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HIGHWAY INFRASTRUCTURE

Quality Improvements Would Safeguard Billions of Dollars Already Invested

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Resources, Community, and
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The Honorable Max S. Baucus
Chairman
The Honorable John H. Chafee
Ranking Minority Member
Committee on Environment
and Public Works
United States Senate

The Honorable Norman Y. Mineta
Chairman
The Honorable Bud Shuster
Ranking Minority Member
Committee on Public Works and
Transportation
House of Representatives

In response to section 1043 of the Intermodal Surface Transportation Efficiency Act of 1991, this report reviews states' experiences with using warranties in highway contracts, identifies efforts to provide adequate maintenance for highways built with federal assistance (federal-aid highways), and identifies opportunities for improving states' procedures for selecting pavement designs.

We are sending copies of this report to the Secretary of Transportation; the Administrator, Federal Highway Administration; the heads of the state departments of transportation mentioned in this report; and other interested parties. We will also make copies available to others on request.

This work was performed under the direction of Kenneth M. Mead, Director, Transportation Issues, who may be reached at (202) 512-2834. Major contributors to this report are listed in appendix III.

Keith O. Fultz
Assistant Comptroller General

Executive Summary

Purpose

If our nation's highways are not adequately maintained, they will not support the level of service needed to sustain a large and growing economy. Federal, state, and local governments will need to invest about $50 billion annually in constant dollars through the year 2011 to maintain the condition and level of performance of the nation's highway infrastructure. This figure substantially exceeds the $26 billion spent in 1991 for construction and capital repairs for highways built with federal assistance (federal-aid highways), as reported in a January 1993 Department of Transportation (DOT) report to the Congress.[1] These funding levels make it imperative that investments in federal-aid highways be cost-effective.

To help protect the investment in the nation's highway infrastructure, the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) required GAO to assess ways of improving highway quality. GAO agreed with the Senate Committee on Environment and Public Works and the House Committee on Public Works and Transportation to (1) review states' experiences with using warranties in highway contracts and the factors that promote or discourage the use of such warranties, (2) identify efforts to provide adequate maintenance for federal-aid highways, and (3) identify opportunities for improving states' procedures for selecting pavement designs. To meet these objectives, GAO reviewed six states in detail and obtained supplemental data from other states on selected issues.

Background

When highway contracts include a warranty clause, contractors guarantee to a state highway department that a project will perform as expected over a number of years. Until 1992, the Federal Highway Administration (FHWA), which administers the federal-aid highway program for DOT, prohibited warranties in federal-aid highway contracts, believing that warranties would entail federal participation in maintenance. However, most states may now generally use warranties for some projects.

Under ISTEA, states can now receive federal funding for certain preventive maintenance projects shown to be cost-effective. States are required to properly maintain their federal-aid highways, and FHWA requires that its field offices annually certify whether the states are doing so. If FHWA determines that a state's maintenance is not adequate and the state does not take corrective action, the Secretary of Transportation can withhold

[1]The Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance, Report of the Secretary of Transportation to the United States Congress (Jan. 1993).

approval of further federal-aid projects for all or parts of the state until proper maintenance is achieved.

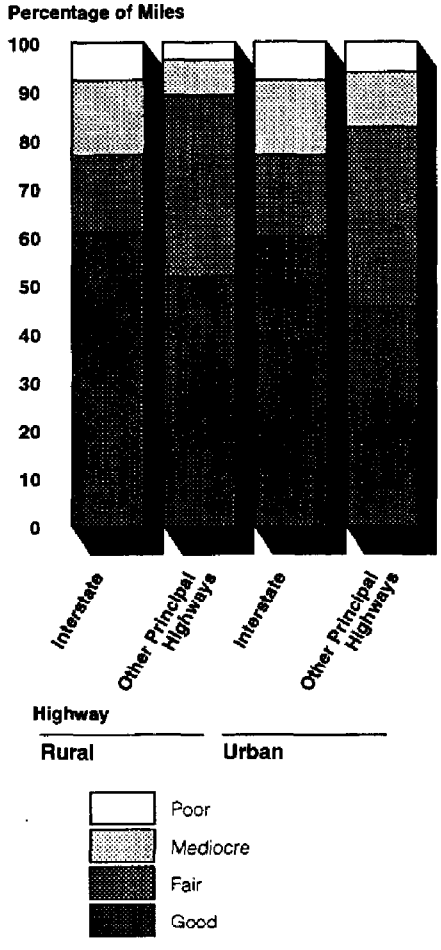
Federal legislation gives the states considerable flexibility in selecting highway pavement designs but does provide broad directives. For example, highway facilities must meet existing and probable future traffic needs in a way conducive to safety, durability, and economy of maintenance. In addition, ISTEA tasks the states with considering life-cycle costs as part of transportation planning. Life-cycle cost analysis is a procedure for selecting a pavement design that will provide a satisfactory level of service at the lowest cost over time.

Results in Brief

Officials in the nine states that GAO identified as having included warranty clauses in contracts for 33 highway or bridge projects have generally been satisfied with these warranties. But the small number of projects that have been completed under warranty makes it difficult to definitively assess warranties' costs and benefits. Contractors and others have raised concerns as to whether warranties are fair and enforceable, but states' initial experiences suggest a number of strategies to address these concerns. Given recent actions by FHWA that generally permit states to use warranties for the majority of federal-aid highway projects, federal guidance could help states assess when warranties can be an effective tool for promoting quality.

Approximately 60 percent or less of the nation's principal highways are considered to be in good condition (see fig. 1). The states GAO visited had backlogs of maintenance projects, mainly because of resource shortages. Nevertheless, four of the six states GAO contacted said they would not use the funds made available under ISTEA for maintenance, in part because doing so would reduce the funds available for capital projects. Furthermore, FHWA's oversight has not ensured that states adequately maintain federal-aid highways. The agency has not established performance standards to guide its determination that maintenance is adequate. Furthermore, in some states where FHWA has identified maintenance problems, it has not followed its procedures for correction and follow-up, resulting in lingering problems.

Figure 1: Pavement Conditions of Principal Highways, 1991



Note: For rural highways, "other principal highways" refers to non-Interstate principal arterials. For urban highways, the term refers to non-Interstate principal arterials, freeways, and expressways.

Source: GAO's analysis of FHWA's data.

In selecting pavement designs, many states do not consider the results of life-cycle cost analysis in their decisions. Even those states that perform such analysis limit its usefulness by excluding important data, such as maintenance costs. A lack of guidance on when life-cycle cost analysis is useful and what factors need to be analyzed undermines the states' use of this approach in making investment decisions.

Principal Findings

States' Use of Warranties Is Limited but Generally Satisfactory

Federal regulations have traditionally prohibited contracts for federal-aid highways from including warranty clauses requiring contractors to guarantee their work. However, recent actions by FHWA now permit states to include such warranty clauses in an array of circumstances.

As of spring 1994, nine states had undertaken 33 projects under warranty, including bridge painting and pavement rehabilitation. While preliminary observations or final results were available for just two-thirds of these projects, state officials generally have been satisfied with their use of warranties. They cited both the quality of workmanship and the opportunity to obtain remedial action when necessary—as was the case in 15 of the 23 projects for which preliminary observations or final results were available. State officials also noted that, with a few exceptions, warranties appeared to have a minimal impact on costs.

Others are more skeptical about the viability of warranties. Contractors in particular fear that warranties could shift an excessive measure of liability to them, since factors beyond their control, such as inadequate maintenance, could affect how a project performs. Reconciling these opposing views of warranties is difficult because of the relative scarcity of warranted projects. Until a broader base of evidence is established, states are dealing with contractors' concerns by using such strategies as limiting the duration of the warranty period.

Maintenance: A Cost-Effective Activity That Is Underfunded

Maintenance can slow deterioration, thus keeping highways and bridges in good condition for a longer time. Maintaining pavement in good condition is highly cost-effective, FHWA said, because $1 spent on pavement in good condition saves $4 to $5 that would be needed if the pavement deteriorated to fair condition and even more if the pavement deteriorated to poor condition.

In the six states GAO visited, maintenance needs often outstrip the resources expended. As a result, needed repair work such as spot-painting bridges and sealing joints and cracks in pavement has been postponed. Four of the six states GAO contacted said they would not use federal funds for maintenance, in part because doing so would reduce the funds available for more costly capital projects. Moreover, the funds available

for capital projects fall far short of needs: FHWA has estimated the cost in 1991 dollars to eliminate the backlog of deficiencies on highways and bridges and related work at $290 billion, yet the actual 1991 capital investment was $26 billion.

FHWA is responsible for ensuring that states perform adequate maintenance. Yet the agency has invoked its regulatory sanction on federal funding for a state's highway projects only once—when Louisiana admitted that it was not adequately maintaining its highways. Furthermore, the agency has not established performance standards to aid in its annual determination that states' maintenance efforts are adequate. FHWA does have guidance calling for identified maintenance deficiencies to be addressed through corrective action by the state and follow-up by FHWA, but the agency has not systematically followed this guidance. As a result, identified maintenance problems linger unresolved for long periods. For example, 2 years after FHWA found that California was not upgrading guardrails and other related equipment to current safety standards during replacement, as required by federal regulations, the issue was still outstanding, with no time frame established for resolution.

Important Tools for Analyzing Design Costs Are Underutilized

Because of geographic and climatic diversity, states have considerable flexibility in the way they select pavement designs. Although ISTEA requires that states consider life-cycle cost analysis as part of their planning processes, it remains unclear what this consideration is to entail. As a result, states have made varied use of such analysis. For instance, 11 of 38 states (nearly 30 percent) responding to a 1993 survey reported that they did not use life-cycle cost analysis in making highway investment decisions. Moreover, FHWA officials note that the total decision-making process encompasses numerous factors, including engineering experience, budget constraints, management prerogatives, and political considerations.

States that used life-cycle cost analysis frequently limited it to new construction and reconstruction projects, excluding rehabilitation strategies. Only 16 states reported using such analysis to evaluate highway repair strategies. A key impediment to states' use of life-cycle costing is the difficulty of quantifying certain costs, including maintenance costs. FHWA intends to issue a policy statement on life-cycle cost analysis in the summer of 1994 and is considering sponsoring training on the subject.

Recommendations

To help protect the nation's highway infrastructure, GAO recommends that the Secretary of Transportation direct the Administrator of FHWA to take a number of actions to enhance states' ability to experiment with warranties, improve oversight of states' maintenance efforts, and improve states' ability to undertake life-cycle cost analysis. GAO's detailed recommendations appear in chapters 2, 3, and 4.

Agency Comments

On August 1, 1994, DOT provided GAO with written comments on a draft of this report. DOT generally agreed with GAO's overall conclusions and noted its commitment to protecting the nation's investment in highway infrastructure and improving highway quality. DOT concurred either fully or partially with all of the recommendations in the draft report. However, in several cases, the Department maintained that action already completed had satisfied the recommendation. In the case of warranties, GAO agrees with DOT that the recent clarification of the policy on instances in which states are allowed to use warranties satisfies the proposed recommendation in the draft report. Therefore, this recommendation has been withdrawn. In other cases, however, GAO believes that the Department needs to take additional action. For instance, DOT partially concurred with GAO's recommendation that FHWA develop and disseminate model warranty provisions for a variety of types of projects. Officials stated that while FHWA made an exception in the case of a particular maintenance process cited in the report, the agency generally prefers to let states develop their own project specifications. GAO believes, however, that other types of projects could also benefit if FHWA assumed an activist stance in working with the states to develop and disseminate model warranty provisions.

GAO also recommended that DOT develop performance measures for maintenance. The Department partially agreed with this recommendation but maintained that its existing requirements and policies were sufficient to determine the adequacy of states' maintenance. However, GAO found that DOT's existing guidance on maintenance is not specific and is silent on whether a deficiency that is severe and frequent is enough to support a finding that maintenance is inadequate. Moreover, the existing guidance is not being systematically followed, since maintenance problems identified by FHWA can linger unresolved for lengthy periods of time, with no strategy developed for corrective action and no time frame set for resolving the deficiencies. Consequently, this proposed recommendation has been clarified to underscore GAO's view that performance expectations and standards that would provide nationally comparable measures, with

specific time frames for corrective action, need to be developed. These expectations and standards should reflect the severity and impact on safety of the maintenance problems.

DOT's specific comments and GAO's evaluation of them are discussed in chapters 2, 3, and 4 and in appendix I. GAO made changes in the report in response to these comments where appropriate.

Contents

Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
DOT	Department of Transportation
FHWA	Federal Highway Administration
GAO	General Accounting Office
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
LCCA	life-cycle cost analysis
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System
NQI	National Quality Initiative
OIG	Office of Inspector General
QC/QA	quality control/quality assurance
SEP 14	Special Experimental Project 14
SHRP	Strategic Highway Research Program
TRB	Transportation Research Board
WASHTO	Western Association of State Highway and Transportation Officials

Introduction

About $50 billion annually through the year 2011 will be needed to maintain the condition and performance of federally funded highways, according to estimates by the Federal Highway Administration (FHWA). This amount is in constant 1991 dollars, and substantially exceeds the 1991 capital outlay of $26 billion by federal, state, and local governments for construction and capital repairs of federally funded highways, as reported in a January 1993 Department of Transportation report to the Congress.[1] It is critical that the highways in which these investments are made realize their expected service life, in part through adequate design and maintenance.

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 authorized funding to sustain and enhance the nation's surface transportation infrastructure. The act provided an unprecedented funding authorization of $122 billion for highways, bridges, and related activities.[2] These funds are targeted in large measure to preserving and improving the quality of existing transportation resources. Section 1043 of ISTEA tasks the Comptroller General with examining methods for improving the quality of the nation's highways through the use of warranties and guarantees, improved maintenance, and alternative design standards.

European Highway Quality Drew Attention of U.S. Highway Experts

In 1990 and 1992, representatives from the highway industry and federal and state highway agencies toured European countries to study the condition of asphalt and concrete pavements there. Tour participants found that, generally, the durability and longevity of European pavements exceeded those of U.S. pavements. Participants on the 1990 tour, for instance, reported that the study team's most striking observation was that the pavements on European motorways and trunk routes were in superior condition. The extreme forms of distress that are evident in the U.S., such as rutting, cracking, and potholes, were rarely seen. The reduced distress on European roads could not be explained by lower truck weights; in fact, European truck axle weights substantially exceed those allowed in the United States.

The tour participants not only considered the condition of European pavements but also compared European methods of designing, building, and maintaining highways with U.S. practices. One finding that generated

[1]The Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance, Report of the Secretary of Transportation to the United States Congress (Jan. 1993).

[2]The full ISTEA authorization for all surface transportation programs, including mass transit, totals $155 billion for fiscal years 1992 through 1997.

intense discussion was that in many European countries, warranties covering highway construction are a standard component of most highway contracts. One potential indication of the quality of European roadways is the fact that, according to FHWA officials, European road authorities have rarely had to invoke the warranty clauses. For example, officials in both Sweden and Denmark reported that during the warranty period, contractors are called to repair or replace their work in only 2 to 3 percent of all cases.

Although the use of warranties in Europe coincides with highways of good quality, the relationship between highway quality and the use of warranties remains uncertain because a number of factors combine to contribute to the performance of European highways. These factors include a high level of investment in highway infrastructure throughout Europe, sophisticated design practices, and a commitment to early preventive maintenance.

Performance Warranties Are New to Highway Construction

Warranties are regularly used to indicate to consumers that a product meets a certain standard of quality and that the manufacturer will repair or replace the product if it fails to meet that standard. As envisioned for highways in the United States, a warranty would bind highway builders and/or designers to guarantee to a state highway department that a project will perform as expected over a given number of years.

During the debate over ISTEA, the administration proposed lifting a long-standing regulatory prohibition on including construction warranty clauses in contracts for highways built with federal assistance (federal-aid highways). The prohibition existed because of FHWA's concerns that warranties would entail federal participation in maintenance, which was outside the scope of federal involvement. A proposed amendment to ISTEA would have permitted states to include either construction or design warranties in contracts. However, professional and industry trade groups argued that warranties would impose an unfair burden of risk on them, and they helped defeat the amendment.

Holding highway contractors responsible for their work is not completely new to the United States. Some construction contracts already carry a 1-year performance bond that allows a state to obtain repairs from the contractor for defective materials or workmanship. Performance warranties, however, go a step beyond this bond, as they typically extend for a longer period of time and target broader performance characteristics of a project—for example, the smoothness of a pavement, the reflectivity

of a lane-marking stripe, or the absence of peeling paint on a bridge. The emphasis on overall project performance is a concern to industry representatives because this focus may penalize them for variables they believe are beyond their control.

What Is Maintenance?

Maintenance for federal-aid highways is defined in 23 U.S.C. 101 as "preservation of the entire highway, including surface, shoulders, roadsides, structures, and such traffic-control devices as are necessary for its safe and efficient utilization." At the state level, however, the definition of maintenance varies from state to state. For purposes of this report, we generally defined maintenance as either corrective or preventive. Corrective maintenance consists of those activities that keep pavements, structures, drainage facilities, and traffic control devices in good condition through the repair of defects or problems as they occur. Typical activities include repairing potholes, removing debris from drainage systems, and repairing and replacing guardrails. Preventive maintenance is planned and is intended to arrest minor deterioration, retard progressive failures, and reduce the need for corrective maintenance.

Highway Design and Construction

The durability, safety, and cost-effectiveness of a highway depends on the quality of both its design and construction. Highway construction involves the processes associated with mixing and placing the pavement materials. Highway design encompasses two major elements: pavement design and geometric design. Pavement design includes determining the appropriate layer structure, composition (mix), and thickness of materials required to withstand the traffic and environmental conditions the pavement will be subjected to. Geometric design entails determining the lane width, slope, and curvature required to adequately and safely serve the level of traffic anticipated.

Current federal laws and regulations do not generally specify detailed requirements for acceptable highway pavement designs; instead, they usually only provide broad directives. Specifically, 23 U.S.C. section 109 requires that highway facilities adequately meet the existing and probable future traffic needs and conditions in a manner conducive to the safety, durability, and economy of maintenance and be designed and constructed in accordance with the standards best suited to accomplish the foregoing objectives and conform to the particular needs of each locality. The Pavement Policy, 23 C.F.R. part 626, requires each state highway agency to

have a process that is acceptable to FHWA for the selection of type and the design of new, reconstructed, and rehabilitated pavement structures.[3]

Objectives, Scope and Methodology

Section 1043 of ISTEA states that the Comptroller General shall report to the Congress on means for improving the quality of highways constructed with federal assistance. Specifically, section 1043 directed the Comptroller General to address three areas: (1) the inclusion of guarantee and warranty clauses in contracts with designers, contractors, and state highway departments; (2) means of enhancing the maintenance of the federal-aid highway system to ensure that the public investment in this system is protected; and (3) alternatives to current federal and state minimum design standards. In addition, we reviewed other areas, such as research and development as well as federal oversight and planning requirements, as they relate to the three primary issues of guarantees and warranties, maintenance, and design standards.

As agreed with the Senate Committee on Environment and Public Works and the House Committee on Public Works and Transportation, our emphasis for the three directed areas centered on

- determining states' experiences to date with the use of warranties and guarantees and the primary factors likely to influence use of these innovative approaches to contracting;
- identifying efforts to provide adequate maintenance for projects constructed with federal-aid highway funds; and
- identifying opportunities for improving procedures for selecting highway pavement designs.

To address these issues, we performed work in six states—California, Michigan, Mississippi, New York, Oregon, and South Carolina. Factors used in selecting these states included the percentage of pavement considered deficient, the guidelines used for pavement design, the status of the states' pavement and bridge management systems, and the states' experiences with warranties and guarantees or other innovative contracting strategies. On the issues of warranties and design, we expanded the information developed on these six states by contacting other states. For warranties, we obtained information from seven additional states (Colorado, Missouri, Montana, Nevada, New Hampshire, North Carolina, and Washington) with known experiences with

[3]Effective January 3, 1994, the Pavement Policy was removed from federal regulations and replaced by a definition of pavement design and a requirement that "pavements shall be designed to accommodate current and predicted traffic needs in a safe, durable, and cost-effective manner."

warranties. For design, we surveyed three additional states—Illinois, Kentucky, and Washington—because they provided a different perspective on pavement design procedures than the original six states.

To review the use of warranties, we first analyzed information available as a result of study tours to Europe in 1990 and 1992. To obtain information on the U.S. experience with warranties, we contacted FHWA officials, who provided information on the legal history and regulatory status of warranties for federal-aid highway projects. We obtained opinions on the potential impact of warranties from top officials of major trade associations representing the engineering, construction, and surety communities as well as organizations representing disadvantaged business enterprises. We contacted a number of individual contractors to obtain their views on the potential benefits and costs of warranties. We also reviewed the findings of research studies on innovative contracting, including reports issued by the Transportation Research Board (TRB) and private consultants.

To obtain state-level information on warranties, we reviewed information provided by states on the factors contributing to their decisions on whether to use warranties. We analyzed project-level information from all nine states that used warranties and reviewed the information we obtained in light of the theoretical arguments both for and against warranties provided in the literature to date.

In reviewing maintenance practices and oversight, we analyzed federal and state efforts to assess the cost-effectiveness of maintenance. We identified any problems states were having with performing adequate maintenance. These problems were identified through our discussions with state and federal transportation officials and our review of annual state maintenance reports; surveys of pavement conditions; maintenance budget allocations; information on system development and scope for pavement management systems; and, when applicable, maintenance management systems, special maintenance studies, and reports such as studies on strategies for addressing maintenance backlogs and state audit reports. Finally, in assessing federal oversight of maintenance, we reviewed legislative and other maintenance requirements, FHWA division (state) offices' maintenance evaluation plans, the results of these efforts, and the offices' certification that the states' maintenance had been adequate, along with accompanying submissions and responses by the states to problems that FHWA identified.

In evaluating means for improving highway design standards, we focused our efforts on pavement design and construction methods. We did not review geometric highway standards, because section 1049 of ISTEA mandated that the Department of Transportation (DOT) conduct a survey and report on this issue. We reviewed nationally recognized design guides and manuals developed by the American Association of State Highway and Transportation Officials (AASHTO), and technical reports and papers published by TRB. In assessing the federal role in pavement design and construction, we reviewed federal laws, regulations, and guidance, including FHWA's Federal-Aid Policy Guide, manuals, technical advisories, training course materials, and policy memorandums.

In addition, as part of our review of highway design, we analyzed (1) a National Cooperative Highway Research Program (NCHRP) report on national pavement structural design practices; (2) information from the Strategic Highway Research Program (SHRP) on the results of its research on pavement design and construction; and (3) materials from the National Quality Initiative, a cooperative effort of FHWA, AASHTO, and highway industry representatives to promote the improvement of highway quality. We also interviewed FHWA officials at headquarters, regional offices, and division offices. In addition, we reviewed reports on design related issues from DOT's Office of Inspector General. We also obtained from the states their current pavement design and construction procedures, and we discussed with state highway engineers the key factors they consider in designing and building their pavements.

Our review was conducted from June 1992 through May 1994, with updates through August 1994, in accordance with generally accepted government auditing standards. DOT reviewed a draft of this report and provided written comments, which appear at the end of each chapter along with our evaluation. The full text of DOT's comments appears in appendix I.

States' Experiments With Warranties Provide Early Indications of Implementation Strategies

As highway experts look for ways to improve the performance and durability of the nation's federal-aid highways, the potential of including warranties in highway contracts has sparked strong interest as well as controversy. A highway warranty would bind a contractor or engineer to repair or replace a project if it failed to perform adequately over a set period of time.[1] Most major trade groups representing the engineering and construction professions oppose warranties for highway work, arguing that warranties would impose an unfair burden of risk on their industries. Other transportation experts, however, assert that warranties would result in a greater measure of accountability in the nation's contracting practices and thus could improve highways by raising the quality of workmanship.

In the past, states' use of warranties was prohibited by federal regulations. Under ISTEA, FHWA has clarified that the regulatory prohibition does not apply in certain circumstances, but states' use of warranties remains limited. As of spring 1994, about 30 highway-related projects, representing a narrow range of project types, had been conducted under warranty. Of that total, only about half had reached the conclusion of the warranty period.

Preliminary indications from these projects are that, with a few exceptions, those few states that have tried warranty contracting have generally been satisfied with the experience. However, officials from some other states fear that warranties could prove difficult to enforce as a result of disputes over who is liable for project failures. Similarly, some state officials doubt that the benefits of warranties outweigh the effort of drafting new contract specifications. For those states that have experimented with warranties, careful design of the warranties has been key to successful outcomes. These initial experiences with warranties provide early indications of a number of strategies that can maximize the potential benefits of warranties with the least threat to states' ability to enforce warranties and contractors' ability to compete in a fair and equitable marketplace.

[1]As noted in ch. 1, the term "warranty" refers to a contracting practice that is distinct from 1-year performance bonds that can accompany local road projects. In this report, we use the term warranty to cover both warranties and guarantees, as the terms are typically used interchangeably. A warranty is technically defined as a direct contractual relationship between owner and warrantor; a guarantee connotes the involvement of a third-party intermediary, such as a bonding agent.

A Few States Are Experimenting With Warranties

Federal regulations have traditionally prohibited states from using warranties on federal-aid highway projects. Since 1990, however, states have had the opportunity to use warranties on an experimental basis under a special FHWA project. Additionally, in October 1992, FHWA clarified that the regulatory ban on warranties did not apply to projects on a large portion of the federal-aid highway system. As of spring 1994, nine states had employed warranties in highway projects, and officials in those states have generally been satisfied with the outcomes, although an overall assessment of the broad benefits, costs, and applicability of warranties remains limited by the relatively small number of cases in which they have been tested.

States Are Not Always Aware of FHWA's Policy on Warranties

In the United States, FHWA's regulations have prohibited the use of warranties for federal-aid highways since 1976.[2] In most cases, federal-aid highway funds may only be used for capital projects, with maintenance being the states' financial responsibility. Warranties were banned because FHWA officials perceived that warranties could indirectly involve the federal government in maintenance. This could occur if contractors raised initial bid prices to cover the costs of returning at a later date to perform repairs.

FHWA took a first step toward liberalizing the policy on the basis of a request by a TRB task force for experimentation with a number of innovative contracting techniques. In February 1990, FHWA established Special Experimental Project 14 (SEP 14) to permit states to try a variety of innovative contracting practices, including warranties, and to promote their evaluation.[3]

In October 1992, FHWA clarified that the regulatory ban on warranties was no longer applicable for certain categories of federal-aid highway projects. Specifically, FHWA officials determined that under section 1016 of ISTEA, those states that were exempt from federal oversight for projects not included in the National Highway System (NHS) had the flexibility to use

[2]The regulation appears as section 635.413 of title 23 of the U.S. Code of Federal Regulations. Warranties for certain mechanical and electrical equipment are specifically exempted.

[3]A description of some of the alternative, innovative contracting methods that states are permitted to try under SEP 14 appears in app. II.

warranties for all federal-aid projects on those non-NHS roads.[4] Non-NHS roads make up about 83 percent of the full federal-aid highway system. As of March 1993, 41 states were exempt from federal oversight for their non-NHS road projects.

The clarification of policy was initially communicated in a question-and-answer format over FHWA's electronic bulletin board system as well as in an FHWA briefing package. However, officials from several states we contacted were not aware of the policy change. In April 1994, FHWA issued an addendum to the Federal-Aid Policy Guide stipulating that states now have the latitude to apply warranty provisions to exempted non-NHS projects. The addendum also reiterated that for projects on the NHS, states may still seek warranties as long as they receive FHWA's approval for the projects under SEP 14.

States' Use of Warranties Is Limited but Generally Satisfactory

Even in the wake of FHWA's creation of SEP 14 and the clarification of federal policy on warranties, states' use of warranties remains limited. According to recent surveys of states' use of warranties performed by FHWA and TRB, nine states have included warranty clauses in highway contracts as of spring 1994, accounting for 33 projects.[5]

Six of the nine states that have used warranties have done so under the auspices of SEP 14: These states are California, Michigan, Missouri, Montana, New Hampshire, and Washington. Two additional states (Colorado and Nevada) have used warranties on projects financed wholly with state funds. Finally, North Carolina used a warranty on a federal-aid project in 1987, although the project was not conducted under SEP 14. Table 2.1 summarizes states' use of warranties as of spring 1994.

[4]The NHS, as established under ISTEA, is to include a network of federal-aid roads of national significance totaling approximately 155,000 miles. Section 1016 of ISTEA permits state exemption from federal oversight for certain categories of roads. If a state opts for the exemption, it may design, construct, operate, and maintain all non-NHS roads in accordance with state, rather than federal, laws and procedures. Thus, warranties may be used for these projects. The Congress must approve the final NHS network by September 30, 1995; until it is approved, an interim NHS serves as a surrogate system for the purposes of the exemption clause.

[5]The warranties under discussion are only those that were previously subject to the federal prohibition. Thus, states' acceptance of warranties for such items as landscaping and premanufactured equipment and materials are not captured in the survey results.

Table 2.1: Summary of States' Use of Warranties as of Spring 1994

State	Type of project	Warranty duration	Project completion date	Source of funding
California	Rubberized asphalt chip seal	1 year	August 1991	State
	Rehabilitation using rubberized asphalt (2 projects)	3 and 5 years	November 1993 and June 1994 (expected)	Federal-aid (SEP 14)
Colorado	Microsurfacing	1 year	September 1992	State
Michigan	Bridge painting (18 projects)	2 years	[a]	State (3) and federal-aid (15) (SEP 14)
	Concrete pavement repair (2 projects)	2 years	August 1992 and June 1993	Federal-aid (SEP 14)
Missouri	Rehabilitation using rubberized asphalt (2 projects)	3 years	February 1992 and October 1993	Federal-aid (SEP 14)
Montana	Pavement marking	4 years	September 1992	Federal-aid (SEP 14)
Nevada	Microsurfacing	2 years	September 1992	State
	Resurfacing using rubberized asphalt	5 years	September 1992	State
New Hampshire	Bridge painting	2 years	Expected 1996	Federal-aid (SEP 14)
North Carolina	Pavement marking	4 years	November 1987	Federal-aid
Washington	Installation of bridge expansion joints (2 projects)	5 years	June 1989 and September 1993	Federal-aid (1 project under SEP 14)

[a]In Michigan, bridge painting on 11 of 15 federal-aid bridge projects was completed as of May 1994. Evaluations of the performance of the projects were available for 8 of the 11 completed bridges. All three state-funded bridge painting projects had been completed and evaluated as of the same date.

Source: GAO's analysis of information provided by FHWA and relevant state departments of transportation.

With a few exceptions, state officials told us that they have generally been satisfied with their experiences, on the basis of preliminary observations or final results from 23 of the 33 warranted projects undertaken to date. These officials' satisfaction resulted from both the initial quality of the workmanship and the opportunity to obtain remedial action when necessary. For instance, Michigan officials have been pleased with the results of their warranted bridge painting projects, with one official noting that two of the projects completed under warranty were of the highest quality the state had ever obtained. Although some type of repair work has been required for all 11 Michigan bridge painting projects for which the warranty period is complete, only two projects required more than minor

repair work. Given both the generally high initial quality of workmanship and the fact that repair work would previously have been performed by state crews, several Michigan engineers said that they would like to see the state enter into warranty contracts for all bridge painting.

The remaining 12 projects for which preliminary observations or final results are available represent other types of highway work. Of these 12 remaining projects, 8 are satisfactory to date, with no repair work required, according to state officials. Some type of remedial action was required for the other four projects, although, again, state officials were able to obtain such action under the warranties. In Missouri, for example, a layer of aggregate came loose from a warranted asphalt pavement rehabilitation project 3 months after the project was completed. The cause of the problem was identified as the failure of the sealing process used to bind the aggregate to the pavement surface, and the contractor returned to repair the failed pavement. According to one state engineer, calling the contractor in to fix it "was one of the best feelings in the world," since state crews funded by taxpayers' dollars would have had to make the same repairs in the absence of the warranty.

Impetus to Use Warranties Centers on Risk Sharing

Two principal factors have contributed to individual states' decisions to try warranties. First, some states have viewed warranties as a possible means of dealing with types of projects that have typically required repair work within just a few years of completion. For example, in Michigan, state officials found that state maintenance crews were devoting an unacceptable amount of time to touching up newly painted bridges. The officials determined that contractors' commitment to quality workmanship could be improved by using a warranty to delay acceptance of the project until the project's performance was determined to be adequate. In California, state engineers told us that they had ongoing problems with aggregate stripping away from new asphalt pavements. These engineers saw warranties as a means of improving contractors' attention to their workmanship.

The second key impetus for trying warranties has been the desire to test innovative but unproven materials or techniques while minimizing the risk to the state. As noted by a federal official, this situation occurred in Missouri, where manufacturers of rubberized asphalt had advocated the benefits of this innovative paving material. State officials, however, had little experience with the material and decided that the only way to increase their confidence in rubberized asphalt would be to couple its use

with the fallback of a warranty. In another example, contractors in Montana urged the state to include new pavement marking materials in the state's specifications. While state officials ultimately agreed to try new materials, they did not want to take the full risk of trying relatively untested materials. A warranty was again used as a risk-sharing device to accommodate contractors' interest in using an innovative material while protecting the state from an undue risk. As noted by officials of the California department of transportation, in some cases suppliers of materials have viewed warranties as a marketing technique.

Costs of Warranties Are Uncertain

At present, experience with warranties in the United States is too limited to provide information on their impact on construction costs, although states' limited experiences with warranties can provide some initial indications. State officials believe that in most cases to date, the presence of a warranty has had a minimal impact on costs. Michigan officials, for instance, told us that their preliminary analyses show that the costs for warranted bridge painting projects throughout the state were generally about the same as the costs for projects that did not carry a warranty. Officials in California, Colorado, and Missouri also believed that including warranty clauses in contracts for seal-coating, microsurfacing, and rehabilitation projects did not lead to any apparent increase in the bid price.

Representatives from a number of trade groups we contacted contended that warranties would dramatically increase the costs of construction. None, however, provided any empirical evidence to document this position. We found only isolated cases in which the inclusion of a warranty may have had a dramatic impact on contractors' bids. In two Michigan pavement marking projects, for example, warranty provisions—in concert with some additional experimental contract features—appear to have driven bid prices far above the state's estimated project costs. In one case, the bid price was 50 percent higher than the state's estimated cost for completing the project; in the other case, the bid price was almost twice the state's estimated cost. Michigan officials ultimately decided to eliminate the contract's warranty provisions, and the projects were completed without a warranty.

States' Experiences Suggest Strategies for Addressing Obstacles to Implementation

The major trade organizations representing the design and construction industries in the United States have voiced a number of concerns about the fairness of warranties. Some state officials have also raised related concerns about their enforceability, citing these concerns as the reason for holding back on trying this contracting technique. Although states' use of warranties remains limited, the experiences of the nine states that have tried warranties to date provide a preliminary perspective on how warranties might be tested prudently during this experimental period.

Opposition to Warranties Centers on Fairness and Enforceability

The major U.S. engineering and construction trade associations are nearly unanimous in their belief that warranties shift an unacceptable amount of risk from the project's owner (the state) to the warrantor. A leading concern is that a number of elements beyond a contractor's control can affect the project's performance. For example, inadequate performance may be caused by an engineer's project design rather than the contractor's workmanship or may result from external factors such as unexpected traffic volumes. Also, there is concern that shifting a greater burden of risk to the contractor will constrict the availability of bonding, particularly for smaller and less well financed firms.[6] Officials from some state departments of transportation fear that an inability to clearly attribute responsibility for a failure may undermine the enforceability of warranties.

Shared Responsibility for Project Performance May Hinder Enforceability of Warranties

The successful implementation of warranties in Europe is facilitated by the fact that European construction firms tend to be large and typically have responsibility for the full range of engineering and construction activities. In contrast, a typical U.S. construction project divides responsibility for a project's quality among a number of participants. For example, an engineer develops plans for the project, the state highway department specifies materials and construction methods, a materials supplier provides raw materials, and a general contractor is responsible for the actual paving process. If a failure occurs 2 years after the project is accepted, to whom should responsibility for that failure be attributed?

Given the splintered nature of the U.S. construction market, contractors and engineers contended that the widespread use of warranties would

[6]For most highway contracts, contractors must obtain surety bonding before undertaking a project. In brief, surety companies provide the owner of a project (in this case, a state highway department) with assurance that the contractor will meet its obligations as contracted. After performing underwriting to ensure that the contractor in question is not assuming risks beyond its capabilities, the surety firm issues its bond stating that if the contractor cannot fulfill its contractual obligations, the surety firm will assume the liability for the contractor's debt, default, or failure.

lead to finger-pointing among the participants and reasoned that the difficulty in attributing responsibility for a failure would increase litigation. Some state officials agreed that the wide assortment of participants contributing to a project's performance raises the likelihood that any attempt to enforce the warranty would be met by legal challenges.

A practical example of the potential dangers of such shared responsibility occurred during the warranty period of a pavement marking project in Montana. Six months after the project's completion, the new pavement stripes began to erode in such a way that the whole pavement needed to be restriped. Officials from the state department of transportation and FHWA's division office told us they feared that a potentially major legal dispute could occur between the state and the contractor if the contractor argued that the erosion could be attributed to a problem with the materials supplied by the manufacturer. Eventually the dispute was resolved out of court and the contractor restriped the area. Nonetheless, one observer stated that the experience may cause state officials to look at warranties somewhat more critically in the future.

External Factors Also Inhibit Enforcement of Warranties

Another set of variables that threatens to undermine the enforceability of warranties is the array of external factors that also have a bearing on a project's performance. In each of the following cases, contractors are concerned that a state might misidentify the cause of a failure and consequently try to hold a contractor liable for outcomes that resulted from external factors beyond the contractor's control. Questions of liability become particularly problematic if warranties are loosely worded, so that their coverage is not limited to performance characteristics tied to workmanship but rather extends to the overall performance of a project.

- Maintenance. While improper or inadequate maintenance would be unlikely to have a noticeable effect within the first year or two following a project's completion, as time passes, inadequate maintenance could cause a premature failure. Typically, providing routine maintenance is the responsibility of the state department of transportation, not the contractor.
- Traffic weights and volumes. Pavements are highly sensitive to traffic weights and volumes: Cracking and rutting are two primary kinds of damage that can result from excesses in these areas. If a state or local government does not enforce legal limits on truck weights, or if the volume of truck traffic dramatically exceeds design projections, a pavement could fail prematurely.

- Preexisting structural flaws. When a project involves adding on to an existing pavement, as in resurfacing, a preexisting but hidden flaw can affect the new surface. Participants in the 1990 tour to examine European asphalt pavements recognized the criticality of a sound existing pavement, noting that the pavements' "structural predictability has helped to make some innovative forms of contracting for surface courses work effectively (namely . . . guarantees)."

Warranties Could Result in a Tighter Bond Market

Surety firms, which essentially assume the contractor's risk of failing to properly execute a contract, typically oppose warranties because they prolong the period of liability. Surety representatives told us that, generally, warranties can cause problems in contractors' abilities to obtain bonds if they (1) extend for longer than 1 year and (2) cover overall performance rather than specific failures of materials and workmanship. A warranty period of 1 year typically does not present a problem for surety companies. Some municipal agencies, for instance, delay acceptance of highway work pending a 1-year assessment of the quality of the workmanship and materials, and surety representatives told us that they find 1-year bonds acceptable. Long-term warranties that cover a project's general performance, however, are considered problematic. For example, during negotiations on a Missouri contract for an asphalt rehabilitation project that ultimately included a 3-year warranty, the state initially sought a lengthier warranty, but, according to a state engineer, the sureties became uninterested in the project. To ensure that contractors would have the ability to obtain bonding, the state reduced the duration of the warranty to 3 years.

Surety agents explained that the reason why the duration of the warranty is of critical importance is that with each additional year of exposure, the chance of a project's failure or of the construction firm's going out of business escalates. Sureties' concern for firms' longevity could prove particularly troublesome for smaller firms, as these smaller construction firms are more likely to go out of business. According to surety representatives, the consequence would likely be that surety agents would tighten underwriting standards if a contractor assumed the responsibility of providing a multiyear warranty. They add that bonding companies would thus screen out all but the most well-financed and well-established firms, denying the necessary bonds to other contractors wishing to bid on a contract that included a warranty clause.

It is unclear whether tighter underwriting could make it particularly difficult for disadvantaged business enterprises to obtain bonding, because these firms tend to be less well financed than their competitors.[7] However, such firms often serve not as prime contractors but rather as subcontractors. Subcontractors are typically not party to a warranty, as the prime contractor has ultimate responsibility for the project's performance. Thus the extent to which warranties will present a problem for disadvantaged business enterprises is uncertain.

States Develop Warranty Language to Address Potential Barriers to Implementation

States have adopted a variety of strategies to address the above-mentioned potential impediments to the fairness and enforceability of warranties. These strategies include restricting the duration of the warranty to 5 years or less and specifically defining what sorts of failures are subject to the warranty. Most of the strategies restrict the scope of the warranty, so that the contractor's unique contribution to the project's performance may be isolated. Well-focused warranty language works not only to the advantage of the contractor, but also to the advantage of the state department of transportation, because fair risk allocation both fosters trust between warrantor and owner and minimizes the chances that legal disputes will arise as a result of a state's efforts to enforce a warranty.

Shorter Warranty Duration Encourages Participation and Promotes Fairness

A critical variable for mitigating each of the potential impediments to viable warranties is the duration of the warranty period. A relatively short warranty period (5 years or less) helps isolate the unique effect of the quality of construction on a project's performance. If a warranty period stretches too far into the future, the effects of uncontrollable or unexpected variables (e.g., inadequate maintenance or excessive traffic loads) can obscure the quality of the original workmanship. Of the warranties we identified in the United States, none lasted longer than 5 years, and most fell within the 2- to 4-year range.

An overly long warranty period can negate the utility of a warranty if contractors view the project as too risky even to bid on. For example, in Montana, state officials initially sought a 5-year warranty period for a pavement marking project, but contractors balked, saying that this duration entailed too much risk for them. As a result, the state scaled back

[7]Federal law and regulations define disadvantaged business enterprises as those small businesses that are owned and controlled by socially and economically disadvantaged individuals. State highway agencies receiving federal-aid highway funds must establish a participation goal for disadvantaged business enterprises, reflected as a percentage of all such funds the state will spend in federal-aid highway contracts during the fiscal year. The goal is subject to FHWA's approval, and must be at least 10 percent, unless otherwise approved by FHWA.

the warranty period to 4 years. Even so, a state official noted that this duration may still have presented a barrier to contractors' ability to obtain bonding and submit bids to perform the contract. According to the state official, of the six to eight contractors that initially expressed interest in the project, only two ultimately submitted bids. He also noted that one contracting firm approached 12 surety firms and was unable to obtain bonding from any of them.

Defining Inadequate Performance Improves Enforceability

Targeting warranty coverage to specific types of failures can reduce the number of variables that affect pavement performance and thus help ensure that what the warranty covers actually corresponds to the types of failures associated with inadequate workmanship. As noted in a March 1993 consultants' report to FHWA on the potential for the use in the United States of contracts covering both the design and construction of projects and including warranties, it is essential that performance characteristics sought under warranty (for example, skid resistance and pavement smoothness) be expressed in quantifiable terms. Moreover, clearly specifying what condition triggers the warranty obligation and what type of repair work is required can improve the warranty's viability. Contract language that specifies and restricts the conditions the project will be subjected to (for example, traffic loads) and the state's responsibilities (for example, frequency of maintenance) may also help reduce the number of unknowns facing the warrantor as well as the potential for legal disputes arising from shared responsibility for the outcome of a project.

State officials appear to be making a good-faith effort to specify what failures are covered under warranty. In Nevada, for instance, contract language for a resurfacing project included a list of specific types of deterioration deemed unacceptable, including rutting, raveling (a wearing away of the pavement surface), and delamination (a loss of the interlock between layers, which can ultimately result in potholes). While the contract stipulated that identification of some of these types of deterioration, such as raveling, was at the discretion of the state engineer, in the case of rutting, the contract specified measurement criteria, stating that the contractor would have to perform repairs for rutting exceeding one quarter of an inch.

In some cases, contract language has been less specific. In Missouri, state officials drafted two asphalt rehabilitation contracts that included warranties for the projects' overall performance. In the case of the second project, FHWA urged that for the purposes of the warranty, the contract

language be amended to distinguish between a surface failure and a failure of the underlying base. FHWA also urged (unsuccessfully) that the language be further amended to target specific performance.

Contractors' Input Into Project Specifications Can Promote Fairness of Warranty

Specifications that offer the contractor greater input into the method of construction improve the acceptability of warranties from the contractor's perspective. A contract that includes these so-called performance-based (or end-result) elements might, for instance, identify specific characteristics, such as the smoothness of the pavement or a minimum amount of pavement rutting. This approach departs from conventional procurement practices because instead of using method-based specifications that are stringent and prescriptive, states identify overall characteristics of the project's performance to be obtained and leave the determination of how to achieve these end results to the contractor. Those contractors willing to consider warranties stress that, in most cases, performance-based specifications are a prerequisite to their acceptance of warranties. In their view, it makes little sense to hold contractors accountable for a project's performance when contractors have little control over the method of construction.

While the development of appropriate performance-based specifications is in its infancy, we found that many states that have tried warranties have included at least a few performance-based elements in the specifications for their warranted projects. For example, the Missouri department of transportation defined overall acceptability standards for the materials to be used and made recommendations as to good practice, such as the preferred ranges of ambient temperatures during the paving process. However, the final decision on materials and paving practices was left to the contractor.

In other cases, states have opted to couple warranty language with method-based specifications. The Michigan bridge-painting projects provide a prime example. State officials reported that they retained method-based specifications for all warranted bridge-painting projects, noting that they felt confident that (1) they had a good ability to distinguish between performance problems attributable to workmanship and factors beyond the contractors' control and (2) the 2-year warranty period was short enough to eliminate most cases of the project's performance being affected by external factors. In a number of cases, the state did request repair work for early peeling that could clearly be attributed to problems with initial workmanship (an example might be a failure to prepare the surface adequately before applying the paint). In

another case, however, state engineers recognized during inspection that nicks in the paint surface did not indicate any problems with workmanship, such as poor surface preparation but rather were likely the result of vandals throwing rocks at the bridge. As noted by a state engineer, the state will not require the contractor to repair these spots.

Heightened Role for FHWA Could Encourage Prudent Experimentation With Warranties

State highway agencies face many uncertainties in developing warranty contracts, including determining the types of projects that are best suited for use with a warranty, the proper duration of a warranty, and, most especially, the way to develop appropriate performance-based specifications. Some states have addressed these uncertainties by approaching other states for advice, and in some cases by borrowing contract language from them. For instance, California patterned its specifications for several projects for asphalt rubber rehabilitation on Nevada's specifications for the same type of project. A state engineer from Montana's department of transportation noted that six to eight states had requested information from Montana on how best to incorporate a warranty clause into a pavement marking contract.

A key tool that could promote prudent implementation of warranties would be model provisions for those types of projects deemed best-suited to warranties. FHWA is already making progress in this area, primarily at the prompting of a materials association that views a standard product warranty as a potential marketing tool. In conjunction with the International Slurry Surfacing Association, FHWA developed generic, standardized warranty language to cover applications of microsurfacing—a thin layer of a mixture of asphalt emulsion and aggregate. The warranty provisions, which were issued in June 1994, serve as a guide that states can adopt and implement with minimal effort. While other opportunities may exist to develop model warranty provisions, FHWA currently has no effort under way to develop model contract provisions in other areas.

Conclusions

The evidence on the advantages and disadvantages of including warranties in highway contracts in the United States is limited. Highway contractors and other transportation experts are polarized at opposite ends of the spectrum in terms of the value of warranties. The states' continued experimentation with warranties affords the opportunity to develop an improved base of knowledge of the impacts of warranties on the quality and costs of construction. FHWA has encouraged states to try warranties by

sponsoring an experimental project as well as by clarifying that the regulatory ban on the use of warranties does not apply to non-NHS projects. Because strategic implementation of warranties appears to be a key ingredient for success, FHWA's continued role in guiding states' implementation decisions can help minimize the chances that loose warranty language or excessive warranty durations could potentially undermine the enforceability of warranties or pose threats to fair and open competition among contractors, particularly with respect to the availability of surety bonds.

FHWA can continue to facilitate the states' appropriate experimentation with warranties and encourage judicious implementation of warranties by providing guidance to all the states on strategies for implementing warranties. In particular, state officials could benefit from information on how to (1) identify the types of projects that most lend themselves to warranties, (2) determine the appropriate duration of warranties, (3) target warranty coverage to specific types of failures, and (4) develop performance-based specifications. We believe that a particularly effective means of disseminating information would be to work with the states to develop generic warranty terms for individual project types that are relatively new or unfamiliar to many states and that are deemed well-suited to a contract that includes a warranty. Such model warranty terms could help ensure that states approach warranties in a manner that promises a fair allocation of risk between the warrantor (the contractor) and the project's owner (the state).

Recommendation to the Secretary of Transportation

The Secretary of Transportation should direct that the Federal Highway Administrator, in cooperation with state departments of transportation, develop and disseminate model warranty provisions for individual types of projects, such as rubberized asphalt pavement overlays. Model provisions might detail

- the duration of the warranty,
- the types of failures the warranty should target, and
- suggested performance specifications.

Agency Comments and Our Evaluation

In the draft report provided to DOT for comment, we proposed two ways for FHWA to facilitate states' appropriate experimentation with warranties. The first was for FHWA to issue formal policy guidance on the instances in which warranties may now be used and to encourage states to share with

FHWA the results of their experiences with warranties. In responding to the proposed recommendation, DOT stated that it concurred with the substance of the recommendation and had addressed it by issuing an addendum to the Federal-Aid Policy Guide in April 1994. Accordingly, we withdrew the proposed recommendation and acknowledged the addendum in the text of the final report. However, since the intent of our recommendation was to help educate state transportation officials, in August 1994 we recontacted contracting and engineering representatives from four state departments of transportation to determine whether this formal clarification of policy had corrected their previous misunderstanding that warranties were prohibited for any federal-aid project not conducted under SEP 14. We found that officials from three of the four states remained uncertain about the circumstances under which warranties were permissible. We believe this finding is a reminder of the shared federal and state responsibility for seeing that needed information is channeled to all key parties. We credit FHWA with issuing the clarification of its policy on warranties and urge the agency to reinforce the message through additional means, such as speeches and conference and workshop materials.

DOT partially concurred with our second proposed recommendation, calling for FHWA to develop and disseminate model warranty language for a variety of individual project types. DOT stated that FHWA generally prefers not to develop standard specifications for use by state highway agencies but prefers rather to assist states in developing their own specifications. The Department acknowledged, however, that in the case of the model microsurfacing specification described in this chapter, FHWA made an exception. The rationale for this action was the states' lack of familiarity with microsurfacing.

We believe that our proposed recommendation calling for FHWA to develop and disseminate model warranty provisions for certain types of projects remains valid. Specifically, we believe that, besides microsurfacing, other techniques and processes are similarly little known to many states and consequently provide opportunities for FHWA to play an active role in developing and disseminating warranty language. We note that such model provisions need not limit the states' ability to modify the language to suit their own particular needs—FHWA noted that it built such flexibility into the microsurfacing specifications mentioned above. While retaining the recommendation, we modified it slightly to recognize that FHWA's development of model warranty provisions would occur in cooperation with state departments of transportation.

Maintenance Is a Strategy for Extending Pavement Life

Maintenance can help protect the multibillion dollar investment in the nation's highway network, as the performance of a pavement is greatly affected by the type, timeliness, and quality of maintenance it receives. Maintenance can slow the rate at which pavement deteriorates, thus keeping it in good condition for a longer period of time. In recent years, the overall percentage of the nation's pavement categorized in good condition has improved. Nonetheless, approximately 60 percent or less of principal highways are considered in good condition. Unmet needs for maintenance could cause further deterioration of these highways.

The federal government is responsible for ensuring that adequate maintenance is provided for projects constructed with federal funds. However, no measurable standards exist for defining what constitutes adequate maintenance. Furthermore, FHWA's guidelines recommend that maintenance deficiencies be resolved through corrective action by the state within an agreed time frame and a plan for FHWA to ensure that the corrective action is carried out. Because this recommendation is not being systematically adhered to, some identified maintenance problems—even safety-related deficiencies—have lingered unresolved for lengthy periods of time.

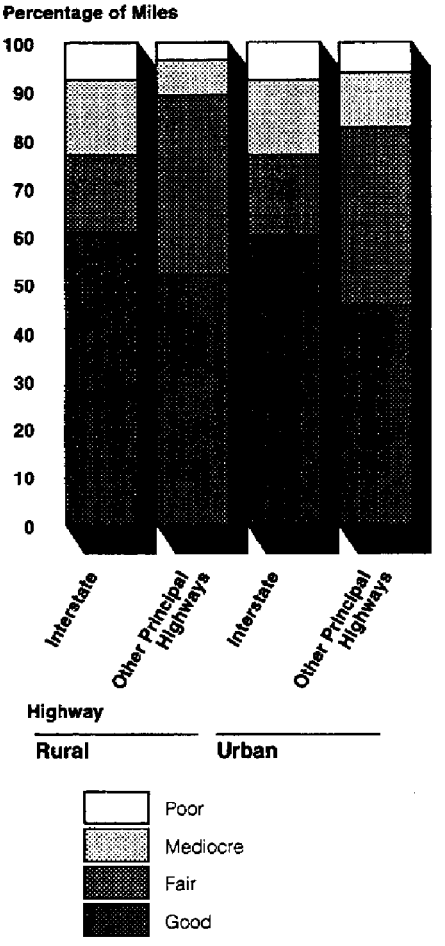
Underfunding for highway maintenance is a long-standing problem. ISTEA responded to the problem in 1991 by authorizing the use of federal funds for maintenance of Interstate highways, if justified as cost-effective. For a variety of reasons, however, most states are reluctant to use federal funds for maintenance. One reason is that since no additional federal funds are being provided, using federal funds for maintenance reduces the moneys available for capital projects.

Pavement Condition Varies by Area and Type of Highway

FHWA uses data from the states that classify pavement into broad categories—poor, mediocre, fair, and good—based on the roughness of the ride and the extent of surface defects. The data show that pavement conditions improved throughout the 1980s and continue to do so into the 1990s. More specifically, in 1991 (the most recent year for which data are available), the indicator shows that the percentage of principal highways classified in good condition ranges from a high of 61 percent for rural Interstate highways to 46 percent for principal non-Interstate highways in urban areas. Consequently, the balance of the nation's major highways are at most in fair condition. According to FHWA, this means that the pavements are noticeably inferior to new ones and may be barely tolerable for high-speed traffic. Figure 3.1 shows the overall condition of the

nation's principal highways—Interstate highways and other principal highways—in rural and urban areas.

Figure 3.1: Pavement Conditions of Principal Highways, 1991



Note: For rural highways, "other principal highways" refers to non-Interstate principal arterials. For urban highways, the term refers to non-Interstate principal arterials, freeways, and expressways.

Source: GAO's analysis of FHWA's data.

FHWA has estimated that each dollar of repair costs not spent when the pavement is in good condition multiplies to $4 to $5 if the pavement

deteriorates to fair condition, and to $10 if the pavement deteriorates to poor condition.

States' Maintenance Needs Exceed Resources Devoted to Maintenance

As a result of budgetary constraints and competing priorities, the six states we contacted lack sufficient funds to cover needed maintenance work. All six states had maintenance backlogs and had postponed needed repair work, such as sealing joints and cracks, clearing and repairing damaged drains, and spot-painting bridges. Deferring maintenance can prove costly if doing so accelerates the need for more expensive repairs. For instance, Michigan officials noted that routine bridge maintenance, such as spot-painting bridges, is necessary to prevent the accumulation of corrosion and rapid deterioration. Not performing this spot-painting can result in the need for completely replacing the deck or accelerate the need for full-scale painting, according to these officials. Similarly, bridges can be protected through periodic cleaning and washing. The New York department of transportation's current policy is to clean and wash bridges on a 2-year cycle. Department officials explained that, among other things, washing bridges unplugs and cleans the drainage system through which water from the deck is carried down and away from vulnerable components of the bridge. However, in 1992 New York reported that the average interval between cleaning of state bridges was nearly double the desired 2-year period.

Difficulty in obtaining adequate funds for maintenance is a common problem for the states we visited for a variety of reasons. In Michigan, for instance, transportation officials cited three primary reasons for the state's backlog of highway and bridge maintenance. First, resources are lacking. According to a senior Michigan maintenance official, this is largely because the state's gas tax rate—the principal source of funds for maintenance—has been capped at 15 cents per gallon for over a decade. Second, providing funds for maintenance has no glamour or political payoff compared with a new highway or bridge construction project. Finally, the state's transportation revenues that are generated have been eroded over the years by inflation and increased liability from lawsuits, among other things.

Mississippi is another state that is having trouble funding maintenance. According to officials from Mississippi's department of transportation, actual expenditures for maintenance are running significantly lower than the amount budgeted for that purpose. A primary reason was that funds originally budgeted for maintenance were shifted to capital projects so

that the state could match federal funds, as required. In fiscal year 1992, the state spent 26 percent less than the original maintenance budget. Some maintenance problem areas bore a significant share of the impact of these reduced expenditures. For instance, expenditures for pavement striping (a center line or edge line for traffic control) were reduced by 61 percent from the amount originally budgeted.

While there is no federal requirement that states develop maintenance standards, Mississippi has developed such standards. Mississippi's maintenance standards include a requirement that 70 percent or more of the original pavement striping must function as intended. A fiscal year 1992 survey of the state's highway conditions disclosed that 43 of 180 highway segments (24 percent) reviewed did not function as intended.

South Carolina also has difficulties with maintenance funding. In 1991-92, South Carolina estimated its ordinary annual highway maintenance needs at $144 million, but expenditures for this period were $117 million—a shortfall of $27 million (19 percent). As a senior South Carolina transportation official observed, the state has unmet maintenance needs in all areas because maintenance has historically been underfunded.

In addition to the problems cited, we note that the 953,241 mile federal-aid system represents only about a quarter of the total national road network of 3,923,830 miles. Maintenance and preservation of the nearly 3 million miles of roads not a part of the federal-aid system is the financial responsibility of state and local governments. This additional responsibility further complicates funding choices at the state level.

Barriers Inhibit the Use of Federal Funds for Preventive Maintenance

Before passage of ISTEA in 1991, federal-aid highway funding was generally limited to new construction and major capital repairs—reconstruction, resurfacing, restoration, and rehabilitation. Preventive maintenance was not eligible for federal funds. Under ISTEA, however, preventive maintenance became eligible for federal Interstate maintenance funding if a state could demonstrate that such activities are a cost-effective means of extending pavement life on Interstate highways. This use of federal funds for maintenance of Interstate highways must be justified through a state's pavement management system. A pavement management system, which was mandated by ISTEA, is intended to provide a consistent, systematic approach for determining pavement needs, setting priorities for those needs, and selecting the "best" actions and the costs of implementing those actions.

Some states assume that they cannot use federal funds for preventive maintenance, because their pavement management system is not able to provide data justifying the cost-effectiveness of preventive maintenance strategies. A senior FHWA pavement management official estimated that about half of the states' systems now have this capability but said that more can be expected to acquire this capability in the future. FHWA recognizes that this data limitation could pose a problem, and officials have told us they will consider various data to justify the cost-effectiveness of using federal funds for preventive maintenance work. Nevertheless, some states do not believe they have data that could be used to demonstrate the cost-effectiveness of using federal funds for preventive maintenance work. For instance, Mississippi transportation officials expressed doubt that the state had any data that could be used for this purpose.

Although officials in all six states we contacted attributed their maintenance backlogs primarily to a lack of resources, officials in four of the six states—California, Mississippi, New York, and Oregon—stated that they do not currently plan to use federal funds for preventive maintenance. Besides some states' belief that they do not have data that could be used to justify the cost-effectiveness of preventive maintenance work, states pointed to a number of reasons for not tapping into a potential funding source. Among their reasons were

- uncertainty over whether states could use federal funds to pay for maintenance work performed by state employees,
- concern that using federal funds for maintenance could prove costly because of paperwork and administrative requirements, and
- the fact that no additional federal funds are being provided for maintenance, so that using federal funds for maintenance reduces the moneys available for capital projects.

Some FHWA division and state officials expressed uncertainty to us about whether federal funds could be used to reimburse a state for maintenance work performed by state personnel. For instance, FHWA division officials in New York expressed doubt that federal funds could be used for this purpose, and they emphasized that maintenance work covered by federal funds should remain under the competitive bid process. FHWA division officials in South Carolina, however, either took a different position or expressed uncertainty regarding this issue. Some of these officials said that states should be able to use federal dollars to fund state maintenance crews if doing so is shown to be cost-effective. However, other division

officials said they were uncertain that federal funds could be used for such purposes.

In addition, some states noted that since the same federal paperwork was required for both large capital projects and small maintenance projects, it was not worth the administrative burden to request federal funds for maintenance. For instance, officials from one state noted that a more streamlined process needs to be developed to secure federal funds for preventive maintenance work. They noted that the current rigorous process for justifying and getting approval for capital projects is not warranted for preventive maintenance work. However, the administrative and paperwork requirements could be mitigated through an overall contract for maintenance. Two of the states we contacted—Michigan and South Carolina—have used, or plan to use, a contract that packages various maintenance activities together for FHWA's approval.

ISTEA did not provide separate funding for preventive maintenance work. Instead, the legislation provided states with more flexibility in using federal funds for capital or preventive maintenance activities. Making trade-offs between capital and preventive maintenance strategies should be facilitated by efforts under way through the Strategic Highway Research Program (SHRP). In 1987, SHRP received a 5-year, $150 million authorization, which was subsequently extended under ISTEA. One of the four major research areas of the program focused on efficient methods of highway maintenance.

One SHRP project was designed to address the need for more reliable, consistent, and comparable data on the effectiveness of pavement maintenance. Six specific maintenance treatments, such as joint and crack sealing and thin overlays, are being monitored on state highways over a 15-year period. The results will be compared with those of a control group of untreated pavements. An FHWA program manager estimated that preliminary data should be available starting in 1995 or 1996.

Nevertheless, because the funds available for highway and bridge capital projects fall far short of needs, transportation officials are likely to continue to face difficulties in making trade-offs between using federal funds for capital versus maintenance projects. FHWA estimates that the 1991 cost to eliminate the backlog of deficiencies in highway pavement was $212 billion. Approximately 42 percent of the backlog is the cost of maintaining the pavement; the remaining 58 percent is the cost of adding capacity to provide the level of service that would meet minimum

condition standards. Furthermore, FHWA estimates the cost of eliminating the backlog of existing bridge deficiencies at $78 billion.

Federal Determinations of the Adequacy of Maintenance Are Questionable, and Problems Persist

FHWA requires that its division administrators annually certify whether states are properly maintaining the federal-aid highway system. If maintenance is not adequate, federal legislation provides that the state be notified that corrective action must be accomplished within 90 days. If the 90-day deadline is not met, the Secretary of Transportation must withhold approval of further federal-aid highway projects of all types for the entire state or for a particular area within the state until proper maintenance is achieved.

FHWA has no measurable standards for determining whether maintenance is adequate, and, until it establishes such standards, FHWA will have difficulty making any meaningful determination of whether maintenance is adequate or inadequate. Furthermore, some FHWA-identified maintenance problems have remained unresolved for lengthy periods of time, in part because no time frames were established for resolving or following up problems.

Sanctions Are Rarely Used

According to FHWA officials, project approvals have only been withheld once on a statewide basis. This occurred in Louisiana, when the state told FHWA that it could not certify that it was adequately maintaining its highways. In this case, the state responded by channeling additional funds to maintenance. As a result, FHWA lifted the funding restriction. On a local basis, FHWA officials have withheld project approvals more often, according to FHWA officials, but FHWA has no data on the frequency or extent that this sanction has been employed. For the six states we contacted, maintenance problems existed to varying degrees, but FHWA had taken no action to impose sanctions in these states.

FHWA officials have historically viewed sanctions as an undesirable and ineffective means of satisfying maintenance requirements. In 1981, we reported that DOT and FHWA believed that sanctions should only be applied when highways become unsafe or unserviceable and not as a mechanism to encourage adequate maintenance.[1] We also reported that FHWA officials viewed sanctions as counterproductive and undesirable because they would result in withholding funds from the states.

[1]Deteriorating Highways and Lagging Revenues: A Need to Reassess the Federal Highway Program (CED-81-42, Mar. 5, 1981).

FHWA's unwillingness to impose sanctions for maintenance deficiencies remains unchanged. The imposition of sanctions for inadequate maintenance does not help to resolve the basic problem, according to a Branch Chief in FHWA's Office of Engineering. One reason is that sanctions do not correct the problem, but instead exacerbate the financial situation of a state that is probably already facing budgetary problems. However, the use of sanctions in Louisiana resulted in the state's channeling additional funds to maintenance. In addition, since FHWA is reluctant to use sanctions, some FHWA officials consider FHWA's role in maintenance to be limited, embodying no real authority to direct that maintenance deficiencies be corrected within a certain time frame.

No Measurable Standards Exist for Determining Whether Maintenance Is Adequate

FHWA requires that its division administrators annually certify whether states are adequately maintaining highways constructed with the assistance of federal funds. However, no measurable federal standards exist to guide assessments of how well states are maintaining projects built with federal assistance. All six states we visited have maintenance deficiencies and backlogs, but FHWA certified that their maintenance was adequate—with the exception of California, which is discussed later in this chapter. Moreover, FHWA's certification will provide limited assurance that the states are maintaining their highways adequately until such time as maintenance performance standards are used to guide the certifications.

In 1991,[2] we reported that FHWA certified that four of seven states we reviewed had performed adequate maintenance of their Interstate highways despite significant maintenance backlogs. The four states with significant backlogs had not performed various kinds of needed maintenance, such as sealing joints and cracks, painting and repairing bridges, and repairing guardrails. Such maintenance deficiencies can cause structural damage to highways, shorten the life of roadways, and create safety problems. To enhance FHWA's annual maintenance certifications, we recommended that FHWA develop measurable standards defining what constitutes adequate maintenance for the Interstate Highway System. DOT disagreed that measurable standards were needed for FHWA to determine whether states' maintenance practices are adequate. According to DOT, existing guidance is sufficient for FHWA to carry out its oversight responsibilities. However, we disagreed with DOT's position. In the absence of measurable standards defining what constitutes adequate maintenance, we questioned FHWA's certification of the maintenance

[2]Transportation Infrastructure: Preserving the Nation's Investment in the Interstate Highway System (GAO/RCED-91-147, Aug. 2, 1991).

efforts in states where we found significant unmet needs. Furthermore, we noted that developing measurable maintenance standards would more clearly delineate the states' maintenance responsibilities, greatly assist FHWA's efforts to ensure that these responsibilities are fulfilled, and provide a measurable basis for imposing sanctions when needed.

Measurable standards for maintenance could be developed by drawing on the standards some states have established. For instance, Mississippi has established standards for various maintenance activities. For example, Mississippi's standard on rutting provides that such areas should not exceed 1/2 inch, a standard for potholes provides that no defects should be greater than one square foot in area and one inch deep, and a standard for pavement marking (striping) provides that at least 70 percent or more of the original installation must function as intended.

In 1992, FHWA officials considered, but dropped the idea of, developing maintenance standards by drawing on standards developed by several states. This issue arose because ISTEA tasked FHWA with developing criteria for transfers of federal Interstate maintenance funds. As part of this effort, a senior FHWA official suggested that FHWA draw on data from several states that had developed maintenance standards for their own use. This suggestion was not pursued, however, since the ISTEA mandate did not require the development of standards on maintenance performance. FHWA officials issued the federal criteria for fund transfers but noted that these criteria would not apply to evaluating the states' responsibility to properly maintain projects constructed with federal funds.

Resolution Is Slow for Identified Maintenance Problems

FHWA's guidance recommends that when maintenance deficiencies are identified, a strategy for corrective action by the state should be developed, along with a plan for future FHWA follow-up to ensure the corrective action is carried out. This guidance, however, is not being systematically followed. Instead, maintenance deficiencies identified by FHWA can linger unresolved for lengthy periods of time, with no strategy developed for corrective action or time frame set for resolving the deficiencies. For instance, in April 1992 FHWA found that, contrary to federal regulation, California's department of transportation was not upgrading highway elements (signs, markers, guardrails) to current safety levels when it was repairing or replacing these elements. FHWA's Division Administrator in California stated that because of the seriousness of this problem, California's highways could not be considered adequately

maintained. Thus, the certification of adequate maintenance was not made.

To facilitate resolution of the issue, in May 1992 FHWA's Division Administrator in California asked FHWA's Regional Administrator for any available guidance on how other states were handling similar issues of compliance with maintenance requirements. FHWA's division office did not receive a response to this request. Furthermore, representatives of FHWA's division and regional offices and California's transportation department told us that efforts to resolve this issue had not yet begun, and there was no schedule for undertaking this work—about 2 years after FHWA determined that the state's maintenance practices were in conflict with a federal requirement.

A case in New York provides another example of a delay in correcting an identified maintenance problem. FHWA's division officials initiated a review of repairs to guardrails (known as guiderails in New York) because of a general sense that damaged guardrails were remaining unrepaired for long periods of time. As a result of this effort, FHWA concluded that the timeliness of guardrail repair was inadequate statewide. FHWA transmitted its guardrail report, which contained a number of recommendations, to New York's transportation department in February 1991. However, the state advised FHWA in May 1992 that a state committee would address the issues; a year later, in May 1993, the state advised FHWA that a committee was being established to address the guardrail issues—just over 2 years after FHWA issued its report.

Conclusions

Although ISTEA provided a source of federal dollars for Interstate preventive maintenance, most of the states we visited do not plan to avail themselves of this resource. FHWA could remove some barriers states identified to using federal funds for this purpose by providing guidance on (1) whether federal dollars can be used to fund maintenance work performed by state employees, (2) what kinds of data can be used to demonstrate the cost-effectiveness of maintenance when these data are not available through a pavement management system, and (3) how states can combine planned maintenance work into an overall request for funding.

In the absence of performance standards, FHWA's annual determinations of whether states adequately maintain their federal-aid highways could be questioned. Although the states we visited all had maintenance

backlogs—some for deficiencies that could result in structural damage and cause safety problems—FHWA has in most cases continued to certify that these states' maintenance is adequate. Working with states, FHWA could develop federal standards that draw on the maintenance standards some states have developed for their own use, such as the standards related to potholes and lane striping.

FHWA has the legal authority to withhold approval of federal-aid highway projects if it determines that maintenance is inadequate. However, FHWA has been reluctant to use this enforcement tool. According to FHWA, it would rather work with the states to address maintenance deficiencies than impose sanctions. However, deficiencies identified by FHWA have persisted, with no corrective action taken, for lengthy periods of time.

Recommendations to the Secretary of Transportation

We recommend that the Secretary of Transportation direct the FHWA Administrator to do the following:

- Provide guidance on the use of federal funds for preventive maintenance that would include (1) clarification on when and under what circumstances a state can use federal funds to pay for work performed by state maintenance personnel, (2) an explanation of the type of data a state could use to justify using funds for preventive maintenance if a state's pavement management system does not capture such information, and (3) advice on how maintenance activities could be packaged into one funding request.
- Work with states to develop performance standards and expectations, including specific time frames for corrective action that depend on the severity and safety impact of maintenance problems.

Agency Comments and Our Evaluation

DOT agreed with our draft report concerning the importance of maintaining the quality of our nation's highways. In addition, the Department concurred with one of the proposed recommendations on maintenance in our draft report and partially concurred with the other.

The Department fully concurred with our proposed three-part recommendation on providing guidance on the use of federal funds for preventive maintenance. Specifically, regarding clarification of when and under what circumstances a state can use federal funds to pay for work performed by state maintenance personnel, the Department responded that FHWA's division offices and state highway agencies are already aware

that work performed by state maintenance personnel could be approved for federal-aid funding under force account procedures.[3] We found, however, that some FHWA division officials and state representatives were uncertain, or had reservations, about whether federal funds could be used to reimburse a state for work performed by state maintenance personnel. Consequently, we believe further clarification is warranted.

DOT concurred with our proposed recommendation that guidance be provided on the type of justification that would allow a state to use federal funds for preventive maintenance. However, DOT maintained that guidance has already been provided through memorandums, an electronic bulletin board, and AASHTO. Nevertheless, we believe that additional guidance is needed because (1) some states do not believe that they have any data that could be used to justify the cost-effectiveness of preventive maintenance work and thus allow them to use federal funds for preventive maintenance work, (2) only about half of the states currently have pavement management systems that are able to justify the cost-effectiveness of preventive maintenance strategies, and (3) some states do not have a preventive maintenance program.

DOT also concurred with our proposed recommendation to provide instructions on packaging maintenance activities into one funding request. DOT responded that FHWA has worked and will continue to work with state highway agencies on developing areawide maintenance construction projects covering counties, state highway districts, or the entire state. The Department noted some examples of work approved in the past for areawide application: areawide paint striping projects, railroad-highway grade crossing projects, and traffic sign replacement. We recognize there have been instances in which FHWA has worked with states in developing areawide maintenance projects. We further believe that publicizing such work may facilitate similar action in other states and increase the use of federal funds for preventive maintenance work. To emphasize that our recommendation is aimed at encouraging FHWA to publicize this type of activity, we have modified the wording of our proposed recommendation from providing "instructions" to providing "advice" on how this packaging can be accomplished.

Finally, DOT partially concurred with our proposed recommendation that FHWA work with states to develop performance measures to be used in determining the adequacy of states' maintenance efforts. The

[3]Force account refers to the use by a public agency or utility of its own personnel and equipment for construction work.

Department's position is that existing guidelines and maintenance policies are sufficient for FHWA to determine whether the states' maintenance is adequate. We observe, however, that existing maintenance guidance lacks specificity in a number of areas. This guidance groups deficiencies into one of four classes, the first class of which concerns safety. The guidance states that timely response and/or correction of safety deficiencies should be the foremost concern of highway maintenance, but no insight is provided on what is meant by timely. This omission seems particularly surprising given that federal legislation provides that if maintenance is not adequate, a state should be notified that corrective action must be accomplished within 90 days. If the 90-day deadline is not met, the Secretary of Transportation must withhold approval of further federal-aid highway projects of all types for the entire state or for a particular area within the state until proper maintenance is achieved.

While FHWA's maintenance guidance is not prescriptive, we found that it is not being systematically followed. Maintenance deficiencies identified by FHWA can linger unresolved for lengthy periods of time, with no strategy developed for corrective action and no time frame set for resolving the deficiencies. We believe that to correct this situation and buttress FHWA's existing maintenance guidance and policies, maintenance performance expectations and standards that provide national comparable measures need to be established. We have clarified the recommendation to underscore our view that performance expectations, along with specific time frames for corrective action, need to be established. Furthermore, maintenance standards and expectations need to be commensurate with the severity and impact on safety of the maintenance problems.

Pavement Design Could Be Improved Through Comprehensive Use of Design Analysis Tools

States are given flexibility to select pavement designs suited to their individual geographic and climatic needs, subject to approval by FHWA. FHWA fosters good highway design practices by encouraging states to consider critical factors in highway design, such as life-cycle cost analysis and improved traffic data. Federal legislation and regulations do not generally prescribe specific pavement design requirements, but there are exceptions. For instance, ISTEA requires that life-cycle costing be considered in pavement design, but the act does not prescribe how it should be considered.

Life-cycle cost analysis is a procedure for selecting a pavement design alternative that will provide a satisfactory level of service at the lowest cost over time. However, states sometimes do not consider this tool in determining cost-effective highway investments or evaluating pavement rehabilitation strategies. Furthermore, when this analysis is used, its value is often limited by the exclusion of important data, such as maintenance costs.

Information on traffic patterns is a key factor in highway design, but the precision of the data used for individual highway projects varies. States often rely on traffic data for the state, a region, or a corridor, rather than project-specific data. The use of project-specific data could yield substantial improvements in the accuracy of traffic forecasts. For instance, a 1991 FHWA-sponsored research effort found that states could realize a 30- to 85-percent improvement in the accuracy of traffic forecasts by determining the number, type, and weight of vehicles using a roadway.

Two other highway design and construction tools hold promise for improving the quality of highways. Quality control/quality assurance programs require contractors to test materials before and after they are placed on the roadbed, making the contractors more accountable for quality. Resilient modulus tests predict pavement deterioration as a function of traffic and environmental conditions, providing engineers with useful information needed to design pavements with new materials or under changing conditions.

States Have Flexibility in Choosing Pavement Design

States can use one of two pavement design guides developed by the American Association of State Highway and Transportation Officials (AASHTO) in 1972 and 1986 or adopt another design guide approved by FHWA. Most states have elected to use the AASHTO guides as the basis for their asphalt and concrete pavements.[1] FHWA estimates that in designing their asphalt and concrete pavements, 40 and 41 states respectively follow in whole or in part the AASHTO 1972 guide, the AASHTO 1986 guide, or a combination of these two guides. The remaining states develop their own designs or base their designs on guidance developed by industry associations or other states and approved by FHWA.

Life-Cycle Costing Is an Underutilized Tool

While ISTEA requires that states and metropolitan planning organizations consider life-cycle costs in the design and engineering of bridges, tunnels, or pavements, the act does not prescribe how such costs should be considered. FHWA recommends all states use life-cycle cost analysis (LCCA) to help ensure that the selection of a highway design is not based solely on initial costs but instead considers all the future costs expected to occur over the highway's serviceable life. FHWA further recommends that states complete life-cycle costing when selecting the type of pavement—asphalt or concrete—and for assessing alternative strategies for rehabilitating existing pavements approaching the end of their useful life.

Furthermore, FHWA requires that pavement management systems for major highways should include an analysis to determine investment strategies using LCCA. FHWA officials noted that a pavement management system provides quantifiable information to help manage highway pavements. Nonetheless, FHWA stresses that the total decision-making process is based on information from a pavement management system coupled with engineering experience, budget constraints, scheduling parameters, management prerogatives, public input, political considerations, and planning and programming factors.

Life-cycle costing is an elusive term subject to varying interpretations of what such analysis should entail. In addition, FHWA provides limited criteria on what constitutes an acceptable LCCA, and some states do not include data, such as maintenance costs, that are integral to an effective

[1]Throughout this chapter, we use the broad terms "asphalt" and "concrete" pavements. Asphalt or asphalt concrete pavements are made from a variety of bitumen found in nature or obtained by evaporating petroleum into a brown or black tar-like substance and mixed with sand or gravel. Concrete or portland cement concrete pavements include any pavement made of sand and gravel bonded together with cement into a hard, compact substance.

analysis. As a result, states' practices vary considerably, and many states either do not routinely perform the analysis or omit critical factors.

States' Use of Life-Cycle Cost Analysis Is Limited

A sizable number of states make highway investments without using LCCA. According to data from a 1993 AASHTO survey, nearly 30 percent of the responding states (11 of 38) reported that they did not use LCCA in making highway investment decisions.

States frequently use life-cycle costing to evaluate new construction and reconstruction strategies, but not for rehabilitation strategies. AASHTO's 1993 survey showed that 27 of 38 state respondents used LCCA when making highway investment decisions. However, while most of these states—25 of 27 states—used the technique in analyzing new and reconstructed pavement types,[2]—only 16 states used it to evaluate rehabilitation designs.

The results of AASHTO's survey indicating underutilization of LCCA bolster concerns raised by DOT's Office of Inspector General (OIG) in a series of audits on states' procedures to select pavement types. For example, in September 1992 the OIG reported that Florida's department of transportation had not prepared such an analysis on 12 of 13 federally assisted projects reviewed. Similarly, in April 1992 the OIG found that South Carolina had not used such an analysis to determine the most cost-effective design for seven pavements reviewed. The OIG estimated that one project's $5.8 million construction cost could have been reduced to about $3.5 million—a savings in excess of $2 million—on the basis of life-cycle costing showing that the choice of an asphalt pavement rather than a concrete pavement would have been less costly over the expected life of the project. For the other six projects, the OIG study reported that the pavements were being underdesigned—that is, designed to last approximately 10 years at forecasted traffic levels rather than 20 years, the more common design life. The OIG estimated that choices made on the basis of the longer design life would yield savings of $2.2 million over a 20-year period. South Carolina, however, assumes that it is generally more cost-effective to build a weaker initial pavement with a 10-year design life and add an overlay to the asphalt surface during the 10th year. The OIG reported that the state had no recent or previous analysis to support the cost-effectiveness of this approach.

[2]Reconstruction involves removing and replacing the road rather than extending the life of an existing road through rehabilitation techniques, such as resurfacing.

FHWA requires that a state's pavement management system for major highways (that is, those highways that are intended to make up a national highway system) be able to set priorities for projects for single-year as well as multiyear periods using LCCA. As of April 1994, FHWA estimated that most states do not produce a multiyear list of recommended projects, ranked by priority, using LCCA. However, a senior FHWA pavement management official is optimistic that most states will comply with the multiyear requirement by October 1995—the date set by FHWA for states to meet the pavement management system requirements for major highways. According to this FHWA pavement management official, there will be no scorecard of states' compliance with specific pavement management system requirements because such reporting could jeopardize FHWA's cooperative working relationships with the states. Nevertheless, this official noted FHWA will be aware of the status of states' compliance with specific pavement management system requirements through its oversight efforts.

A related pavement management requirement tasks states with estimating the remaining life of major highways, which is considered important because it provides a snapshot of the long-range health of a network and can improve the budgeting for and management of these important roads over a multiyear period. But as of April 1994, FHWA noted that only 10 states had performed an analysis of the remaining service life for highways. The head of FHWA's Pavement Management Branch expects that this requirement will be met by most states by October 1995.

Certain Life-Cycle Costs Are Difficult to Quantify

AASHTO's guidance suggests that states include costs both to the highway agency (e.g., initial construction and maintenance costs) and to the highway users (e.g., traffic delays and other user costs associated with traffic congestion during rehabilitation) in their life-cycle costing of alternative pavement designs. However, many of the states performing LCCA encounter problems in considering maintenance and user costs in their analyses.

In responding to AASHTO's 1993 survey, states indicated that a major weakness of LCCA is the difficulty of predicting the future, especially predicting future rehabilitation strategies and their timing. As the states noted, future maintenance costs, deterioration rates, and salvage values are difficult to model or estimate. In addition, states noted problems in

selecting the appropriate discount rate.[3] Furthermore, our analysis of data from a 1984 TRB survey found that 22 of 45 states responding did not include maintenance costs in their economic analysis.[4] Of those states that did consider maintenance costs in their analysis, half rated the maintenance data as either poor or fair. One reason is that states' data on maintenance are often limited to historical information on the dollars spent throughout the system or in each county or region. This broad information excludes site-specific data that would allow the state to calculate the costs related to different types of pavement (asphalt or concrete) or different features in the pavement, such as drainage.

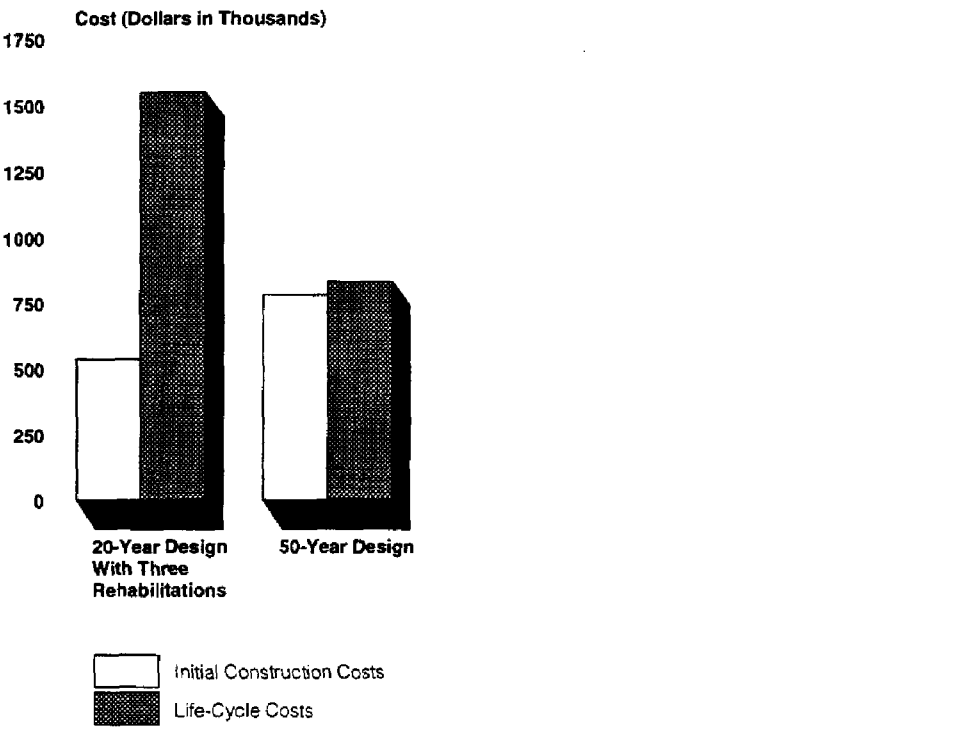
Similarly, user costs are frequently omitted from LCCA. AASHTO's 1993 survey found that only 16 of the 27 states that performed LCCA included any type of user costs. Moreover, there are various types of user costs—such as fuel costs, delay costs, and other vehicle operating costs—and states often recognize some of these costs but exclude others from the analysis. For instance, of the states that reported considering user costs in their LCCA, only seven states considered fuel costs.

Difficulty in estimating the user costs of a project is a primary reason that states often leave these costs out of LCCA. Nevertheless, factoring in the user costs resulting from delays in construction zones or detours is an important determinant of even the least-expensive project, especially in an urban area, according to a senior FHWA policy official. This official illustrated the importance of user costs by comparing two pavement design alternatives. As figure 4.1 shows, on the basis of initial cost, a 50-year design looks about 50 percent more expensive than the shorter 20-year alternative. But, using LCCA, the 50-year pavement reconstruction strategy is shown to be the optimal, most cost-effective strategy, primarily because of user costs resulting from delays during the rehabilitations that will be needed on the pavement designed to last for 20 years.

[3]The discount rate is the interest rate used to determine the present value of a future stream of benefits and costs.

[4]Dale E. Peterson, Life-cycle Cost Analysis of Pavements, NCHRP, Synthesis of Highway Practice 122, TRB (Dec. 1985). Note: Some of the states responding to this question performed economic analysis other than life-cycle cost analysis.

Figure 4.1: Initial and Life-Cycle Costs of 20-Year and 50-Year Portland Cement Concrete Pavement Designs



Note: An analysis period of 50 years and a discount rate of 4 percent were used. Costs for initial construction, maintenance, traffic control, rehabilitation, and users' delays were included.

Source: GAO's illustration based on FHWA's data.

The need for additional research and guidance on quantifying user costs was a common theme among a number of the states responding to AASHTO's 1993 survey. States also noted other life-cycle costing areas that presented them with problems. For example, states made comments like the following:

- The projection of costs, particularly fuel costs, has always been the "weak link" in this type of analysis. It is unlikely that environmental factors can be quantified. Despite these problems and related issues such as determining the appropriate discount rate, LCCA remains a useful technique. The most useful product would be a technical manual that describes methods for LCCA, including acceptable value ranges.

- The greatest difficulty in conducting LCCA is including user costs. Guidance and research are needed in this area.
- Future research should concentrate more on the valuation of social costs and other nontraditional costs (e.g., pollution, congestion, fuel usage, and disposal costs at landfills[5]).
- Determining the value of travel time and forecasting fuel costs are difficult tasks. Furthermore, many maintenance costs and salvage values of infrastructure are only guesses.

FHWA formed a task force in 1992 to review LCCA and identify problems that may hinder its application. The task force gathered information on this technique and problems with its use from state, industry, and university representatives and from consultants. FHWA officials are currently reviewing the task force's data with a view toward developing training courses and technical assistance materials and determining an appropriate research agenda to address such issues as how to quantify user costs and how to better predict the performance life of pavements.

In addition, a January 1994 executive order on principles for federal investments in infrastructure supports broader use of LCCA. In response to this executive order, FHWA's Executive Director noted that in the summer of 1994, FHWA will be issuing a policy statement on life-cycle costing, laying out the agency's position on some of the more common technical issues.

Using Site-Specific Traffic Data Would Enhance the Quality of Pavement Design

Research and state practices demonstrate that up-to-date, site-specific information on the amount, type, and weight of traffic offers the potential for significant improvements in pavement design by ensuring a better match between the pavement and the traffic load it is expected to accommodate. Most states we contacted, however, continued to rely on traffic data that are not project-specific in selecting their highway designs. FHWA officials view this use of non-specific data as acceptable. They further noted that the expense of collecting site-specific traffic data, rather than using the more readily available data on corridors, may not be warranted. FHWA officials believe that the added expense would be warranted for certain projects, but there is no FHWA guidance or criteria on the size of highway project that would benefit from site-specific traffic data. Nevertheless, FHWA is encouraging states to improve the accuracy of their traffic data through the use of computerized technologies for determining the weight and classification of traffic.

[5]If disposal costs were calculated, recycling of materials would become more cost-competitive.

Furthermore, FHWA officials noted that to be effective, state pavement management systems need to recognize traffic volume and load analysis for specific routes. Yet FHWA officials said that very few state highway agencies can produce data on load analysis. Since collecting load data on a route-specific basis is more expensive than the existing process for collecting traffic information, FHWA officials stated that it is not known if the additional expense (which has not been calculated for each state) is justifiable. Nevertheless, the research that FHWA has already sponsored demonstrates that substantial savings can be realized through site-specific traffic data.

FHWA's Policy Guide recommends refinements in traffic data through the use of weigh-in-motion and automatic vehicle classification technologies.[6] Specifically, the guide suggests that states purchase and use these technologies for collecting traffic data to improve the current base traffic data used to forecast future truck volumes and loads. In discussions with officials in nine states,[7] we found that all of the states had improved or planned to improve their capabilities to collect traffic data through weigh-in-motion or automatic-vehicle classification technology. However, states generally continued to rely on data on statewide, regional, or corridor traffic, rather than site-specific data, when developing highway designs, especially when determining traffic loads.

While data averages for statewide, regional, or corridor traffic are often all that states have available, such average data can result in sizable errors in estimating the traffic at a particular site. Sizable errors in traffic forecasting can be quite costly, as they can lead to a misallocation of resources. If traffic is overestimated, it could lead to the construction of thicker, more costly pavement than needed. Conversely, an under investment occurs when major repairs are needed prematurely because the highway was designed to support less traffic that actually materialized. A 1988 FHWA-sponsored study illustrated the effect with an example from Washington state.[8] Approximately $6.6 million could be misallocated in a 2-year period, the study estimated, if planned overlay projects to cover

[6]Weigh-in-motion systems utilize a measuring device that estimates a moving vehicle's weight and the portion of that weight that is carried by each wheel, axle, or axle group and classifies the vehicle by axle configuration. Automatic vehicle classifiers record the continuous passage of vehicles across a given section of roadway by type and axle configuration using computerized electronic equipment.

[7]California, Illinois, Kentucky, Michigan, Mississippi, New York, Oregon, South Carolina, and Washington.

[8]Harshad R. Desai, et al., Traffic Forecasting for Pavement Design, FHWA (Mar. 1988).

1,200 miles of highway were under- or overdesigned by as little as one-quarter inch.

The cost of using imprecise traffic data was also illustrated in one of the states we visited. Mississippi constructed a concrete pavement between 1986 and 1988 that had an expected design life of 20 years. Within approximately 3 years, the pavement began to show premature distress. A 1990 state investigation faulted the quality of construction but noted that poor traffic predictions contributed to the problem. Current traffic data indicate that traffic levels have increased about 70 percent above the design estimates. The investigation concluded that the state had not accurately predicted the weight of the trucks that actually used the highway.[9]

Studies have demonstrated the benefits that could be realized through the use of site-specific traffic data. For instance, a 1991 FHWA-sponsored study showed that dramatic improvements could be realized through the use of site-specific data,[10] as the research found that states could realize (1) a 30-percent improvement in the accuracy of traffic forecasts by determining the number, type, and weight of trucks by manually counting them over a 24-hour period or (2) an improvement of over 85 percent by using weigh-in-motion technology over a 1-week period. The study also described the cost of such data collection and the size of project for which this type of data would prove cost-effective, as shown in table 4.1.

Table 4.1: Costs and Benefits of Site-Specific Traffic Data

Data collection method	Cost of data collection	Break-even size of project
24-hour manual count	$550	$248,000
Week-long weigh-in-motion session	$2,790	$543,000

Source: Based on data in Traffic Load Forecasting for Pavement Design.

[9]Mississippi has subsequently modified its techniques for forecasting traffic.

[10]Anthony J. Vlatas and George B. Dresser, Traffic Load Forecasting for Pavement Design, Texas A&M University (Aug. 1991).

Quality Control/Quality Assurance Programs Could Help States

States can also potentially improve the quality of the pavement design and construction of their highway projects through quality control/quality assurance (QC/QA) programs. First, in the quality control stage, the contractor is responsible for testing the construction materials before they are mixed and after they are placed on the roadbed. The tests are conducted to ensure that the materials meet state-prescribed standards. Second, in the quality assurance stage, the state assesses the quality of the contractor's work. For example, the state would randomly take samples of the mix and pavement and determine if the contractor had met agreed upon standards for density, asphalt content, and aggregate gradation.

Slightly over half of the states we visited did not routinely use QC/QA for their asphalt pavements. Of the nine states we contacted, four used QC/QA on all or nearly all of their asphalt pavements, and five states used this approach on asphalt pavements on a pilot basis.

The use of QC/QA is even less common for concrete pavements. In this case, only one of the nine states we contacted used this approach on all or nearly all of its concrete pavements. Three states used QC/QA on an experimental basis on their concrete pavements, and the remaining five states did not use it at all for concrete pavements.

Resource and technical reasons were the primary obstacles noted by state officials for not using QC/QA with concrete pavements. State transportation officials stated that contractors often do not have the equipment and/or trained staff required to do the testing. One state official also mentioned technical obstacles, including uncertainty about which pavement characteristics to measure and what test methods were best.

States using QC/QA provided some examples of improved pavement quality as a result of using the procedures. For example, Oregon evaluated the costs and benefits of its QC/QA program for asphalt, and found that pavements were better compacted and had lower moisture contents after the program was implemented. The state estimated that the improvement in pavement compaction alone would increase pavement life by 16 percent, requiring only a nominal cost increase to cover bonuses for contractors who surpassed the standards that had been set.

In 1989, FHWA recommended that a QC/QA approach be established for the processing and production of highway pavement materials, construction inspection, and maintenance operations. At that time, there was no national information or guidance on what an acceptable QC/QA program

would entail or on what properties of the materials should be measured. Since then, AASHTO and its western division, WASHTO (Western Association of State Highway and Transportation Officials), have taken the lead in developing and disseminating guidance on QC/QA.

In 1991, WASHTO published a QC/QA implementation guide—a step-by-step discussion of how to establish a successful program. In 1993, AASHTO expanded on WASHTO's guide, publishing the Quality Assurance/Quality Control Specifications and Implementation Guide to assist states in adopting such a program. This guide identifies characteristics of asphalt and concrete materials—roadway density, smoothness, and strength—that states should consider when developing their programs.

In addition, FHWA sponsored a quality management workshop for highway industry managers in late 1990. The results of this workshop, together with concurrent AASHTO quality initiatives, resulted in the formation of a National Quality Initiative (NQI), a partnership of FHWA, AASHTO, and various industry associations. The NQI is geared to making a continuing commitment for quality products, information, and services to enhance highway design and construction. One of the major objectives of this initiative is to promote quality through proper design, construction specifications related to performance, adherence to specifications, use of quality materials, use of qualified personnel, and sufficient maintenance. NQI efforts geared to furthering this objective include research on performance-related specifications and guidance on QC/QA programs.

Strategic Highway Research Program (SHRP) research will also benefit states implementing QC/QA programs. For example, SHRP developed a number of advanced testing procedures to measure the performance characteristics of asphalt and concrete pavements. One example is test equipment and procedures to more precisely measure the water content of fresh concrete. The correct water content in the mix is a key determinant of the concrete's quality, since it affects the durability of the hardened concrete.

Tests to Determine Materials' Elasticity Could Aid in Improving Design

FHWA's Federal-Aid Policy Guide encourages states to become familiar with the concept of resilient modulus and its application in the pavement design process. Resilient modulus tests allow engineers to predict pavement deterioration as a function of traffic and environmental conditions. The tests measure a material's elasticity or ability to withstand an applied pressure without permanently deforming. Traditionally,

pavement engineers have characterized soils and pavement materials through empirical strength tests rather than tests of elasticity. Strength tests identify the amount of stress that a material can withstand before breaking apart or rupturing. However, elasticity tests provide more useful information, since highway pavements generally do not suddenly break apart or rupture but slowly rut or crack as heavy trucks pass over the pavement.

Information from resilient modulus testing could help states in designing their pavements. Unlike empirical tests that require historical knowledge, resilient modulus tests of the material properties simulate field conditions and can be used to help a pavement design engineer predict the performance of new materials that have not been used before. The resilient modulus tests also allow engineers to evaluate the performance of traditional materials under new conditions, such as increased truck axle weights.

While a number of researchers and AASHTO support resilient modulus as the definitive method for characterizing the suitability of materials in pavement design and construction, practical application of resilient modulus testing has been slow. A 1993 report from the National Cooperative Highway Research Program found that only 10 states had incorporated resilient modulus or material elasticity testing to characterize roadbed soils in their pavement design processes. Most states continued to use strength tests to characterize the properties of materials. State and FHWA officials cited several reasons for slow adoption of resilient modulus testing: (1) problems with the accuracy of test methods for determining resilient modulus, (2) the extra costs associated with laboratory equipment, and (3) the increased time required to adequately perform the tests for a project.

These impediments may be eased through SHRP's efforts. As of May 1994, the research and development of new resilient modulus test procedures and equipment is nearly complete through projects undertaken as part of SHRP. AASHTO adopted SHRP's new test method for determining the resilient modulus of soils and aggregates and is waiting to review SHRP's test method for determining the resilient modulus of asphalt pavement materials. However, the rate or extent that states will adopt resilient modulus testing in the future remains unknown. FHWA stated that upon completion of the current research efforts, it will undertake implementation of the resilient modulus procedure as part of the SHRP implementation program.

Conclusions

Not all states are ensuring the cost-effectiveness of their highway investment decisions by using important tools such as life-cycle costing to decide between concrete and asphalt pavements or to examine rehabilitation strategies. FHWA officials expect this technique to be more widely used in the future because the agency is requiring that states' pavement management systems use LCCA to set priorities for projects for major highways. To date, however, FHWA estimates most states do not produce a multiyear list of recommended projects, ranked by priority, using LCCA.

Furthermore, when the states that do use LCCA omit factors such as user and maintenance costs from the analysis, the results are skewed because all costs are not considered. Thus, the usefulness of such analysis in identifying the design alternative that will provide a satisfactory level of service at the lowest cost over time is undermined.

FHWA is aware of states' problems in quantifying LCCA-related costs and plans to issue a policy statement in the summer of 1994 laying out its position on some of the more common technical issues associated with this technique. If this policy statement provides clear guidance on the (1) types and size (dollar amount) of projects that would benefit from LCCA, (2) the factors that constitute a complete analysis, and (3) the discount rate that should be used, then FHWA's policy statement would clarify federal requirements and address some of the concerns that states have raised. Moreover, linking such policy guidance to a research program would address the range of problems that states face in effectively using life-cycle costing, such as the difficult issue of quantifying user costs.

Improving traffic projections through the use of site-specific data could also enhance the quality of highway designs, making them more accurately reflect design requirements for the traffic that will use the highways. Using data from larger geographic areas can result in highways that are either overdesigned or underdesigned based on the extent to which the actual traffic patterns at the site differ from those described by the data. While collecting site-specific data may not be warranted in all cases, studies have shown that doing so is cost-effective for some projects. Guidance could provide a benchmark for when collecting such data would be cost-effective. For instance, it could be determined that site-specific traffic data are generally warranted for all highway projects over a specified dollar threshold.

Recommendations to the Secretary of Transportation

We recommend that the Secretary of Transportation direct the FHWA Administrator to

- issue guidance to states on factors to be considered as part of life-cycle cost analysis, such as setting priorities for projects over multiyear periods; establishing acceptable value ranges, particularly for social and other nontraditional costs like pollution, congestion, and fuel usage; and refining maintenance costs and salvage values and
- issue guidance on the type and size (dollar amount) of highway projects that warrant collection of site-specific data when a highway project is being designed.

Agency Comments and Our Evaluation

DOT partially concurred with our proposed recommendations concerning life-cycle costing and the need for site-specific traffic data in selecting pavement design. The Department noted that an FHWA working group is preparing an action plan for addressing issues related to applying LCCA to highway planning and construction. The working group is expected to provide guidance, which may include suggestions on appropriate LCCA values for, among other things, user costs, discount rates, salvage values, and the useful life of pavements. Guidance may also be provided on how to estimate factors such as sources of information and default values or ranges for various types of highway projects.

We credit DOT with moving to strengthen life-cycle costing in a number of areas and recognize that work continues in this field. We would encourage the Department, however, to be bolder and more definitive when it provides guidance. Federal guidance that "may include suggestions" on appropriate LCCA values for user costs, discount rates, salvage values, and the useful life of pavements may not provide states with a clear picture to guide them in their use of LCCA for various highway projects.

DOT concurred in part with our proposed recommendation that guidance be issued concerning site-specific traffic data. The Department noted its intent to evaluate the states' pavement design procedures in the next 2 years. The evaluation will include procedures for estimating and forecasting traffic. Thereafter, the Department will determine whether specific guidance is needed in this area. We believe that this planned action will lay the groundwork for satisfying our recommendation.

Comments From the Department of Transportation

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

U.S. Department of Transportation

Assistant Secretary for Administration

400 Seventh St., S.W.
Washington, D.C. 20590

August 1, 1994

Mr. Kenneth Mead
Director, Transportation Issues
U.S. General Accounting Office
441 G Street, N.W.
Washington, D.C. 20548

Dear Mr. Mead:

Enclosed are two copies of the Department of Transportation's comments concerning the U.S. General Accounting Office draft report titled, "Highway Infrastructure: Quality Improvements Would Safeguard Billions of Dollars Already Invested," RCED-94-198.

Thank you for the opportunity to review this report. If you have any questions concerning our reply, please contact Martin Gertel on 366-5145.

Sincerely,

for Paul Weiss
Jon H. Seymour

Enclosures

DEPARTMENT OF TRANSPORTATION REPLY

TO

GENERAL ACCOUNTING OFFICE (GAO) DRAFT REPORT

ON

"HIGHWAY INFRASTRUCTURE:

Quality Improvements Would Safeguard Billions of Dollars Already Invested"
RCED-94-198

SUMMARY OF GAO FINDINGS AND RECOMMENDATIONS

The GAO reviewed states' experience with warranties in highway construction contracts, identified ways to provide adequate maintenance for Federal-aid highways, and examined several methods intended to improve pavement design selection. The draft report concluded that because warranties have received limited application, it was difficult to assess their associated costs and benefits. In addition, the draft report states that while the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 authorized the use of Federal funds for preventive maintenance on Federal-aid highways, four of the six states GAO visited did not plan to utilize these funds for maintenance primarily because the funds were needed for capital spending. Finally, the draft report maintains that the use of methods such as life-cycle cost analysis (LCCA) could improve pavement designs.

The draft report recommends that the Secretary of Transportation direct the Federal Highway Administrator to take the following actions:

- Issue formal policy guidance to ensure that all state departments of transportation are aware of the instances in which warranties may now be used.
- Develop and disseminate to the Federal Highway Administration (FHWA) region and division offices model warranty terms for individual types of projects, such as bridge painting and rubberized asphalt pavement overlays.
- Provide guidance on the use of Federal funds for preventive maintenance that would include: (1) clarification on when and under what circumstances a state can use Federal funds to pay for work performed by state maintenance personnel, (2) the type of data justification that would allow a state to use funds for preventive maintenance if a state's pavement management system does not capture such information, and (3) instructions on how maintenance activities could be packaged into one funding request.

- Work with the states to develop performance measures, such as pothole depth and width, to be used in determining the adequacy of state maintenance efforts.
- Issue guidance to states on factors to be considered as part of LCCA.
- Issue guidance on the type and size (dollar amount) of highway projects that warrant collection of site-specific data when a highway project is being designed.

DEPARTMENT OF TRANSPORTATION POSITION

The Department agrees with GAO's draft report concerning the importance of maintaining the quality of our nation's highways. We further agree that it is imperative for investments in highways built with Federal funds to be cost effective. The draft report does an excellent job of documenting the state highway agencies' (SHA) limited experience with warranties and in addressing factors likely to influence states' use of highway projects warranties. Additionally, we agree that SHAs should be encouraged to increase the timely use of preventive maintenance techniques, and we will continue to promote this concept. However, the selection of projects and the determination of which projects should be submitted for approval as Federal-aid projects remains an SHA prerogative. The Department also appreciates the recognition given in the draft report to the ongoing efforts within FHWA to improve the application of LCCA for highway programming and project decisions. The Department is committed to protecting the nation's investment in highway infrastructure and improving highway quality. We maintain that this can best be accomplished by continuing our tradition of fostering a cooperative partnership with SHAs.

RESPONSE TO GAO DRAFT REPORT RECOMMENDATIONS

Recommendation: Issue formal policy guidance to ensure that all state departments of transportation are aware of the instances in which warranties may now be used.

See comment 1.

Response: Concur. This recommendation was addressed in an April 22, 1994, addendum, Transmittal 10, NS 23 CFR 635D, to the Federal-Aid Policy Guide (FAPG). The updated FAPG provides guidance to SHAs regarding the use of warranties on exempted non-National Highway System (NHS) projects. Guidance on evaluating warranties for NHS projects under Special Experimental Project No. 14 (SEP 14) is also included in the FAPG. In addition, the guidance requests that SHAs share their warranty experiences on exempted non-NHS projects.

Recommendation: Develop and disseminate to FHWA region and division offices model warranty terms for individual types of projects, such as bridge painting and rubberized asphalt pavement overlays.

See comment 2.

Response: Concur-in-part. As a general rule, FHWA prefers not to develop standard or model specifications for SHAs. Rather, we provide guidance and assistance to the SHAs and in some instances industry. Typically, SHAs are encouraged to develop draft warranty provisions that meet their perceived needs. The draft warranty provisions are reviewed by the FHWA to assure that items such as those mentioned in the GAO draft report, are properly addressed. Any suggested revisions are provided to the SHA for consideration in the final warranty. Examples of warranty provisions developed through this process include California's rubberized asphalt pavement specification, Michigan's bridge painting specification, and Montana's pavement marking specification. The final warranty provisions are then shared with other SHAs that indicate interest in using and evaluating warranties under SEP 14.

Now on p. 32.

As noted on page 37 of the draft report, the FHWA has made an exception to this process. At the request of the International Slurry Surfacing Association, FHWA in conjunction with industry and SHA representatives, developed a guide warranty specification for micro-surfacing.[1] Micro-surfacing is a technique that may have application to Federal-aid projects; however, many of the SHAs have not used nor have they developed specifications for the product. Due to this lack of familiarity with micro-surfacing, FHWA determined that providing an extra level of assistance to SHAs was warranted. The guide specifications have been finalized and were distributed to the SHAs through FHWA field offices on June 24 . SHAs will have flexibility to modify the guide specifications as necessary to fit their particular program.

Recommendation: Provide guidance on the use of Federal funds for preventive maintenance that would include:

(1) clarification on when and under what circumstances a state can use Federal funds to pay for work performed by state maintenance personnel,

(2) the type of data justification that would allow a state to use funds for preventive maintenance if a state's pavement management system does not capture such information, and

(3) instructions on how maintenance activities could be packaged into one funding request.

See comment 3.

Response:

(1) Concur. FHWA provided regulatory procedures concerning the use of force account versus competitive contracting for work on Federal-aid projects in

[1]Application of a thin layer of asphalt emulsion and aggregate mixture.

23 CFR 635, Subpart B.[2] The requirement for a determination of cost effectiveness prior to approving highway work by force account is contained in §635.204. FHWA division offices and the SHAs are already aware that work performed by state maintenance personnel could be approved for Federal-aid under force account procedures. In order for this work to be approved, the state must submit a request to the FHWA Division Administrator providing the reasons that the use of force account rather than competitive contracting, is considered to be cost effective.

See comment 4.

(2) Concur. The FHWA has provided guidance through memoranda, its electronic bulletin board, and professional groups such as the American Association of State Highway and Transportation Officials to describe the type of justification that would allow a state to use Federal funds for preventive maintenance. The FHWA has issued several memoranda that include information on eligibility for preventive maintenance activities. In addition, as a part of the 1991 ISTEA implementation process, we answered two questions concerning preventive maintenance eligibility on the FHWA ISTEA Electronic Bulletin Board which is available to the SHAs.

One of the responses on the bulletin board captured the essence of FHWA's direction on the use of interstate maintenance funds for preventive maintenance. It said that the intent of this section of ISTEA is to promote preservation of the Interstate System through increased preventive maintenance activities. Although not specifically stated in ISTEA, we maintain that it also sought to encourage SHAs to integrate pavement management, bridge management, and maintenance management systems into a program which will better ensure the preservation of the Interstate System. If a state's pavement management system, whether or not that system fully meets the requirements outlined in Title 23, Code of Federal Regulations, can identify cost-effective preventive maintenance activities; those activities may be eligible for Federal-aid funding. Further, in those states which have an ongoing preventive maintenance program, the activities which are a part of the ongoing program may also be eligible. The guidance directed field offices to work with SHAs to promote improved interstate pavement preservation and provide as much flexibility as possible to approve those activities which are generally accepted as both preventive in nature and cost effective.

See comment 5.

(3) Concur. The FHWA has and will continue to work with SHAs on developing area-wide maintenance construction projects covering counties, state highway districts, or the entire state. These area-wide projects have included both competitive contracting

[2]The term force account means the direct performance of highway construction work by an SHA, a county, a railroad, or a public utility company by use of labor, equipment, materials, and supplies furnished by them and used under their direct control.

and force account contracting work. Some examples of work which has been approved in the past for area-wide application include area-wide paint striping projects, railroad-highway grade crossing projects, and traffic sign replacement.

Recommendation: Work with states to develop performance measures, such as pothole depth and width, to be used in determining the adequacy of state maintenance efforts.

See comment 6.

Response: Concur-in-part. We agree that there is a need for states to adequately maintain highway infrastructure, and FHWA has been working with states for some time to develop improved maintenance management practices and techniques. However, we maintain that requirements of the Interstate Maintenance Guidelines and current FHWA maintenance policies provide sufficient guidance to determine the adequacy of state maintenance activities while leaving enough flexibility to recognize necessary differences between individual state programs, capabilities, and needs. Additional performance measures are not necessary to determine the adequacy of state maintenance activities.

Since 1988, FHWA has required states to develop pavement management systems to select, design, and manage highway pavements in a cost-effective manner. Pavement management systems are intended to assist states in assessing system maintenance adequacy as well as the adequacy of various construction and rehabilitation treatments in preserving pavement serviceability. The states are using several criteria to assess pavement conditions and analyze maintenance and rehabilitation techniques. Rather than focus on the size of individual potholes and the spatial distribution that would warrant corrective application, states are developing a comprehensive set of evaluation factors. Specifically, pavement management systems assess several surface condition indicators including rutting, cracking, faulting, and skid resistance as well as loading history and other environmental factors. Analyses of these and other factors such as traffic growth and truck size and weight changes, will yield information for use in budget formulation, system efficiency determinations and identification of appropriate maintenance and rehabilitation proposals. Pavement management systems will assist in formulating plans for optimum treatments ranging from preventive maintenance to more complex rehabilitation and reconstruction.

Recommendation: Issue guidance to states on factors to be considered as part of LCCA.

See comment 7.

Response: Concur-in-part. The FHWA LCCA working group is preparing an action plan to map out its strategy for addressing issues related to applying LCCA to highway planning and construction. As presently envisioned, the group will be preparing technical advisories and training courses to provide guidance to the states on techniques, procedures, and advice on appropriate values to be used in LCCA. The group will attempt to synthesize relevant information, define the state-of-the-art, and

address knowledge gaps in areas such as predicting performance lives, quantifying user, social and environmental costs, and integrating safety assurance considerations. The group intends to develop technical advisories that provide simplified procedures and examples of good practice for applying LCCA in all program areas such as pavements, bridges, planning, environment, policy, and safety. Guidance may include suggestions regarding appropriate LCCA values for areas such as user costs, discount rates, salvage values, and useful lives. Guidance may also include assistance on how to estimate factors including sources of information and default values or ranges for new construction, maintenance, rehabilitation, reconstruction, restoration, and resurfacing existing facilities.

See comment 8.

Recommendation: Issue guidance on the type and size (dollar amount) of highway projects that warrant collection of site specific data when a highway project is being designed.

Response: Concur-in-part. The Department concurs with the need to address the type of traffic data used for pavement design. During the next 2 years, FHWA will be evaluating the SHAs' pavement design procedures. During this evaluation, emphasis will be placed on states' traffic estimating and forecasting procedures. At this point, FHWA has not determined that the decision to collect site specific data for a particular project will be a function of the type and size of the project or consideration of the adequacy of the network or system information for a specific site. Additional analysis will be needed before specific guidance can be issued.

6

Attachment I

SPECIFIC COMMENTS

The Department offers the following specific comments regarding statements in the draft report.

See comment 9.
Now on p. 3.

- **Page 2, last paragraph,** states that "For certain categories of principal highways, less than half are considered in good condition." The FHWA's 1993 Report to Congress entitled "The Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance," page 105, Exhibit 3-11, shows that of the 5 categories of principal arterials, only 1, identified as "Urban Other Principal Arterials," had less than 50 percent of mileage with good pavement condition. The categories of "Rural and Urban Interstate," "Urban Other Freeways and Expressways," and "Rural Other Principal Arterials," all contain more than 50 percent mileage of pavement in good condition. For both rural and urban Interstate, the percentage of pavement mileage in good condition is 60 percent or more.

See comment 10.
Now on p. 32.

- **Page 37, paragraph 2, sentences 3 and 4,** require the following technical corrections:

  In conjunction with the International Slurry ~~Seal~~ [redacted] Association . . . applications of ~~slurry seals~~ [redacted] . . . [redacted] thin layers of a mix[redacted] of asphalt emulsion and ~~fine~~ aggregate. The objective . . . ~~a ready-made set of~~ [redacted] warranty ~~terms~~ [redacted] that states could [redacted] implement ~~a~~ with minimum ~~of~~ effort.

I-1

The following are GAO's comments on the Department of Transportation's (DOT) letter dated August 1, 1994.

GAO's Comments

1. In response to a proposed recommendation in our draft report that called for issuing formal policy guidance on the instances in which warranties may be used, DOT concurred with the recommendation and said it had addressed the issue with an April 22, 1994, addendum to the Federal-Aid Policy Guide. Accordingly, we have deleted the proposed recommendation from our report. However, since the thrust of our proposed recommendation was to ensure that responsible personnel in state departments of transportation were apprised of the change in policy on warranties, in August 1994 we recontacted engineering and contracting staff from four of the states in our review. We found that among these officials, the substance of the Federal Highway Administration's (FHWA) clarification of the policy was still generally unknown. This finding is a reminder that the duty of ensuring that such information filters through to key personnel responsible for implementing such changes is a shared one. It lies not only within the headquarters offices of FHWA but also with regional and division officials who serve as the main conduit of information and with the respective state departments of transportation.

2. Although DOT notes that FHWA prefers not to develop model or standard specifications, the Department elected to make an exception in the case of a procedure—microsurfacing—with which states were generally unfamiliar. As noted in our report, states are often most inclined to try warranties in the context of unfamiliar types of projects. We believe that microsurfacing is just one of a number of processes that are relatively new to most state transportation agencies; another example is rubberized asphalt pavement overlays. We believe that the use of new processes and products resulting from recent research might provide another opportunity for FHWA to assume an activist role in developing model warranty provisions in cooperation with state departments of transportation. We note that such warranty provisions need not be unduly prescriptive. As DOT points out, the recently issued microsurfacing specifications may be modified as necessary by the states to meet their individual needs. Thus, in our opinion, the development of certain model specifications need not deprive states of their ability to tailor such specifications to their own circumstances. Furthermore, we have modified our recommendation to acknowledge that FHWA's development of guide specifications would be done in cooperation with state agencies.

3. DOT asserts that FHWA's division offices and state maintenance personnel are already aware that work performed by state maintenance personnel could be approved for federal-aid funding under force account work.[1] We found, however, that some FHWA division officials and state representatives were uncertain, or had reservations, about whether federal funds could be used to reimburse a state for work performed by state maintenance personnel. Given this confusion and uncertainty, we continue to believe that further clarification is warranted.

4. We believe that the type of guidance DOT is describing here provides a broad framework for the justification a state needs in order to use federal funds for preventive maintenance work. Nevertheless, we believe additional guidance is needed because (1) some states do not believe that they have any data that could be used to justify the cost-effectiveness of preventive maintenance work and thus allow them to use federal funds for such work, (2) only about half of the states currently have pavement management systems that are able to justify the cost-effectiveness of preventive maintenance strategies, and (3) some states do not have a preventive maintenance program.

5. We recognize there have been instances in which FHWA has worked with states in developing areawide maintenance projects. We further believe that publicizing such work may facilitate similar action in other states and increase the use of federal funds for preventive maintenance work. To emphasize that our recommendation is aimed at getting the word out on how states can package maintenance activities into one funding request, we have modified the wording of the recommendation from providing "instructions" to providing "advice" on how this packaging can be accomplished.

6. Although DOT maintains that existing guidelines and maintenance policies are sufficient for FHWA to determine the adequacy of states' maintenance, we observe that the guidance lacks specificity in a number of areas. For instance, if maintenance deficiencies are statewide, the guidance says that it would be "desirable" to highlight those deficiencies considered to be of statewide significance to assist in planning future monitoring and follow-up activities.

In addition, FHWA's guidance groups maintenance deficiencies into one of four classes, the first class being safety. The guidance states that timely

[1]Force account refers to the use by a public agency or utility of its own personnel and equipment for construction work.

response and/or correction of safety deficiencies should be the foremost concern of highway maintenance, but no insight is provided on what is meant by timely. This omission seems particularly surprising given that federal legislation provides that if maintenance is not adequate, a state should be notified that corrective action must be accomplished within 90 days. If the 90-day deadline is not met, the Secretary of Transportation must withhold approval of further federal-aid highway projects of all types for the entire state or for a particular area within the state until proper maintenance is achieved.

Furthermore, FHWA's guidance provides examples for the four classes of maintenance deficiencies. In the first class of deficiencies—safety-related deficiencies—FHWA's guidance lists a number of examples, such as missing signs and signals, inadequate roadway delineation, and severe pavement distress in the form of potholes, depressions, and ruts. The guidance notes, however, that these are not the types of problems routinely found on the federal-aid system. Yet we observe that these appear to be common maintenance problems identified in state and FHWA maintenance reports. However, such reports are generally silent on whether the severity and frequency of the deficiency is enough to support a finding of inadequate maintenance. Without such a finding, there is no basis for pursuing the legislatively provided remedy.

While FHWA's maintenance guidance is not prescriptive, we found that it is not being systematically followed. Moreover, maintenance deficiencies identified by FHWA can linger unresolved for lengthy periods of time, with no strategy developed for corrective action and no timeframe set for resolving the deficiencies. To correct this situation and buttress FHWA's existing maintenance guidance and policies, we believe that maintenance performance standards and expectations need to be established. We have clarified the recommendation to underscore our view that performance expectations, including specific timeframes for corrective action, need to be established and that these standards and expectations need to reflect the severity and safety impact of the maintenance problems.

7. We recognize the Department is moving to strengthen life-cycle cost analysis (LCCA) in a number of areas and that this effort is continuing. We would encourage the Department, however, to be bolder and more definitive when it provides guidance. Federal guidance that "may include suggestions" on appropriate values for user costs, discount rates, salvage values, and the useful life of pavements may not provide states with a clear picture to guide them in their use of LCCA for various highway projects.

8. We believe this planned action will lay the ground work for satisfying our recommendation.

9. We revised the relevant passages to reflect the substance of DOT's comment.

10. We made DOT's suggested technical corrections.

States Consider Alternative Innovative Contracting Approaches

While the prospect of highway warranties has attracted especially pronounced attention over the past few years, warranties are but one item on a large menu of innovative contracting approaches that states are considering. Some approaches aim to speed the process of construction; others seek to improve the quality of design and construction. Many of these approaches came to the forefront as a result of the efforts of a task force on innovative contracting practices that was convened by the Transportation Research Board (TRB) in 1987.[1] The task force's findings formed the basis for FHWA's decision to establish Special Experimental Project 14 (SEP 14). This appendix describes the three principal procurement methods being tried under SEP 14 as well as other alternatives.

Experimental Approaches Authorized for Evaluation Under SEP 14

In addition to warranties, states have experimented with three other types of innovative contracting methods under SEP 14. Two of these approaches—lane rental and cost-plus-time bidding—principally seek to reduce the duration of the construction process. The objectives of the third approach, known as design/build, are to (1) improve the efficiency of the design and construction process by permitting certain activities to occur concurrently and (2) foster maximum flexibility in the selection of innovative designs, materials, and construction techniques.

Lane Rental and Cost-Plus-Time Bidding

Under the formulation considered by FHWA most adaptable to the United States, lane rental provides for charging the contractor a specified amount, based on road user costs, for the period during which the contractor occupies part of the highway for the purpose of construction. Under cost-plus-time bidding (also known as A+B bidding), the successful low bid is determined as a combination of cost of construction and the cost associated with the expected duration of construction. (This formula is only used to determine the lowest and best bid and is not used to determine how much the contractor is paid.) According to FHWA, as of March 1993 four states had launched one or more projects involving the lane rental concept. Sixteen states and the District of Columbia were experimenting with one or more projects that use the cost-plus-time approach.

[1]The task force issued its report, Innovative Contracting Practices (Transportation Research Circular No. 386), in Dec. 1991.

Design/Build

Additionally, SEP 14 permits states to try an innovative contracting approach known as design/build. This method of procurement departs from the traditional separation of responsibility for the design and construction of a project. Instead, both functions are combined in a single contract. As envisioned by FHWA, under a design/build contract, the state highway agency identifies the desired end results and establishes minimum design criteria. Prospective bidders prepare proposals encompassing both the design and construction of the project, and the state highway agency subsequently selects the successful bid on the basis of a combination of factors, including the quality of the design, the delivery time, and the cost. According to FHWA, as of March 1993, five states and Puerto Rico had initiated design/build highway contracts.

Additional Alternative Methods of Procurement

Aside from the experimental approaches that states are trying under SEP 14, states may consider a wide array of other innovative methods of procuring highway construction services. The National Quality Initiative, a government-industry partnership devoted to raising awareness of technical and procedural approaches to the quality of highway design, construction, and operations, is one mechanism by which information on some of these contracting methods is being disseminated.

One approach for states' consideration is known as quality control/quality assurance (QC/QA). QC/QA provides contractors with greater flexibility in determining the construction processes they use as well as greater responsibility for the resulting outcomes. As detailed in chapter 4, QC/QA contracts hold contractors responsible for their own quality control activities (e.g., testing the characteristics of the asphalt mix). The state performs quality assurance tests to determine whether the product meets the performance characteristics outlined in the contract. The QC/QA approach can be coupled with provisions for adjusting payments to reward or penalize contractors for a given project's conformance to the desired quality levels. For the process to work successfully, the performance characteristics sought in the contract must be both measurable and clearly linked to the actual quality and durability of a project.

Another approach under consideration is prequalification, in which a state highway agency may evaluate contractors on the basis of quality indicators and performance factors before selecting a contractor on the basis of the bids that are ultimately submitted. Typically contractors already face a type of prequalification when they obtain bonding because surety

underwriters assess contractors' stability and fiscal capability of undertaking a job of the anticipated magnitude of the project in question. Prequalification goes a step further by permitting a state highway agency to compare competing contractors on the basis of their past performance.

States are also using an approach known as partnering to improve the contracting process. Under a partnering agreement, participants in a project form a cooperative team to identify common goals and resolve disagreements; the objective is to minimize the adversarial relationship that can develop in the course of a problematic construction project. With an emphasis on participatory dispute resolution, partnering aims to minimize the use of litigation as a means of resolving conflicts. By fostering a cooperative atmosphere, partnering also has the potential to improve the climate for warranties by ensuring that all parties to the warranty are fairly represented in developing equitable specifications and by minimizing the chances that misunderstandings will occur.

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