

Legal research, to the degree that a major Federal policy can be substantially supported on this issue, is required. A policy, binding on all Federally funded highway programs, past, present, and future, is required if rational acquisition, design, construction and maintenance activities are to be pursued.

Key Words:

Highway program objectives, roadside features, right-of-way, vegetation preservation, billboard visibility, legal federal policy.

Related Work:

Report to the Transportation Research Board, Committee on Roadside Maintenance, January 1980 by Ross D. Netherton, Environmental Division, Office of Research, Federal Highway Administration: This report discusses the problem and provides some indication as to the need for a thorough study which would define the problem, and provide the information necessary for formulation of the policy, needed to enable the states to handle this problem.

Urgency/Priority:

The roadside business community is actively pursuing a state by state program of obtaining permission to remove visually obstructing on right-of-way vegetation under authority contained in the Federal Highway Administration Memorandum (HRE-1) dated March 15, 1977, issued jointly by Mr. J. M. O'Connor, Associate Administrator for Right-of-Way and Environment and Mr. H. A. Lindberg, Associate Administrator for Engineering and Traffic Operations.

Cost:

Less than $50,000.

Problem No. 4 - An Assessment of Functional Landscaping

Problem:

Many areas of the right-of-way are high cost maintenance areas due to varying reasons. Some can be mowed but require special equipment. Others cannot be mowed because access is denied by fences, ditches, guardrail, etc. Many states attempt to reduce these maintenance costs by taking the area out of maintenance by placement of "Functional Landscaping."

Is this cost beneficial or in fact have we traded one type of maintenance for another merely because it looks good.

Objectives:

Determine if the establishment of "Functional Landscaping" is cost beneficial when compared to occasional mowing or annual mowing with herbicide treatment.

Key Words:

Functional, herbicide treatment, occasional

Related Work:

None known. However, it is felt that some research has been done in this area in the past.

Urgency/Priority:

With the emphasis on reducing cost the issue of landscaping should be re-examined.

Cost:

$50,000.

Problem No. 5 - An Assessment of Fencing Techniques Materials and Maintenance

Problem:

With the emphasis on right-of-way regeneration, access to fences for maintenance purposes is more difficult. An investigation should be made to determine what level of maintenance should be performed on limited access control fences.

In urban areas fencing can be ineffective and impede maintenance, in addition to requiring maintenance itself. When damaged fence is not replaced in kind or when one section is somewhat older than another it can be unsightly.

Consideration should be given to the need for right-of-way fencing as opposed to increased use of right-of-way markers.

Objectives:

1. Review existing criteria for determining fencing needs. This should be with respect to both: the type area to be fenced and the type fence required.
2. Determine if it is more economical to allow fencing to deteriorate to a certain level and then replace, or to maintain on a continuing basis.

3. Determine the best material to use to satisfy the conclusion reached in objective number two.
4. If the conclusion of objective number two is to provide continual maintenance, then develop suggested methods of maintenance.

Related Work:

No known studies nor research being conducted.

Urgency/Priority:

Many states are spending large sums of money to maintain fences and a clean fence line. Improvements in materials or a change in maintenance philosophy might result in substantial savings nationwide.

Cost:

$100,000.

A3C09 - WINTER MAINTENANCE

Problem No. 1 - Develop Standard Snowplow Designs to Provide Optimum Efficiency at the Least Expenditure of Energy

Problem:

In the United States today, there are 46 states and approximately 15,000 local agencies involved in providing snow removal and ice control service.

The snowplows in use today were originally designed for use on an earlier generation of prime movers, different roadway configurations, for operations under low speed traffic conditions, and without the benefit of modern aerodynamic technology. As a result, the following shortcomings are often noted:
1. Energy requirements are disproportionate to the work being performed.
2. Snow is not being displaced in the most efficient manner considering modern highway designs.
3. There is no standardization in either the manufacturing industry or in the specifications of the using agencies.
4. Many plows cannot operate safely at speeds desirable for modern highway snow removal conditions.

Objective:

This project is directed toward producing standard specifications for various systems of truck mounted snowplows required by the several sizes of trucks normally utilized by highway agencies. Those items that should be considered in designing standardized snowplows are aerodynamics, width, weight, hitching arrangements, mold board surface friction, and blade attachment. Specifications should include front mounted plows, under body plows, and wing plows operated individually or as a system. The following tests should be included in the accomplishment of the project objectives:
1. A search for available information on the subject to evaluate the results of research that has already been performed.
2. Direct contact with major manufacturers of snowplows to take into consideration work that has been performed by that industry and to assemble recommendations pertinent to the process of standardization.
3. Contact snow belt states to determine desirable capabilities to be incorporated in new designs.
4. Establish and utilize laboratory techniques to test designs for optimum capabilities.
5. To test prototype full scale models of recommended plow designs under field conditions.
6. To develop final recommended specifications and designs.

Key Words:

Snowplows, snow removal, aerodynamic design, highway design.

Related Work:

Related fields that might offer valuable information are agricultural engineering and vehicle aerodynamic design.

Urgency/Priority:

This has been a longstanding priority request. With current fuel shortages and limitations on resources, this problem should be given high priority.

Cost:

The estimated cost would be $300,000.

Implementation:

Because of the magnitude of the project, the highly technical aspects and the need for laboratory testing techniques, it would appear that a sizable research institute or a major university would be most capable of performing the work.

Effectiveness:

Scientific snowplow design has a potential for reducing prime mover effort by 10 percent or more. Efficiency gains from improved plow designs could be translated into smaller prime movers, substantial fuel savings, and a reduction in fleet size for municipalities, local highway agencies, state departments of transportation, and airports.

Problem No. 2 - Testing of Calcium Magnesium Acetate as a Viable Alternative for Chlorides as a Snow Melting and Deicing Agent

Problem:

The use of calcium chloride and sodium chloride as melting agents has brought about a great deal of criticism from public groups, environmentalists, biologists, botanists, and automotive groups/industry due to potential damage to biological and aquatic life, alleged damage to health and corrosive accelerations which may develop in automobiles and other items that may be exposed to chlorides. The costs of highway deicing salt have tripled during the past decade making the costs of alternative compounds, which have heretofore been prohibitive, more attractive.

Recent extensive studies sponsored by the FHWA, representing current state of technology, have identified calcium magnesium acetate (CMA) as one of the best alternatives for chlorides as a melting agent for highway use. CMA has melting capabilities of sodium chloride, is non-corrosive and causes no known damage to the environment. It is a solid material that can be crushed to desired gradations and has no apparent handling problems. Application could be made with spreading equipment now used for sodium chloride.

As time passes and the costs of mining and

shipping chlorides from limited sources increases, the cost effectiveness of alternative melting agents becomes more attractive.

However, CMA is not now in normal production and the costs associated with producing limited amounts for testing by individual states is prohibitive. The encouragement for exploratory production of CMA and the extended potential for its use as a common deicing agent needs to be fostered at this time if the full potential for its use is to be realized.

Objectives:

The overall objective of the project is to test, on a reasonably large scale, the effectiveness of CMA as an alternative for chlorides for snow and ice control on highways and streets. This should be accomplished in two phases:

Phase I

A - Explore current processes for production of CMA on a limited basis (1,000 tons) and determine the most attractive source and costs.

B - Research and evaluate possible large scale production potential for production of CMA.

Phase II

If the contracting agency feels that Phase I results indicate sufficient potential for production of CMA, Phase II will be initiated.

A - Gain agreement for establishing test sections with adjoining control sections in at least 3 snow belt states.

B - Monitors evaluate the effectiveness of CMA as an alternative melting agent, comparing with sodium chloride for one winter season.

C - Produce a report on the effectiveness of CMA addressing the following:

1. Melting capabilities.
2. Short and long range costs.
3. Potential environmental effects.

Related Work:

Recent FHWA Study

Urgency:

Due to problems currently identified with extensive salt usage and rapidly escalating costs of salt, the identification of suitable alternatives should be of high priority.

Estimated Costs:

| | | |
|---|---|---|
| Phase I | 1 man year (4 mos) | $ 60,000 |
| Phase II | 1½ man years (8 mos) | $ 90,000 |
| | 100 tons CMA | $110,000 |

Potential:

Potential success excellent. Possible benefits long term very high.

Committee Suggestion: Add Phase III, and initial marketing effort to make state aware and encourage industry to produce - if Phase II is successful.

Cost:

1/3 man year and travel expenses $35,000

COMMITTEE A3C10 - TRANSPORTATION OF HAZARDOUS MATERIALS

Problem - Highway Movement of Hazardous Waste

Section 3003 of the Resource Conservation and Recovery Act (RCRA) requires the establishing of such transporter regulations as are necessary to protect human health and the environment from inadvertent or unlawful release of hazardous wastes in the environment. The full magnitude of the scope of these regulations is not known, as there is no reliable data on the volumes moving in transportation, nor by highway movement in particular.

Sound planning, policies, and practices in administering such regulations are dependent upon reliable estimates of the types, volumes, and principle pathways of movements of such materials, in order to avoid inadequate or excessive regulatory control.

Objective:

The objective of the study is to scope the extent to which hazardous wastes are now moving, and project volumes of movements in the future for use by decision makers in the public and private sector.

Key Words:

Environmental protection, trucking risks, highway transport, hazardous waste.

Related Work:

The Environmental Protection Agency has estimates of the volumes of hazardous wastes produced each year, estimates of the number and location of lawful and unlawful sites for disposal, and estimates of volumes of clandestine disposal.

Urgency/Priority:

Federal and state regulatory agencies are developing and promulgating rules for the movement of hazardous materials but both the public and private sector need information to plan for implementation of and compliance with such rules. A danger exists that rules will not accomplish desired results in the absence of adequate planning data on which to base rule making.

Costs:

Estimates of costs indicate about the $100,000 level of effort.

Implementation:

The federal regulatory agencies (EPA and DOT) and the highway transportation industry (motor carriers and their associations) and state agencies have an interest in ascertaining the magnitude of the problem, the cost associated with implementing a solution, and the requirement for reliable information for planning and programming resources.

Effectiveness:

The societal impacts have been described as the "sleeping giant of the environmental field" by Congressman James Florio (N.J.) and as "one of the most serious problems facing the nation" by Deputy Administrator Barbara Blum of EPA. It is estimated that taxpayers will be required to pay from $22 billion to $44 billion to clean up hazardous wastes.

COMMITTEE A3C11 - RIDE QUALITY AND USER ACCEPTANCE

Problem - Human Responses and Acceptance Levels for Discontinuous Motion and Acceleration Transients

In many forms of transportation, the vehicle riding qualities can be degraded by discrete, discontinuous, but repeated acceleration and motion transients. Current ride quality evaluation methods and guidelines are insensitive to such transient motions, and therefore they are overlooked in most, if not all, ride quality evaluations. Knowledge as to human responses to and perception of repeated motion and acceleration transients is meager and guidelines as to evaluation methods and acceptance levels are non-existant.

A comprehensive research program is needed to codify human responses to randomly applied acceleration and motion transients and to establish guidelines for their evaluation when taken by themselves, or in conjunction with other ride quality factors.

Supporting Data:

Environmental factors such as vibration, noise and temperature are important considerations in the design of transportation systems, because such factors may adversely affect passenger and operator acceptability (ride quality) of the system. In the development and design of transportation systems, the designer cannot directly deal with and evaluate passenger acceptance or ride quality since these factors are by definition the human perception of the overall environment. The designer, analyst, and even the specifications must therefore rely heavily upon quantitative measures of the environment (motion, temperature, noise, etc.), and upon interpretations of these measures as to the resultant ride qualities.

Over the past decade, the scientific community has been systematically analyzing and quantifying human responses or preception of these environmental factors in order to better facilitate designs for improved ride quality. Recent and ongoing studies are gradually building up a comprehensive overview of the separate and collective effects of the physical environment upon ride quality. For example, vibration evaluations are expanding to better account for frequency related factors, and to accommodate random as well as regular motions. The influence of exposure duration upon acceptance is under continuing investigation, as are the effects of combined vibrations in multiple axes. Other studies have accounted for the effects of roll motions on ride quality; the combined effects of noise and vibration; and the effects of the various motions and noise parameters on operator performance as well as comfort.

A potentially important element of the ride quality characterization has been thus far neglected, that being the response and acceptance of the passenger and/or operator to discontinuous but repeated motion and acceleration transients. Most forms of transportation encounter such discontinuous motion transients, but to varying degrees. For example, the airliner encounters a one-time only shock transient upon landing. In contrast, rail vehicles encounter frequent lateral and vertical transients due to rail discontinuities. Longitudinal and lateral transients are frequently introduced into surface transportation by operator inputs. Pavement or roadway discontinuities such as chuck holes and transition joints introduce similar non-continuous motion transients into the highway vehicle. All types of ships operating in a seaway experience severe discontinuous motion and acceleration transients associated with bow slamming. Some ships, such as hydrofoils and surface effect ships, encounter similar transients when the supporting element comes free of the water surface and loses lift. Automated transportation systems encounter similar motion transients due to guideway irregularities, breaking and speed control transients and non-linear suspension systems. The response of a magnetically levitated vehicle when the suspension system bottoms out is an example of non-linear suspension transients.

Current measurements and evaluations of vehicle ride quality tend to be insensitive to discrete transients of the nature described. For example, a series of acceleration transients having peak amplitudes each in excess of 1g, might not raise the low level rms value, or 1/3 octave rms value, by as much as one percent. This happens because the discrete transients, when averaged out over the total time period, do not represent a significant addition to the dynamic energy of the system. That is not, however, to say that they are insignificant in the ride quality assessment.

A comprehensive program is required to develop and quantify human response and acceptance guidelines for discrete but repeated motion transients. The program should develop methodology and measurements for assessing their effects on ride quality when taken by themselves and when taken in concert with other environmental factors such as vibration and noise. The program must develop measurement and evaluation methodology for transients that occur at random intervals, have randomly varying magnitudes, and random shapes and pulse widths.

Program Plan:

A comprehensive and intensive program of research and evaluation is needed to bring this element of ride quality to a level of understanding commensurate with vibration and noise evaluation standards. An overview of such a plan follows. A key element to attaining the desired results is to adequately define the starting point(s) and developing detail plans to get to the desired ends. Thus step one in the outline is considered critical to the overall program. The subsequent elements will follow from step one, and may take on different perspective as a result of findings in preceding steps.

Research Program Outline:

1. Background Research and Program Development
   - A. Establish Current Data Base
     - Literature review
     - Catalog current research activities that bear on topic
   - B. Develop Broad Study Plan for Implementation
     - Comprehensive list of study topics
     - Topic priorities
     - Study methods, goals, and facilities required
     - Flow chart to show topic interdependence

11. Biomedical and Psychological Characterization
    - A. Initial investigations - perception and response evaluators and transient measurement parameters
    - B. Detailed studies
      - Characterize perception and response to transient motion vertical, lateral, longitudinal
      - Expand to include randomly repeated transients

- Identify transient measurement requirements and standardize
- Expand to include operator performance evaluators

C. Combined effects studies
- Combined transients in 2 and 3 axes
- Combine transients with continuous motions

III. Correlation
Correlate and anchor results to appropriate ride and performance rating scales. Both laboratory and field testing are necessary.

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