SEPTEMBER–OCTOBER 2003
NUMBER 228

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

TR NEWS

Preserving Highway Infrastructure

- Benefits, Issues, Barriers, and Toolboxes
- Strategies for Leveraging Limited Funds
- A Movement Driven by Partnerships
- Research Frontiers Opening to Safety
- Improving Conditions of Bridges
- Canada Assembles a How-To Guide

TR NEWS

NUMBER 228 SEPTEMBER–OCTOBER 2003

Highway Infrastructure Preservation

3 Introduction
Highway Infrastructure Preservation: Completing the Owner's Manual
Reconstruction, rehabilitation, and preventive maintenance—or a "mix of fixes" approach—are components of the new strategy to preserve the highway infrastructure with maximum cost-efficiency.

4 Principles of Pavement Preservation: Definitions, Benefits, Issues, and Barriers
Larry Galehouse, James S. Moulthrop, and R. Gary Hicks
Pavement preservation involves a variety of timely treatments and repairs—tailored to each highway agency's system needs—to extend the life of the asset at a relatively low cost.

10 Preserving Pavements and Budgets: California's Strategies Leverage Limited Funds
Susan Massey and Pattie Pool

12 Looking at Long-Term Results: Performance of Test Section After 13 Years
Gary Hildebrand and Scott Dmytrow

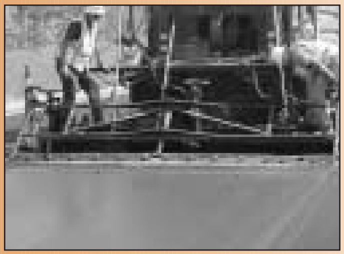
14 Protecting Roads in the Desert: Chip Sealing over Fabric Retards Reflective Surface Cracks
Lita Davis

16 Advancing the Pavement Preservation Movement: Federal Highway Administration Cultivates Partnerships
King W. Gee and Steve Mueller
The Federal Highway Administration is developing partnerships with other agencies, state and local governments, industry associations, and academia to support and direct the pavement preservation movement with engineering-based analytical tools and sensible economic guidelines.

19 University Center Paves the Way
Larry Galehouse

22 Research Frontiers in Pavement Preservation
Roger M. Larson, Larry Scofield, and James B. Sorenson
The new pavement preservation technologies may enable researchers to develop guidelines for the functional surface characteristics of pavements that maintain ride comfort but also contribute to reductions in fatalities and injuries, as well as in highway noise.

26 Improving the Condition of Bridge Networks: Michigan Crafts a Preservation Program
David A. Juntunen
Michigan's strategic investment plan for its network of trunkline bridges includes an important role for preventive maintenance.



4

16

26

Cover: Ultrathin bonded wearing course applied to California State Route 39 at night. The preventive maintenance technique is part of the toolbox for pavement preservation presented in this issue. (Photograph courtesy of G. Hildebrand.)

TR NEWS

features articles on innovative and timely research and development activities in all modes of transportation. Brief news items of interest to the transportation community are also included, along with profiles of transportation professionals, meeting announcements, summaries of new publications, and news of Transportation Research Board activities.

TR News (ISSN 0738-6826) is issued bimonthly by the Transportation Research Board, National Research Council, 500 Fifth Street, NW, Washington, DC 20001. Internet address: www.TRB.org.

Editorial Correspondence: By mail to the Publications Office, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001, by telephone 202-334-2972, by fax 202-334-3495, or by e-mail jawan@nas.edu.

Subscriptions: North America: 1 year $55.00; single issue $9.50. Overseas: 1 year $75.00; single issue $13.50. Inquiries or communications concerning new subscriptions, subscription problems, or single-copy sales should be addressed to the Business Office at the address below, or telephone 202-334-3216, fax 202-334-2519. Periodicals postage paid at Washington, D.C.

Postmaster: Send changes of address to *TR News*, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001.

29 Bridges to Innovation: Scanning Tour Gains International Pointers
Ian M. Friedland

30 Lengthening the Span of Bridge Service Life
Raymond McCormick

31 Tried-and-True Infrastructure in Canada: Guide Assembles Best Practices for Municipalities
Normand Levac, Jerry Hajek, and David Hein
Canada is assembling a National Guide to Sustainable Municipal Infrastructure, a compendium of best practices in planning, management, and construction, including roadway preservation.

35 TRB SPECIAL REPORT
Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles
Joseph R. Morris
In a Congressionally requested study, a TRB committee appointed by the National Research Council recommends organizational arrangements to promote reform of federal regulations for commercial motor vehicles, as well as changes to improve the efficiency of freight transportation and to reduce the public costs of truck traffic.

39 NEW TRB REPORT
Access Management Manual: TRB Committee Documents the State of the Art
Kristine M. Williams
Practical information on access management—the systematic control of the location, spacing, design and operation of driveways, median openings, interchanges, and street connections—is now available in a single, comprehensive resource.

41 Calendar

42 Research Pays Off
High-Capacity Piles
Confirming the Viability of Cost-Efficient Bridge Designs
Brian A. Liebich

44 Profiles
Transportation policy consultant William A. Hyman and civil engineering Professor John B. Metcalf

46 TRB Highlights
CRP News, 46

48 News Briefs
In Memoriam, 48

50 Bookshelf

CORRECTION: In the Point of View article by Christopher D. Grant, "Improving Urban Air Quality Requires Multimodal Measures" (July–August 2003, pages 22–25), Table 3 (page 23) mislabeled two rows of data for U.S. ton-miles by freight. The row labeled "Maritime" should have read "Rail"; the row labeled "Rail" showed the statistics for "Maritime." The correct source table is available on the web, http://www.bts.gov/publications/national_transportation_statistics/2002/html/table_01_44.html. Thanks to readers Lawrence J. Fabian and Jonathan Upchurch, who pointed out the editorial error.

COMING NEXT ISSUE

Transportation asset management, the challenge of livable cities, and more—plus TRB's 2003 Annual Report—are highlights of the November–December *TR News*.

INTRODUCTION

Highway Infrastructure Preservation

Completing the Owner's Manual

Responsible automobile and truck owners recognize the importance of properly maintaining their vehicles. Millions of dollars are spent each year for routine oil changes and for the more intensive and exhaustive preventive maintenance activities recommended by vehicle manufacturers. Owners generally accept these recommendations as necessary to extend the vehicle's trouble-free life and to maintain its safe operation.

Until recently, however, little was done nationally to apply the same principles to preserve the highway infrastructure on which the vehicles operate. During the Interstate era, highway agencies focused on new construction, with minimal attention to proactive measures to preserve highways and bridges. The reactive treatments that were applied to repair deteriorated pavements and structures were not necessarily the most cost-effective for the long-term condition of the infrastructure.

New construction no longer is the mainstay of the highway industry. The focus instead is on reconstruction, rehabilitation, and preventive maintenance—or a "mix of fixes" approach—to preserve the highway infrastructure with maximum cost efficiency.

This issue of *TR News* presents an overview of highway infrastructure preservation—what it involves, what is being done, and what needs to be done. The articles direct attention mostly to pavement preservation, the area of greatest activity—since pavement management already has become a standard practice. Bridge preservation, however, also has innovative efforts under way, as several articles report.

This theme issue is sponsored by the TRB Committee on Pavement Maintenance. Committee Chair Larry Galehouse and member Jim Moulthrop, who also chairs the TRB Bituminous Section, were instrumental in acquiring and assembling the variety of information presented in the following pages.

—Frederick Hejl, Engineer of Materials and Construction, and
Frank Lisle, Engineer of Maintenance
TRB Technical Activities Division

Principles of Pavement Preservation

Definitions, Benefits, Issues, and Barriers

LARRY GALEHOUSE, JAMES S. MOULTHROP, AND R. GARY HICKS

Galehouse is Director, National Center for Pavement Preservation, Michigan State University, Okemos; Moulthrop is Senior Consultant, Fugro-BRE, Austin, Texas; and Hicks is Principal, MACTEC, Sacramento, California.

Americans are accustomed to easy mobility on safe, smooth, and well-maintained roads. These same roads play a critical role in the nation's economy, bolstering agriculture, industry, commerce, and recreation.

During the 1990s, the nation's highways experienced a 29 percent increase in use, and more growth is expected in the next 10 years. Large commercial truck traffic increased by nearly 40 percent, with growth projected to continue at more than 3 percent per year during the next 20 years. In addition, more than 95 percent of personal travel is by automobile.

Increasing the capacity of highways, therefore, is important in meeting the nation's needs. But can the United States finance future highway capacity while addressing the needs of the current system? Yes—by developing a strategic plan that includes pavement preservation.

TABLE 1 Public Highway Ownership by Miles

Jurisdiction	Miles (Thousands)	Percentage
Federal	118	3.0
States	775	19.6
Local	3,055	77.4
Total	3,948	100.0

Economical Alternative

Pavement preservation gives highway agencies an economical alternative for addressing pavement needs. Moreover, with pavement preservation, highway agencies gain the ability to improve pavement conditions and extend pavement life and performance without increasing expenditures. The focus is on preserving the pavement asset while maximizing the economic efficiency of the investment. Pavement preservation provides greater value to the highway system and improves the satisfaction of highway users.

Pavement preservation is not about a single treatment, nor is it a one-size-fits-all philosophy. Instead, pavement preservation must be tailored to each highway agency's system needs in the most cost-effective manner. This involves using a variety of treatments and pavement repairs to extend pavement life.

According to the Federal Highway Administration (FHWA), the United States maintains nearly 3.95 million miles of public roads (*1*). Table 1 shows highway mileage by agency ownership. The problem facing highway agencies is that many roads are wearing out because of increased traffic, environmental effects, and a lack of proper maintenance.

Every highway agency must deal with the effects of regional environments on pavement performance, in addition to the effects of traffic. Pavement

sections originally projected to last many years can accumulate distress at an accelerated rate and fail prematurely. Most highway agencies experience and understand this problem but are daunted when budget allocations do not keep pace with the needs of highway pavement upkeep.

Toolbox Approach

In the past, many maintenance practices have not been effective, because they were applied reactively to roads in poor condition instead of proactively to roads still in good condition. Succinctly stated, the correct approach to preventive maintenance is to "place the right treatment on the right road at the right time."

Preservation became a topic in the early 1990s, when highway agencies examined effective maintenance practices. The preservation concept—whether for pavements or for bridges—is a departure from traditional approaches, which wait until deficiencies are evident and until reconstruction or major rehabilitation are the only means to correct the problem.

Preservation, however, addresses minor deficiencies early, before the defects become major problems, and extends the life of the asset at a relatively low cost. A strong preservation program is essential to asset management.

Because preservation activities include so many kinds of treatments, agencies should build their own preservation toolboxes to serve their particular needs. Just as a mechanic's toolbox contains many different tools, each designed for a specific job, a preservation toolbox should include a host of treatments to address specific conditions.

No treatment will be suitable for every location. For example, a chip seal may be a long-lasting, cost-effective surface treatment in a rural area, but not in a large urban area. Conversely, concrete ultrathin whitetopping may be cost-effective in a large urban area, but not in a rural area. Similarly, performance and cost-effectiveness should be evaluated in the context of the areas in which the preservation treatments are applied.

Definitions of Terms

A clear presentation of pavement preservation in the United States requires the development and adoption of standard definitions:

Asset Management

FHWA and the American Association of State Highway and Transportation Officials (AASHTO) define asset management as a systematic process of maintaining, upgrading, and operating physical assets cost-effectively (2). Asset management combines engineering principles with sound business practices and economic theory and provides tools to facilitate an organized, logical approach to decision-making. Asset management provides a framework for both short- and long-range planning.

Asset management is important to state and local governments because of the Governmental Accounting Standards Board's (GASB) Policy Statement 34, "Basic Financial Statements for State and Local Governments," issued in June 1999. GASB 34 encourages government agencies to promote asset management practices and to report the value of capital assets such as utilities, roadways, and other infrastructure (3).

The value and maintenance of these assets eventually affects the bond ratings of government agencies, which in turn affect the government's ability to bor-

Load transfer restoration on portland cement concrete pavement: (*left*) cutting a slot in the pavement; (*right*) inserting dowel.

Microsurfacing on Interstate 75 in Michigan—one of 14 pavement preservation techniques in FHWA's program.

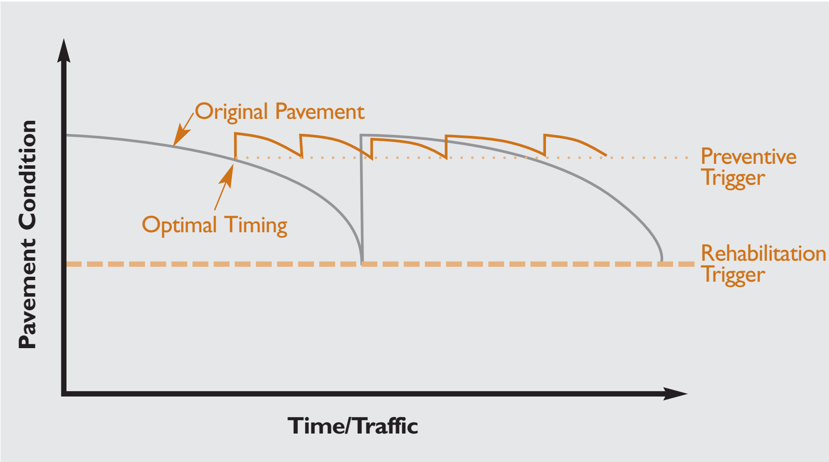


FIGURE 1 Pavement preservation concept.

row the money to repair and replace the investments. The objective of an asset management program, therefore, is to

- Consider various investment strategies,
- Provide a more rational decision process, and
- Improve the overall condition of the highway system at a lower cost.

Preventive Maintenance

According to AASHTO, preventive maintenance is a planned strategy of cost-effective treatments that preserves and maintains or improves a roadway system and its appurtenances and retards deterioration, but without substantially increasing structural capacity (3). Preventive maintenance is a tool for pavement preservation—nonstructural treatments are applied early in the life of a pavement to prevent deterioration. In other words, preventive maintenance applies the right treatment to the right pavement at the right time.

Pavement Preservation

Pavement preservation is the sum of all the activities to provide and maintain serviceable roadways, including corrective and preventive maintenance, as well as minor rehabilitation. The strategy does not include new pavements or pavements that require major rehabilitation or reconstruction.

A pavement preservation program aims at preserving investment in the pavement network, extending pavement life, enhancing pavement performance, ensuring cost-effectiveness, and reducing user delays. In short, the goal is to meet customer needs.

Reactive Maintenance

Reactive maintenance comprises activities that respond to conditions beyond an agency's control—activities such as pothole patching, rut filling, or unplugging drainage facilities. Reactive maintenance, therefore, is unscheduled; sometimes immediate response is necessary, to avoid serious consequences.

Emergency Maintenance

Extreme conditions, when life and property are at risk, require emergency maintenance. Examples include washouts, rigid pavement blowups (the shattering or upward buckling of concrete slabs along a joint), and rockslides or earthslides.

Establishing Values

Understanding the costs and benefits of pavement preservation is important because the nation's highway system has matured—that is, the system has begun to deteriorate. Preservation requires a customer-focused program to provide and maintain serviceable roadways cost-effectively, encompassing preventive and corrective maintenance, as well as minor rehabilitation (Figure 1).

The concept is gaining acceptance—initiatives in the business arena also are focusing on asset preservation, like the GASB policy emphasizing the preservation of infrastructure. GASB establishes requirements for the

TABLE 2 Traditional Alternative: Project Life Cycle Cost

ACTIVITY	D.I. (Before)	D.I. (After)	AGE	LIFE EXTENDED (Years)	R.S.L. (Years)	COST (Lane-Mile)	COMMENTS
New Construction		0	0		25	$ 508,000 $ 21,000	Construction cost User cost
Major Reconstruction	51	0	25		25	$ 490,000 $ 19,000	Construction cost User cost
Total						$ 998,000 $ 40,000	Construction cost User cost

D.I. = distress index, a measure of pavement condition. Scale values: 0 = no distress, 50 = reconstruction required.
R.S.L. = remaining service life, the remaining time in which a pavement can be preserved.

annual financial reports of state and local governments. Since June 1999, GASB 34 has required state and local agencies to provide more specific information in annual financial statements, following the model of the reports by private-sector companies and governmental utilities.

GASB recommends that state, county, and city government agencies apply historical costs to establish values for the transportation infrastructure. Agencies must identify the annual cost of maintaining and preserving the infrastructure assets at—or above—an established condition level. Pavement preservation, therefore, becomes integral to investment decision-making at highway agencies.

Chip sealing protects new pavements, increases macrotexture, and prolongs the life of structurally sound pavements that show surface distress.

Describing the Benefits

The benefits of implementing a pavement preservation program are not immediate and dramatic but accrue over time. Roads that generally are in good condition do not register a major change in condition rating after a treatment is applied—the rating continues as good. What is important, however, is the condition rating several years later—roads that receive preservation treatments are in better condition than those left without treatments.

A comparison of the project life-cycle costs of identical pavement sections with and without treatments illustrates the benefits of pavement preservation. In the example of a traditional alternative, shown in Table 2, a highway is constructed for $508,000 per lane-mile to last 25 years without any preservation activity. After 25 years, the highway must be completely reconstructed at a cost of $490,000 per lane-mile.

In the preservation alternative, shown in Table 3, a highway is constructed with a 25-year design life, also at a cost of $508,000 per lane-mile. After 5 years, the first short-term preservation action is performed for $15,000 per lane-mile, extending the pavement life 2 years. A second preservation is applied 10 years after initial construction—a different treatment that costs $39,500 per lane-mile but that extends the pavement life an additional 8

TABLE 3 Preservation Alternative: Project Life Cycle Cost

ACTIVITY	D.I. (Before)	D.I. (After)	AGE	LIFE EXTENDED (Years)	R.S.L. (Years)	COST (Lane-Mile)	COMMENTS
New Construction		0	0		25	$ 508,000 $ 21,000	Construction cost User cost
First Preservation	11	6	5	2	22	$ 15,000 $ 350	Construction cost User cost
Second Preservation	21	0	10	8	25	$ 39,500 $ 350	Construction cost User cost
Third Preservation	16	8	14	1	22	$ 15,000 $ 350	Construction cost User cost
Fourth Preservation	33	0	20	5	21	$ 55,500 $ 700	Construction cost User cost
Fifth Preservation	14	7	25	2	18	$ 15,000 $ 350	Construction cost User cost
Total						$ 648,000 $ 23,100	Construction cost User cost

D.I. = distress index, a measure of pavement condition. Scale values: 0 = no distress, 50 = reconstruction required.
R.S.L. = remaining service life, the remaining time in which a pavement can be preserved.

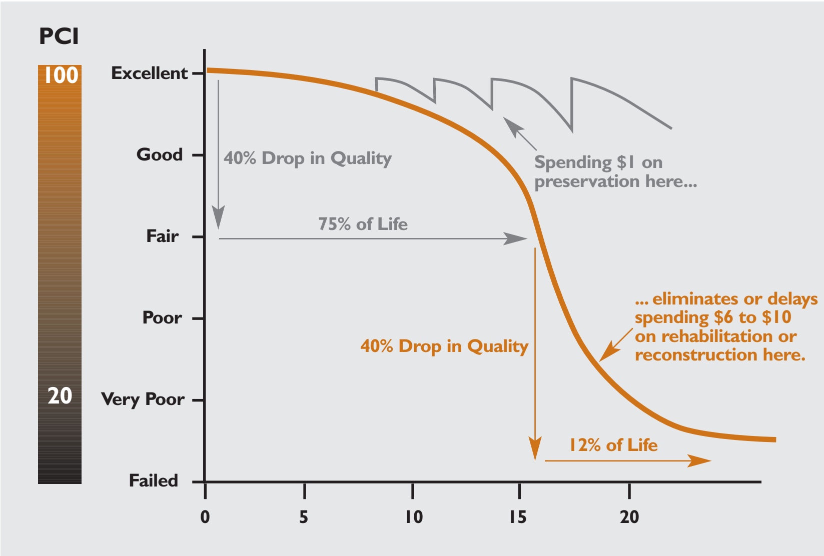


FIGURE 2 Pavement option curve (example). (PCI = Pavement Condition Index.)

years. A third preservation is applied in Year 14, a fourth in Year 20, and another in Year 25.

The preservation alternative offers potential savings in construction. In the traditional alternative, the pavement must be completely reconstructed after 25 years at a cost of $490,000 per lane-mile to extend the expected service life another 25 years. In contrast, preservation treatments cost $140,000 per lane-mile over 25 years and extend the expected service life another 18 years. Moreover, if the deterioration rate does not accelerate, pavement preservation can continue for more cycles, assuming that the pavement was designed and constructed properly.

Considering the user costs shown in the tables, additional savings will accrue. As shown in Figure 2, substantial savings can accrue with a well-planned pavement preservation program.

Essentials for Success

Pavement preservation is not a maintenance program, but an agency program. Almost every part of an agency should be involved. Success depends on support and input from staff in planning, finance, design, construction, materials, and maintenance. Two other essentials for an effective program are long-term commitment from agency leadership and a dedicated annual budget.

Agency personnel must address many critical issues before implementing a pavement preservation program. For example, terminology must be defined clearly and concepts such as cost-effectiveness, optimal timing, and pavement performance should be understood. Integrating pavement management with pavement preservation, to maximize the benefits to the highway network, also is imperative. In addition, agency personnel should be instructed about each preservation treatment and its appropriate use.

After preparing the groundwork, the next step is to tailor a program that meets agency needs. People with a thorough understanding of pavement engineering should develop preservation guidelines that relate to various pavement conditions, the purpose and limitations of each treatment, and the expected performance. The guidelines will assist in treatment selection and program assessment.

A good preservation program should establish continual monitoring to assure effective feedback for improvement of the guidelines. A process model is shown in Figure 3.

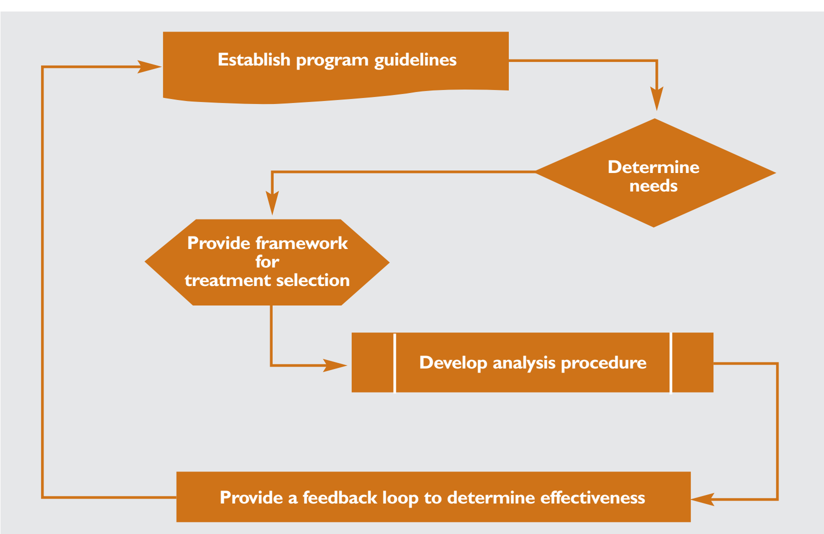


FIGURE 3 Pavement preservation process.

Issues and Barriers

Several issues and barriers may arise as an agency develops and implements a pavement preservation program. The issues and barriers, however, vary for each group involved.

Institutional Changes

Some of the issues and barriers from the transportation agency point of view may include the following:

◆ *Identifying a champion for the program.* Like any new effort or program within an agency, pavement preservation needs a champion. Without a champion to promote the importance and benefits, the new effort will not succeed.

◆ *Dealing with the paradigm shift from worst-first to best-first.* One of the biggest obstacles is convincing agency personnel to move from the tried-and-true practice of fixing the worst pavement problems first to fixing good pavements while the bad ones continue to deteriorate.

◆ *Gaining commitment from the top management.* The program's success requires top management commitment. This includes a commitment for dedicated funding and for the resources needed to collect information on the effectiveness of preventive maintenance treatments. Pavement preservation projects will not warrant ribbon-cutting ceremonies—unless the top management recognizes the program's importance.

◆ *Showing early benefits.* Pavement management systems that can show the early effects of the preventive maintenance treatments on extending life or on reducing life-cycle costs are essential.

◆ *Selecting the right treatment for the right pavement at the right time.* Failure can result if the correct treatment is not used. For a new program, a single failure can overshadow hundreds of successes. The right treatment must be applied to the pavement in a timely manner.

Marketplace Pressures

The issues and barriers for industry groups mostly involve reluctance to disturb the status quo and include the following:

◆ *Competition between the suppliers of maintenance and rehabilitation treatments.* With the shift from the traditional rehabilitation programs of pavement overlays applied every 10 to 20 years to pavement preservation programs using new or different treatments, resistance can be expected from the suppliers of traditional rehabilitation materials. For example, hot-mix suppliers will resist new cold-mix treatments because of the likely loss in market share.

◆ *Competition between various suppliers of maintenance treatments.* When markets have been established for certain types of treatments and a new treatment type is being introduced, industry often works to block the new products, whether for technical reasons or for business reasons, again to avoid loss of market share.

◆ *Political lobbying to prevent use of new maintenance treatments.* In some cases, industry will rely on political lobbying to prevent new technologies from entering the market. Again the reasons may be technical but more than likely are related to the effect on the market if an agency adopts the new technology.

◆ *Establishing the benefits of new technologies or treatments.* Suppliers often introduce new technologies without adequate evidence of the benefits. The supplier must provide the agency with detailed documentation of the product's benefits and performance.

Convincing the Public

The introduction of preservation programs also affects the traveling public—the ultimate customer—raising a different set of issues and barriers:

◆ *Understanding the shift from repairing the worst pavements first to the best pavements first.* The public does not understand why agencies would be working on good roads but letting the bad roads deteriorate. Most of the public understands the importance of maintaining a car or a house to prevent major repairs. Pavement preservation engineers should be able to explain the value of preventive maintenance treatments now compared with the cost of major repairs later.

◆ *Understanding the effects of the various maintenance and rehabilitation strategies on delays and vehicle costs.* Primary benefits of pavement preservation include the potential for reducing traffic delays by using faster repair techniques and for reducing user costs by maintaining pavement networks in better condition. Although widely acclaimed, these benefits still lack the documentation of national studies.

◆ *Understanding safety issues.* Increased safety for the traveling public and for workers in the work zone are other potential benefits from keeping roads in good condition through pavement preservation treatments; these benefits also need to be documented and communicated.

References

1. *Status of the Nation's Highways, Bridges, and Transit: 2002 Conditions and Performance Report.* Federal Highway Administration, U.S. Department of Transportation, 2003.
2. *Asset Management Primer.* FHWA-IF-00-010, Office of Asset Management, Federal Highway Administration, U.S. Department of Transportation, December 1999.
3. *Pavement Preservation: A Strategic Plan for the Future.* FHWA-SA-99-015, Federal Highway Administration, U.S. Department of Transportation, 1999.
4. *Primer: GASB 34.* FHWA-IF-00-010, Office of Asset Management, Federal Highway Administration, U.S. Department of Transportation, November 2000.

"Preventive maintenance has gone high-tech and is now being used in conjunction with other applications to preserve pavements—it is moving beyond the low-volume road sector to extend the service lives of our most heavily traveled Interstate highways."
—Gayle King, Koch Pavement Solutions, Wichita, Kansas

Preserving Pavements and Budgets
California's Strategies Leverage Limited Funds

SUSAN MASSEY AND PATTIE POOL

Pavement preservation is a priority in California, which is spending nearly $1 billion in 2003 to keep its highway system—the most heavily traveled in the nation—in working order. An effective pavement preservation program protects the taxpayer investment and improves user perceptions. Pavement preservation on the 50,000 lane-miles of California highways includes a range of preventive maintenance (PM) techniques applied to pavements in good condition.

PM strategies for flexible pavements include seal coats such as chip seals, slurry seals, microsurfacing, thin overlays, and crack sealing. PM treatments for concrete pavements include crack and joint sealing, dowel bar retrofit, partial depth slab repairs, and diamond grinding for smoothness and improved pavement texture.

These treatments reduce the amount of water infiltrating the pavement, slow the rate of deterioration, or correct surface roughness. Timely application can maintain or extend a pavement's service life another 5 to 10 years before a significant maintenance effort.

Retiring Distressed Lane-Miles

When resources are scarce, a policy of funding the worst pavement rehabilitation projects first will not retire enough distressed lane-miles to maintain a healthy state highway system. PM has restored more lane-miles at less cost per lane-mile than a rehabilitation-only program would have accomplished.

The 2003–2004 state fiscal year budget for pavement rehabilitation was nearly $300 million. To include some pavement preservation projects in that budget, a statewide rating system was used to allow projects normally covered in the Capital Preventive Maintenance (CAPM) program to compete with the worst roadway rehabilitation projects. Through the CAPM program, the California Department of Transportation (Caltrans) addresses projects in the category between maintenance contracts and full rehabilitation.

The option that targeted only the worst pavement rehabilitation projects would have retired only 326 lane-miles of distressed pavement. But the option that included the CAPM projects would retire more than 1,200 distressed lane-miles with the same budget, underscoring the effectiveness of pavement preservation. A mixed program of rehabilitation and preservation would include such strategies as preventive maintenance contracts, CAPM projects, nonconventional asphalt concrete treatments, and warranties to help maintain the state highway system through the budget crisis.

Budgeting for PM

Caltrans set a budget goal of $100 million annually for preventive maintenance: $50 million for state-funded maintenance projects and $50 million for federally funded CAPM projects. After several budget reductions in the 2002–2003 state fiscal year, Caltrans was able to secure $38 million for PM, adding service life to 1,635 lane-miles of pavement.

In the same state fiscal year, the pavement rehabilitation budget was $340 million, with approximately $30 million from CAPM program funds. Approximately 300 lane-miles were rehabilitated at a

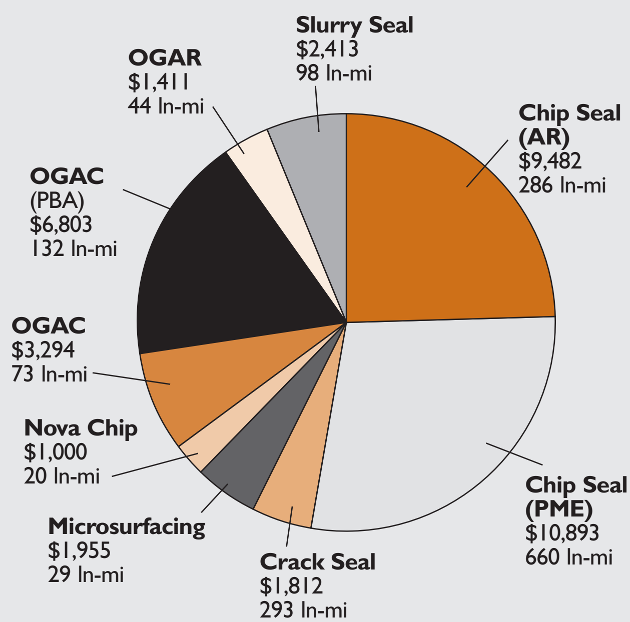


FIGURE 1 How Caltrans allocated 2002–2003 budget of $38 million for preventive maintenance on 1,635 lane-miles. (OGAR = open-graded asphalt rubber; OGAC = open-graded asphalt concrete; PBA = performance-based asphalt; PME = polymer-modified emulsion; AR = asphalt rubber; ln-mi = lane-miles; Nova Chip is a thin-bonded wearing course.)

cost of less than $80,000 per lane-mile. In short, PM enabled Caltrans to leverage the reduced funds to restore more lane-miles than with dedicated funds (Figure 1). Typical preventive treatments include modified binder (rubberized and polymer-modified), asphalt overlays, chip seals, slurry seals, microsurfacing, thin bonded wearing course, and recycled materials.

According to the 2002 Pavement Condition Survey, candidate projects for PM represent approximately 15,000 of the 50,000 total lane-miles in the state highway system—that is, about 30 percent of the roads are already in good condition. The goal is to treat one-fifth of all PM locations in the first year, establishing a 5-year cycle for PM.

Budget cuts in the 2002–2003 state fiscal year, however, allowed allocations for only 60 percent of the targeted lane-miles. Nonetheless, earmarking part of the budget for PM has made it possible to keep up the overall condition of the state highways despite the rate of pavement deterioration.

Caltrans determined that for every $1 spent on PM, $3 can be saved on CAPM, $6 on rehabilitation, and $20 on reconstruction, if the treatment is applied at the right time (Figure 2). Reconstruction in urban areas has been more expensive than expected—instead of the originally estimated $500,000 per lane-mile, costs have exceeded $2 million per lane-mile.

The primary savings for PM comes from a reduction in the time spent on design and construction. Before PM, Caltrans performed as much corrective maintenance as the budget allowed, until full rehabilitation or reconstruction was necessary. PM projects, which involve pavement only, require less design time and can be delivered faster. Pavement surfaces are renovated with thinner treatments, contributing to faster production. Fewer construction working days reduce the disruption to the traveling public.

Warranties

The one-year warranty provided another incentive for trying nonconventional asphalt concrete products for pavement preservation. The purpose of the warranty is to protect the pavement from failure during the first year after construction. The contractor must meet the performance requirements in the specifications.

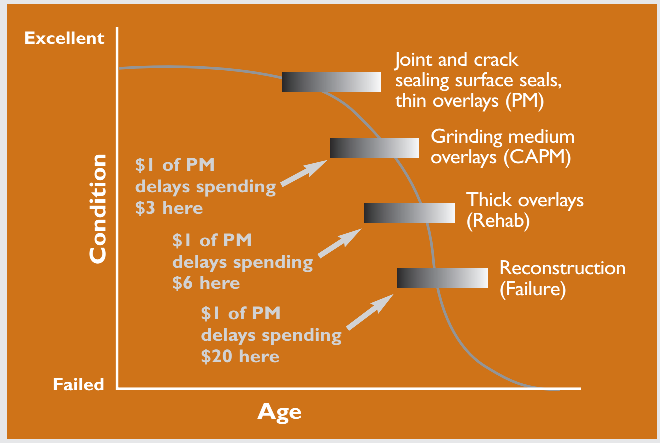


FIGURE 2 Cost-effectiveness of PM and CAPM projects.

In this way, the contractor assumes more responsibility for the materials and workmanship and must ensure a high-quality product free from defects for one year. Responsibility is placed on the contractor, not on the contracting agency.

When the nonconventional treatments were new, the warranty reduced the risk to the state if the performance criteria were not met. If there was a failure, the contractor had to come back and make repairs. A one-year warranty for performance covers such defects as rutting, potholes, raveling, flushing, streaking, and delamination; the financial impact on the Caltrans maintenance budget is minimal.

Although the California state budget is uncertain, the Caltrans Offices of Roadway Rehabilitation and Roadway Maintenance will continue to use pavement preservation and to dedicate funds to cost-effective PM treatments. Caltrans has relied on a combination of PM contracts, CAPM projects, nonconventional asphalt concrete treatments, and warranty projects to make the pavement budget go farther. Simple and more cost-effective PM treatments will maintain the highway system at a higher level of service, despite a reduced budget for maintenance and rehabilitation.

Massey is Supervising Transportation Engineer, Caltrans Office of Roadway Rehabilitation; Pool is Transportation Engineering Technician, Caltrans Pavement Management, Sacramento.

Looking at Long-Term Results

Performance of Test Section After 13 Years

GARY HILDEBRAND AND SCOTT DMYTROW

To evaluate the "preventive maintenance effectiveness of flexible pavement treatments," the Strategic Highway Research Program placed sections for Specific Pavement Studies 3 (SPS-3) throughout the United States and Canada in the late 1980s and early 1990s. Each SPS-3 project included test sections that received different treatments. The project test sites were in four climate zones; exhaustive information was recorded at construction; and performance data were captured periodically by the Long-Term Pavement Performance team and stored in the DataPave software.

After 13 years, what conclusions can be drawn? What is the effectiveness of the preventive maintenance treatments? Following is a report on one SPS-3 project in California,[1] observed on May 23, 2003.

History

A brief history of the California SPS-3 project is as follows:

- Circa 1980: Roadway was paved.
- 1985: Conventional chip seal was applied.
- 1990: SPS-3 maintenance test section was constructed.
- 1990 to 2000: No maintenance was performed except that crack seal was applied to test and control sections.
- 2000: Entire roadway was crack-sealed by a Caltrans maintenance crew.

[1] 06A300; GPS Section 061253; Butte County, California; State Route 32; PM 15.96–18.71; average annual daily traffic: 2,900 vehicles.

Treatments and Conditions

Different preventive maintenance strategies were applied to 11 segments of the test section in 1990. One segment was routed and crack sealed, one was slurry sealed, five had different chip seals applied, and four received different overlays of hot-mix asphalt (HMA). The control section received no preventive maintenance.

After 13 years, the segment with rout and crack seal was only in marginally better condition than the control section. The entire rout-and-crack-seal test section had to be crack-sealed during the first few years (circa 1992) and again in 2000 to fix adhesion problems. Ride quality on the rout-and-crack-seal section is similar to that on the control section. In addition, part of this test section has deteriorated badly, possibly because of an underlying condition.

The slurry seal has performed well, with no delaminating (i.e., separation from the surface) or raveling (i.e., loss of aggregate from the surface)—the roadway remains protected. Most of the cracks seem to have reflected through the slurry but have been crack-sealed, preventing moisture intrusion and base damage.

Overall, the five different chip seals have performed well, with minimal raveling, bleeding (i.e., a layer of asphalt binder migrating to the surface), or flushing (i.e., minor bleeding of binder). Some chip seals, however, had more reflective cracking than others.

The four HMA overlays also have performed well, although reflective cracking has occurred in the two sections with con-

Control section (background) and test section (foreground) for California SPS-3.

Asphalt concrete and fiber test section constructed in 1990. Emulsion chip seal after 13 years.

ventional HMA overlays. The fiber and asphalt rubber HMA overlays, however, appear to have an increased resistance to reflective cracking.

In contrast to the 11 test segments, the control or "do nothing" section is in very poor condition. The ride quality is bad and the section is in need of more than preventive maintenance. The crack filler appears to be the only thing keeping this section intact.

Between each test section is an unofficial control section. Each of these is also in very poor condition and will require more than preventive maintenance.

Evaluation

With the exception of the rout-and-crack-seal section, all of the maintenance strategies are performing well. The treatments have extended the life of the pavement and have kept the roadway in a condition acceptable to the motoring public. Each of the maintained sections could gain extended life with the application of another maintenance treatment.

The slurry and seal coat sections require a thin blanket or leveling course to restore ride quality. The thin overlay sections could benefit from either a slurry seal or another seal coat, because the ride quality generally is good. To obtain long-term service from the rout-and-crack-seal or control sections, extensive and costly rehabilitation strategies may be necessary.

The treatments applied to this test section demonstrate the benefits of PM for roads in good condition. When the SPS-3 strategies were applied in 1990, the 1985 chip seal was in good shape, the ride quality was good, and the distress consisted of transverse and longitudinal cracks approximately one-quarter inch wide. After 13 years, almost all of the PM-treated sections are still serviceable.

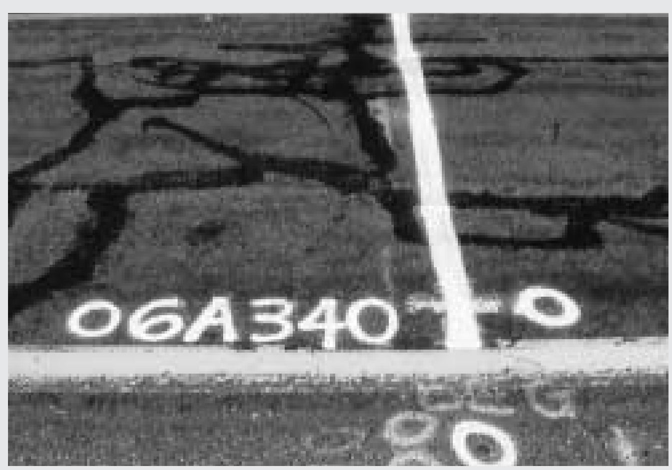
The test site is a very low-volume roadway in a non-freeze–thaw area. Achieving the same magnitude of success elsewhere with any of these strategies, therefore, requires comparable traffic and weather conditions.

The test sections prove the viability of PM treatments. Another PM treatment on the test sections could extend the life of this roadway another 5 to 10 years. This site shows that a pavement placed in 1980 can be maintained for more than 30 years in a condition acceptable to the general public—and to taxpayers—at the cost of a few PM treatments.

For more information contact Gary Hildebrand, Telfer-Windsor Fuel Co., P.O. Box 38, Windsor, CA 95492 (telephone 916-354-9760; e-mail: ghildebrand@telferoil.com).

Hildebrand is Pavement Preservation Specialist, Telfer-Windsor Fuel Company, Windsor, California; Dmytrow is Technical Marketer, Koch Pavement Solutions, Sacramento, California.

Hot-applied chip seal section.



Control section, 13 years old.

Protecting Roads in the Desert

Chip Sealing over Fabric Retards Reflective Surface Cracks

LITA DAVIS

The county of San Diego, California, like many other public agencies, is always looking for cost-effective ways to maintain roads. Innovation and creativity are necessary because the funding often does not increase from year to year, although the maintenance needs and costs continue to escalate.

The county of San Diego maintains approximately 2,000 centerline-miles of public roads in the unincorporated area of San Diego. The county includes coastal areas, inland valleys, mountains, and desert valleys.

The county Department of Public Works (DPW) follows a preventive maintenance system that applies surface treatments to extend the life of structurally sound roadways. The surface treatments in the DPW "toolbox" are chip seal, fog seal, slurry seal, cape seal, thin lift overlay, and chip seal over fabric.

Chip Seal over Fabric

In Borrego Springs, the desert area of San Diego County, the adverse climate and rainfall conditions generate many large surface cracks in the asphalt roadways. Elevations at Borrego Springs range from mean sea level to 1,830 meters (6,000 feet), with ambient temperatures from freezing in the winter to 57°C (135°F) in the summer. Rainfall is short in duration, but forceful, and is associated with flash floods.

Crack sealing was a common maintenance method for desert roads, but the cost of addressing the large quantities of surface cracks did not leave sufficient funds to apply the final surface treatments to the road. In 1987, DPW developed test sections on Yaqui Pass Road to evaluate the performance of several surface treatments. The goal was to find a treatment to retard reflective surface cracks under desert conditions.

The following surface treatments were applied and evaluated:

- Chip seal with latex emulsion;
- Slow-curing, 2-inch road mix;
- Chip seal with ground rubber and paving asphalt binder;
- Chip seal with latex emulsion over pavement reinforcing fabric; and
- Chip seal with latex emulsion on recycled asphalt surface.

All of the treatments sealed the road surface well, but only chip seal over fabric eliminated reflective surface cracks. Moreover, a 30-year life-cycle cost analysis showed that the annual cost was one-half that of chip sealing with crack sealing.

Chip sealing over fabric, therefore, has become the standard surface treatment for heavily cracked roads in the desert area of San Diego County. Material specifications and application procedures are as follows.

Fabric Properties

The requirements for the pavement-reinforcing fabric follow the California Department of Transportation's standard specifications: fabric manufactured from polyester, polypropylene, or polypropylene-nylon material. The fabric is nonwoven and is heat-treated on one side.

TABLE 1 Application of Chip Seal over Fabric

Seal Coat Type	Size of Screenings	Emulsion Application Rate	Screening Application Rate
Medium Fine	8.0 × 2.36 mm 5⁄16 inch × No. 8	1.1 to 1.6 liter/m^2 0.25 to 0.35 gal/yd^2	8.7 to 13.6 kg/m^2 16 to 25 lb/yd^2
Medium	9.5 × 3.35 mm 3⁄8 inch × No. 6	1.1 to 1.8 liter/m^2 0.25 to 0.40 gal/yd^2	10.9 to 16.3 kg/m^2 20 to 30 lb/yd^2

Fabric Placement

The roads are prepared by cleaning the surface, removing pavement markers, and placing protective covers on public improvements such as valve cans (which provide access to underground utilities), survey monument covers, and storm-drain inlets. Liquid paving asphalt (AR8000) is the binder for the fabric, applied between 290°F and 350°F at a rate of 0.25 to 0.30 gallon per square yard.

After placement, the fabric is lightly sanded and then seated with pneumatic rollers into the underlying paving asphalt, until the pavement texture is replicated on the fabric surface. On low-speed roads (35 mph or less), the sanded fabric is exposed to traffic for 5 to 10 days before the chip seal is applied. On high-speed roads (40 mph or more), the fabric and chip seal are placed on the same day.

Chip Seal Placement

When the fabric is properly saturated, the chip seal is applied at the same rate as on an asphalt surface (Table 1). If the fabric is not saturated, the chip seal emulsion must be increased to allow for absorption by the fabric and to leave enough emulsion to bind the chips. If the fabric is oversaturated, the emulsion must be reduced.

Product Performance

The 1987 test section on Yaqui Pass Road is still functioning. The fabric spans the surface cracks, so that crack sealing or crack filling have not been necessary.

For more information contact Lita Davis, Project Manager and Resident Engineer, County of San Diego, Department of Public Works, 5469 Kearny Villa Road, Suite 201, San Diego, CA 92123 (telephone 858-874-4067; e-mail Lita.Davis@sdcounty.ca.gov).

The author is Project Manager and Resident Engineer, Department of Public Works, County of San Diego, California.

Crack-sealed segment of desert road near Borrego Springs, California.

New paving asphalt is spread on roadway in first step of process.

Fabric is then placed on paving asphalt.

Fog seal is applied to the chip-seal-over-fabric surface.

Advancing the Pavement Preservation Movement

Federal Highway Administration Cultivates Partnerships

KING W. GEE AND STEVE MUELLER

Gee is Associate Administrator for Infrastructure; and Mueller is Systems Preservation Engineer, Office of Asset Management, Federal Highway Administration, Washington, D.C.

Americans are traveling on roads in record numbers. In 2000, Americans traveled more than 2.7 trillion vehicle miles, nearly four times the amount in 1960, and more than half of the travel was in urban areas, on crowded and often congested highways.

Nonetheless, large, new road construction projects, once considered routine, have shrunk dramatically in number. Trends suggest that most road construction will be limited to improving the level of service and efficiency within highway corridors. The immediate need of preserving and maintaining the highway investment, therefore, has become a nationwide challenge.

The nation's highways, built by earlier generations, are valued at more than $1.75 trillion. As responsible stewards of the highway system, present and future generations must not allow this investment to deteriorate.

Preservation Investments

Although the methods and assumptions for estimating highway and bridge investments are evolving, projects that preserve the infrastructure are good investments from a public policy perspective. Preservation investments improve the condition and performance of the highway system and reduce the backlog of deficiencies.

Crack sealing is a first line of defense in pavement preservation.

The deficiencies projected for the next 20 years can be attributed primarily to pavement deterioration and travel growth. Since the early 1990s, when construction of the Interstate system wound down, the Federal Highway Administration (FHWA) has increased focus on preservation to address the deterioration of the nation's infrastructure. The approach combines traditional engineering-based analytical tools with sensible economic guidelines to preserve transportation investments.

Preservation activities make invested dollars go farther. Pavement and bridge preservation approaches select the most cost-effective action to address a specific condition and performance need, providing agencies with the optimal means of minimizing life-cycle costs. Preservation extends highway service life and provides smoother, safer, and more reliable roads. Preservation programs are important in implementing asset management concepts and are demonstrating good returns on investments.

Evolving Policy

Historically, the Federal-Aid Highway Program has centered on capital improvement projects. Starting in the 1950s, emphasis was on construction and rehabilitation of the Interstate Highway System; in the 1990s, attention turned to the National Highway System.

For many years, federal regulations restricted federal-aid highway funds to capital improvements, prohibiting use for most activities involving preservation and maintenance. Maintenance was considered necessary to ensure that the highway was safe and serviceable in fulfilling the expectations of the traveling public and in meeting functional needs. Maintaining highways generally was regarded as the responsibility of the state or local jurisdiction and was a condition for receiving federal-aid construction dollars.

3R to 4R

The 1976 Federal-Aid Highway Act changed that policy, giving greater flexibility to state and local highway agencies in the use of federal funds. The legislation allowed for funding of resurfacing, restoration, and rehabilitation projects and became known as the 3R program. An objective was to enhance highway safety on nonfreeway projects by having each state develop its own criteria and procedures for design.

In 1981, the Federal-Aid Highway Act redefined Interstate system construction to provide a minimum level of acceptable service and added a fourth R, reconstruction, to the 3R program. The 4R program applied specifically to the Interstate Highway System. Maintenance remained the responsibility of the states in the federal funding equation.

Macrosurfacing is a single-pass, cost-efficient treatment suitable for low- to high-volume roads in good condition but with minor surface distresses.

Funding Preservation

The landmark Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) restructured the Federal-Aid Highway Program in the post-Interstate era. ISTEA allowed federal-aid funds for preventive maintenance activities—but a state had to demonstrate, through its pavement management system, that the activities were cost-effective in extending the pavement life of the Interstate. ISTEA was the first federal funding mechanism for system preservation by FHWA.

The National Highway System Designation Act of 1995 presented another endorsement of system preservation. Preventive maintenance became eligible for federal assistance as a cost-effective means of extending the useful life of all federal-aid highways, not just the Interstates. The act gave flexibility to each state in determining the most cost-effective strategies to extend the service life of pavements, bridges, and highway appurtenances on federal-aid highways. With this legislation, Congress acknowledged and underscored the importance of preventive maintenance programs.

The Transportation Equity Act for the 21st Century (TEA-21), the 1998 reauthorization of ISTEA, removed some funding barriers, increased flexibility for addressing safety concerns, and substantially increased transportation funding. In May 2003, the Administration released the Safe, Accountable, Flexible, and Efficient Transportation Equity Act of 2003 (SAFETEA), a proposal to reauthorize the TEA-21 programs. The proposal makes preventive maintenance on any federal-aid highway eligible for funding. As proposed, SAFETEA would increase federal transportation funding by approximately 19 percent above current levels.

Overseeing Improvements

FHWA, working with state departments of transportation (DOTs), is responsible for the general management and administration of the federal requirements governing highway maintenance (Title 23, United States Code, Section 116). Each state DOT is responsible for maintaining each project constructed with federal-aid funds. FHWA provides general oversight of the state DOT programs, including maintenance and preservation.

If FHWA finds that a state DOT is not properly maintaining a federal-aid highway and that the state DOT is not restoring the highway to proper condition after receiving notice, FHWA may withhold project approvals. Only once, however, has FHWA withheld federal-aid funds from a state DOT because of poor maintenance—a tribute to the partnership between the state DOTs and FHWA.

Through this FHWA–state DOT partnership, the expansion of highway funding, and the introduction of preventive maintenance concepts, roadway conditions on the nation's network generally are improving. For example, the percentage of rural Interstate miles in poor condition has declined from 8.7 percent in 1990 to 1.9 percent in 2001. Other functional classes of rural roads and highways have recorded similar success.

Goals and Approaches

Meeting customer demands and improving customer satisfaction are primary goals of FHWA's pavement preservation program. When capital investments can be made to last longer, available funding can stretch farther, and the number of costly, time-consuming, traffic-disrupting rehabilitation and reconstruction projects can be reduced.

Preservation is the best way to provide safe, smooth, and quiet pavements. In 1995, a survey indicated that 50 percent of U.S. motorists were satisfied with the nation's highway system. A similar survey conducted in 2000 indicated that 65 percent were satisfied. This improvement correlates with improved ride quality for rural and urban roadways, as measured by the International Roughness Index.

A single urban road segment in poor condition can taint opinions about the overall condition of the network. In the past, some favored the approach of fixing "bad" roads first. This "worst first" approach, however, has proved costly for many jurisdictions—by the time the bad roads were fixed, many other roadways had slipped from fair into poor condition.

The lesson showed that it is significantly less expensive to "keep good roads good" and to improve and maintain the other roads from falling into poor condition. "Keep the good roads in good condition" is a fundamental tenet of roadway asset management.

The concept applies to evaluating nearly all infrastructure assets, including bridges, water systems, sewer and drainage systems, buildings, waterways, and airports. Many agencies are moving toward comprehensive asset management programs for several reasons, including

- Funding constraints,
- Aging infrastructure,
- User demands,
- Loss of experienced senior staff, and
- Public demands for accountability and for returns on investments.

Preventive Maintenance

The American Association of State Highway and Transportation Officials (AASHTO) recently adopted a definition of preventive maintenance. Preventive maintenance activities include work that

- Prevents the intrusion of water into the pavement structure—for example, with seal coats, joint seals, crack seals, and thin overlays;
- Provides for the removal of water from the pavement structure—for example, with underdrains and restoration of drainage systems;
- Restores pavement rideability—for example, with profiling and milling; and

Hot in-place recycling asphalt train replacing roadway surface in one pass.

◆ Prevents deterioration of bridges—for example, with cleaning and painting, scour countermeasures, deck rehabilitation, and deck drain cleaning.

Under this definition, pavement preservation includes preventive maintenance activities for pavements, minor rehabilitation, and some routine maintenance. In contrast, pavement preservation does not include new pavement construction, reconstruction, major rehabilitation, or corrective maintenance.

Partners in the Cause

FHWA is developing partnerships with other federal agencies, state and local governments, industry associations, academia, and others to support and direct the pavement preservation movement. FHWA has committed staff for the effort and is providing funds to assist partners in developing new technology and curricula to manage public assets effectively.

AASHTO

In January 2002, AASHTO launched a community-of-practice website offering a comprehensive source of information on transportation asset management, with 15 topic areas, including information on pavement preservation, as well as activities and studies by FHWA and state DOTs, plus chat rooms.[1] In addition, the Pavements Task Force of the AASHTO Subcommittee on Maintenance has adopted several resolutions supporting pavement preservation.

Expert Task Group

FHWA established the Pavement Preservation Expert Task Group (PPETG) in 1991, with members representing government agencies and industry. The PPETG provided support and technical assistance to FHWA on how to apply and implement performance findings from the Specific Pavement Studies of the Strategic Highway Research Program.

The PPETG continues to evaluate and support activities to promote and institutionalize pavement preservation concepts and practices. The group has assisted in the development of pavement preservation training programs for managers and practitioners, of videos and other media outreaches, and of national and regional workshops on pavement preservation.

Foundation for Pavement Preservation

In 1992, related industry associations formed the Foundation for Pavement Rehabilitation and Maintenance Research to promote research and education on pavement preservation. Renamed the Foundation for Pavement Preservation (FP^2) in 1999, the group provides the funding, research, and training for the appropriate selection, design, and construction of pavement treatments and keeps agency and industry practitioners informed about pavement preservation.

FHWA has worked with FP^2 to foster and advance pavement preservation programs and applications. The foundation also supports the activities of the PPETG. FHWA and FP^2 meet with industry trade organizations throughout the year to promote effective public-private cooperation in advancing pavement preservation strategies.

An FP^2 partner, the University of Illinois at Urbana–Champaign, has developed an upper-level college course on pavement preservation; a web-based version should be available later this year. The course supplied a curriculum need, since engineering students receive minimal training in maintenance, pavement preservation, or infrastructure renewal.

[1] http://assetmanagement.transportation.org

University Center Paves the Way

LARRY GALEHOUSE

Michigan State University (MSU) has established a National Center for Pavement Preservation—the first of its kind—within the Department of Civil and Environmental Engineering, focusing on activities such as routine maintenance, preventive maintenance, and minor rehabilitation, to offer sound solutions for the highway system. MSU is providing the facilities, services, and amenities for the center, located in the university's Engineering Research Facility in Okemos.

The center offers specialized services to government agencies and to the private sector and will lead to collaborations among government, industry, and academia to advance and improve pavement preservation practices through education, research, and outreach. The objectives of the center are to

◆ Serve as a resource and provide advice on pavement preservation activities;
◆ Promote the benefits of pavement preservation, in partnership with the Foundation for Pavement Preservation;
◆ Enhance pavement preservation knowledge through research; and
◆ Provide advice and assistance to other groups establishing pavement preservation programs.

For more information contact Larry Galehouse, telephone 517-432-8220, e-mail ncpp@egr.msu.edu, or visit www.pavementpreservation.org.

Directions for Research

Managing and preserving the nation's investment in the highway system is a goal for state DOTs. The benefits of a sound pavement preservation program range from improved performance and increased highway safety to reduced life-cycle costs. Because applying pavement preservation treatments is faster than rehabilitating or reconstructing pavements, preservation can contribute to increased mobility, improved work zone safety, and overall customer satisfaction.

Transportation departments establishing pavement preservation programs face the challenge of determining which pavement treatments are best. Preservation treatments must be carefully selected and must be applied when the pavement is still in good condition with no structural damage. New and innovative research therefore is necessary to assist agencies in applying the right treatment to the right road at the right time.

Research, however, has lagged behind the demand for knowledge. To meet this challenge and increase the knowledge available to state and local agencies, FHWA is building partnerships among states, industry, academia, and the Transportation Research Board.

FHWA also is exploring options for launching a multiyear, coordinated pavement preservation research program to address the research, development, and technology needs of the nation's transportation departments and to meet the safety, efficiency, and mobility requirements of the public.

Expanding the Vision

Pavement preservation has been an active federal program for the past 12 years. The vision is expanding to embrace preservation for all roadway assets. FHWA has initiated a national program on transportation system preservation (TSP) to address all components of the highway transportation infrastructure, such as bridges, roadside hardware, and safety features.

The FHWA Office of Bridge Technology has expanded the use of federal bridge replacement funds for acceptable preservation activities, advancing preservation as a business strategy to protect the public investment. The policy does not offer additional funding but allows state DOTs flexibility to spend federal-aid funds on appropriate projects.

A TSP team was formed to guide and advance the entire preservation program. The team has developed a website compiling information on best practices, promoting new materials to extend service life, offering technical guidance and policy, identifying and developing the necessary training, and linking to related websites.[2]

Research Activities

Several research activities relating to pavement preservation are under way—on sealers and rejuvenators and on emulsified sealers and binders for extending the service life of asphalt pavements. The National Cooperative Highway Research Program (NCHRP) is developing a Guide for Optimal Timing of Pavement Preventive Maintenance Treatment Application (NCHRP Project 14-14) for flexible and rigid pavements.

FHWA is supporting a multistate pool-funded research project on the design and application of slurry seal and microsurfacing treatments, as well as a study of crack sealant materials and application specifications. Managed by the California Department of Transportation, this study is in its initial stages.

The Pavement Preservation Research Consortium—a working group of FHWA, state DOTs, academia, and FP^2—met in June 2001 to identify and prioritize more than 50 preservation-related research topics. The consortium drafted research problem statements for 22 projects, published in a January 2002 report.[3]

Technology Transfer

FHWA supports the development and distribution of publications and other products to promote the concept and applications of pavement preservation. Following is a sample of the products:

- *Fact sheets.* The fact sheets relate the experiences of Ohio and North Carolina DOTs in pavement preservation, advanced performance-related specifications, accelerated reconstruction, and contract administration.
- *Checklists.* FHWA is preparing checklists for the pavement preservation products in common use around the United States. To aid agency inspectors and contractors, the checklists include best practices and are printed pocket-size, for easy use in the field.
- *Videos.* In conjunction with FP^2, FHWA has produced a video, *Concepts of Pavement Preservation and the Selection of Proper Treatments*, which received an award from the Public Relations Society of America. More videos are planned.

[2] www.fhwa.dot.gov/preservation

[3] www.fhwa.dot.gov/preservation

◆ *Toolbox.* A resource toolbox, developed in cooperation with FP[2] and available from FP[2], contains publications, CDs, and videos from industry and government sources.

◆ *CD-ROMs.* FHWA has updated a state-of-the-practice CD of publications and resources on pavement preservation. In addition, a CD with the presentations and background materials from the National Pavement Preservation Forum II, held in November 2001, is available, and another CD, with all of the materials in the toolbox, is in production and will be available later this year.

Websites. FHWA websites offer extensive information about pavement preservation.[4]

In addition, FHWA and its partners are cooperating to provide national and regional workshops on pavement preservation materials, application techniques, specifications, and systems integration.

Best Practices

In summer 2001, FHWA and AASHTO conducted an international scanning tour of pavement preservation technologies. A team of government and industry professionals visited three nations that are implementing innovative programs and new treatments for pavement preservation—Australia, France, and South Africa. The scanning tour reviewed and documented the techniques, materials, procedures, and equipment used for pavement preservation and evaluated applications in the United States (see related article, page 29).

The team discovered that U.S. pavement preservation initiatives are on target, sharing many techniques and a similar focus with countries at the leading edge of the technologies. The team identified several technologies for further evaluation and possible implementation, including innovative chip seal design and construction procedures and contract maintenance techniques. Demonstrations of these technologies are planned.

Training Courses

FHWA's National Highway Institute (NHI) is working with state DOTs and the pavement industry to develop a series of courses in pavement preservation. The series will consist of four courses (Table 1), offering a comprehensive understanding of preservation strategies and treatments. Two courses are available now for transportation departments initiating preservation programs.

TABLE 1 NHI Pavement Preservation Training Courses

Course	Status
Pavement Preservation: The Preventive Maintenance Concept (NHI 131054)	Available
Pavement Preservation: Selecting Pavements for Preventive Maintenance (NHI 131058)	Available
Pavement Preservation: Design and Construction of Quality Preventive Maintenance Treatments (NHI 131103)	2004
Pavement Preservation: Integrating Preventive Maintenance with Pavement Management Systems (NHI 131104)	Late 2003

A 15-minute video, *Preventive Maintenance: Protecting Our Pavements*, supports the first training course and presents the case for preventive maintenance programs. A 30-minute video, *Preventive Maintenance: Project Selection*, supports the second training course, focusing on selection of the right treatment for the right pavement at the right time.[5]

Continuing Commitment

Public transportation agencies are responsible for maintaining, replacing, and preserving the country's largest publicly owned assets—nearly 4 million miles of streets, roads, and highways and more than 590,000 bridges. The agencies have limited resources and are accountable to their stakeholders, the American public.

To advance the momentum in promoting and applying pavement preservation, FHWA will continue to strengthen and build partnerships with state and local government agencies, industry, academia, and other parties. The partnerships have shown the advantages of pavement preservation in maintaining the nation's highway infrastructure. Drawing on the strengths and perspectives of all levels of government and the private sector, as well as from technologies in development abroad, the partnerships can determine ways to enhance the decision-making process, preserve transportation assets, and meet the traveling public's present and future needs.

FHWA is committed to providing focus, policy, technical assistance, and support in technology deployment to states and local agencies. The implementation of improved asset management concepts, such as a cost-effective pavement preservation program, is here to stay.

[4] www.fhwa.dot.gov/preservation and www.fhwa.dot.gov/construction

[5] Videos and other products are available without charge to agencies, from the FHWA Office of Infrastructure, Division of Asset Management; e-mail requests to Steve.Mueller@fhwa.dot.gov.

Research Frontiers in Pavement Preservation

ROGER M. LARSON, LARRY SCOFIELD, AND JAMES B. SORENSON

Larson is Senior Engineer, Applied Pavement Technology, Inc., Springfield, Virginia; Scofield is Research Engineer, Arizona Department of Transportation, Phoenix; and Sorenson is Construction and System Preservation Team Leader, Federal Highway Administration, Washington, D.C.

In the past, the major emphasis in the area of pavement was on structural design—project specifications addressed the issues of material quality. Today, material properties are being tied directly to structural design and distresses. The surface characteristics that contribute to good functional performance, however, often are ignored until problems develop.

Surface characteristics have gained significance with the shift of focus from new construction and major rehabilitation to pavement preservation. But despite the increasing use of preservation treatments on pavement sections in good structural condition, many state highway agencies still have no specifications for the improved functional performance of the pavements.

Functional performance is determined by how well the pavement serves the user. Until now, riding comfort—a concept developed in 1957—had been the dominant concern. Today the greater need is to improve other important functional surface characteristics of pavements.

Highway User Surveys

In May 1996, a national survey identified highway user concerns. Safety was first, followed by pavement condition, and then traffic flow. Highway users wanted an increased focus on the quality of roadway surfaces.

A follow-up infrastructure survey in 2000 found that highway users rated improvements to traffic flow, safety, and pavement condition as the highest priorities. The survey also discovered overall increases in dissatisfaction with safety and with pavement condition. These are findings that professional engineers can address.

The results again supported greater consideration of the functional characteristics of pavements. In terms of safety, concerns include pavement markings, friction in wet weather, and clearing accidents more quickly. Pavements need more durable surfaces, a smoother and quieter ride, and better surface appearance.

Longer-Lasting Pavements

Good highway drainage is fundamental to increase surface durability by eliminating or minimizing potholes and extending service life. A good cross slope is important for surface drainage, improving ride quality, improving wet weather friction, and reducing splash and spray. Cross-slope deficiencies should be corrected as part of any pavement preservation project.

Because durability affects all other pavement characteristics, higher-quality materials and better workmanship are necessary for cost-effective construction and preservation. Greater attention to materials and workmanship would reduce deterioration and minimize rutting. With current staff reductions at many highway agencies, increased use of warranties, guarantees, or performance-related specifications can help ensure more durable pavement surfaces for highway users. Improved guidelines and incentives for obtaining desirable—not minimal—levels of critical surface characteristics are necessary.

Periodic distress surveys are a means of evaluating surface durability—lack of distress indicates durability. Established warning levels of texture and friction can identify potentially hazardous locations before significant numbers of crashes occur. Cost-effective corrective actions can be undertaken as appropriate.

Ride Comfort

Most highway users can relate to ride comfort as a criterion for pavements. Several recent publications have addressed the research under way to improve guidance for pavement smoothness. Improvements are needed in the measurement and evaluation of overall smoothness, the detection of bumps, and the identification of roughness that would increase dynamic loading impacts from trucks.

Texture, Safety, and Noise

Pavement texture is often overlooked in project specifications. Many state highway agencies have no requirements for texture or friction on paved asphalt surfaces.

Specifying friction above minimum levels can raise liability concerns. However, considerable evidence shows that higher levels of texture and friction significantly reduce fatalities and injuries—and the resulting traffic delays—and can be cost-effective for congested routes and for work zones. Improved guidance on the desirable macrotexture to reduce splash and spray and hydroplaning and on the microtexture to increase friction at low and high speeds is needed. National Cooperative Highway Research Program Project 1-43, Guide for Pavement Friction, is under way to address this concern.

Safety in work zones—reducing deaths, injuries, and traffic delays—also was a concern for highway users. In 2002, 1,083 highway workers and users were killed in highway work zones. This critical area has few guidelines on texture or friction characteristics, particularly in work zone transitions, which involve lane changing, slowing, or stopping. The demand for friction, therefore, is greater than it is in typical roadway operations. Increasing the texture or friction would have a significant effect in reducing the stopping distance, which would be expected to reduce crashes in highway work zones.

Safety Plans

The American Association of State Highway and Transportation Officials (AASHTO) has developed a comprehensive Strategic Highway Safety Plan to reduce highway fatalities by 5,000 to 7,000 annually. Eight or more states are piloting an Integrated Safety Management Process to help implement the plan.

Most of the emphasis in safety-related pavement research has been on wet-weather crashes—however, up to 86 percent of all crashes occur on dry roadways. The assumption has been that friction on dry roadways was adequate; however, friction has a significant effect on stopping distance, which can be expected to reduce crashes from roadway departures and at intersections.

The Federal Highway Administration (FHWA) also has set safety goals for the next 10 years, including the following performance measures:

- 20 percent reduction in fatalities,
- 20 percent reduction in injuries,
- 50 percent reduction in truck-related fatalities, and
- 10 percent reduction in fatalities at intersections and in roadway departures by 2007.

The prevention of all wet-weather crashes would not achieve these goals. Therefore a comprehensive program is necessary. Research indicates that up to 70 percent of wet-weather crashes could be prevented with improved texture and friction. A recent study in New York reported that at 40 intersections with high

Ultrathin bonded wearing course is one way to improve roadway surface texture.

crash rates and low friction values, accidents were reduced an average of 61 percent after the approaches were given a more skid-resistant surface.

More than 3 million crashes occurred at intersections in 2002, causing nearly 9,000 deaths and 1.5 million injuries. Since wet-weather crashes represent about 14 percent of all crashes, improved skid resistance could result in a 10 percent reduction in fatal and serious injuries from crashes and also could reduce travel delays.

Performance Measures

The effect of increased texture and friction on reducing crashes on dry roadways also must be considered, however. None of the AASHTO or FHWA goals specifically target the expected overall benefit of increased texture and friction on reducing fatalities, injuries, and the resulting traffic delays; pavement skid resistance, however, is among the topics under roadway departure.

Corresponding performance measures are needed—for example, average macrotexture depths that can be measured continuously at highway speeds—to help monitor whether texture and friction levels on the network are increasing as a result of construction or preservation activities. An analysis of friction and texture versus average crash rate by major roadway classifications would demonstrate more clearly the benefit of increased texture and friction on reducing fatalities and serious injuries. The lack of an accident reduction goal linked to increased texture and friction and a corresponding performance measure to monitor progress is a deficiency to be addressed.

Texture also affects noise. Reduced tire–pavement noise levels will benefit highway users, as well as adjacent property owners. Specifying desirable noise levels has received little emphasis even in noise-sensitive projects in urban areas. Therefore, completed projects have had large variations in noise levels, and the monitoring of noise levels on constructed projects has been limited.

The Arizona Department of Transportation (DOT) has one of the most comprehensive studies under way to evaluate pavement texture characteristics—both friction and noise—on representative surface types in approximately 200 pavement preservation test sections. A goal is to develop ranges of texture—and the resulting friction and noise levels—for a variety of preservation treatments. In addition, both Arizona and California DOTs are pursuing quieter pavement surfaces to reduce noise at the source.

Surface Appearance

Specifications for a uniform, pleasing surface appearance have received little attention. The FHWA Federal Lands Division, however, has made this a major issue on the projects it administers for the National Park Service. Spot grinding to remove bumps can produce differential friction—differences in textures changing the skid resistance—and also can cause a nonuniform appearance. Surface repairs such as partial lane patches also affect both friction and appearance. Specifications should not reward corrective measures that result in poor appearance or that contribute to differential friction, which may increase skidding crashes.

Traffic markings are particularly important for visibility at night and in poor weather. Sixty percent of roadway departure crashes occur during dark or reduced-light conditions. Excluding alcohol-related crashes, the nighttime crash rate is about twice the daytime rate. Improved durability in traffic markings is required—also important is that the markings do not increase the risk of skidding, particularly for motorcycles.

Rumble strips are being used successfully to warn drivers that the vehicle is departing from the roadway or crossing into an area with a potential for a head-on crash. These low-cost treatments have been effective in reducing crashes.

Evaluation Technologies

Technological advances have facilitated data collection and data analysis. In many cases, results are available in real time and presentable in either graphical or statistical formats for pavement management, maintenance management, or safety management systems.

These powerful tools can guide engineering decisions that extend the service life of highways and increase highway user satisfaction. Obtaining the greatest benefit for the highway agency, however, requires increased integration of all management systems.

New high-speed, nondestructive evaluation techniques are available or are in development that will help differentiate structural and functional pavement problems. A rolling-wheel deflectometer is in development that will allow continuous high-speed evaluation of the structural strength of asphalt pavements by monitoring pavement deflections. The instrument also would help distinguish top-down environmental cracking versus bottom-up structural fatigue cracking. In Texas and other states, ground-penetrating radar is being used to locate structural problems in pavements.

Advances in laser technology allow the measurement of a pavement surface macrotexture at highway speeds. This could minimize the need and expense for network-level friction testing. Laser sensors and the newly developed scanning lasers can improve evaluation of rutting, aggregate polishing, bleeding, surface raveling, and aggregate segregation of mixes at relatively low cost.

These tools can improve decision-making for pavement preservation. The techniques will help to improve surface durability and will reduce the need for frequent, routine, or reactive pavement maintenance.

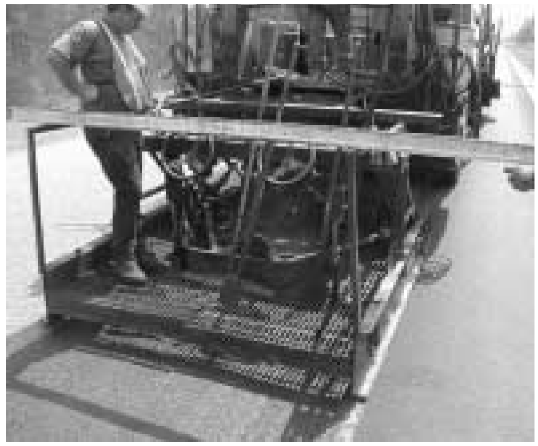
Portable devices, such as the circular track (or texture) meter and the dynamic friction tester, are available to evaluate pavement texture and friction values and to develop an international friction index. These stationary devices require lane closures for testing but allow a relatively quick comparison of surfaces. Arizona DOT, the National Center for Asphalt Technology, and others are using the equipment in studies.

Performance and Ride

The FHWA Office of Asset Management has initiated a project that uses pavement management systems to evaluate the performance of Superpave mixes. Many states have adopted the Superpave system and need to verify that the forecast benefits—including improved safety, durability, and longer service lives—are being achieved.

These evaluations should substantiate improvements to safety and to surface durability—two of the major concerns of highway users. FHWA's emphasis on pavement preservation also should lead to improved surface durability and should minimize the amount of routine or reactive maintenance of pavement surfaces.

The FHWA Pavement Smoothness Initiative has made significant changes in evaluating ride comfort—for example, adopting the International Roughness Index (IRI) as the standard measurement unit and using the lightweight laser profiler to monitor construction quality and to provide an initial value for monitoring long-term performance. A new effort is under way to develop bump specifications, including grinds or repairs, and to ensure that roughness does not cause dynamic loading by trucks that would increase the rate of structural damage to the pavement.



Microsurfacing on an asphalt pavement. Further research is needed to evaluate the impact of surface textures on friction and roadway noise.

Addressing Texture

Few specifications address texture or friction. Texture is important to the friction and noise properties of the pavement surface. The few states that have guidelines typically address the minimum, not the desirable, values. No state has requirements that address the maximum or desirable noise levels for the various surface types.

The FAA guidelines for airport runways are a best-practice example that could be modified to address various highway pavement classes. The FAA guidelines address friction and texture for new construction and for maintenance activities, including desirable friction and texture for new surfaces, maintenance threshold levels, and minimum acceptable levels.

Texture affects both noise and friction and should not be considered independently. Texture and friction should be addressed specifically to reduce the current, unacceptable levels of 43,000 fatalities and 2.9 million injuries annually in highway crashes and to minimize the resulting traffic delays.

Refining the Tools

Technological advances are providing the tools to assist practitioners in developing more cost- effective pavement preservation strategies. The new technologies should enable researchers to develop cost-effective pavement guidelines that contribute to reducing fatalities and serious injuries and that also reduce noise impacts for highway users and adjoining property owners. Additional research must refine these tools further and introduce the advances into widespread use.

Improving the Condition of Bridge Networks

Michigan Crafts a Preservation Program

DAVID A. JUNTUNEN

The author is Bridge Operations Engineer, Michigan Department of Transportation, Lansing.

Michigan's network of trunkline bridges was built primarily in the 1960s and 1970s. In the 1990s, many of the bridges began to show their age, and the condition of the trunkline bridge network began to decline. Funding was inadequate, and the state did not have a long-range plan to preserve its bridges.

In 1998, the Michigan legislature passed a bill to solve this problem, substantially increasing highway funding, and the leadership of the Michigan Department of Transportation (DOT) responded by developing a strategic plan to preserve, maintain, and improve the state's trunkline bridges. Fulfilling the plan would require a paradigm shift in Michigan DOT, however, making asset management and long-range strategic planning routine parts of daily business. The strategic investment plan for bridges includes a key role for preventive maintenance.

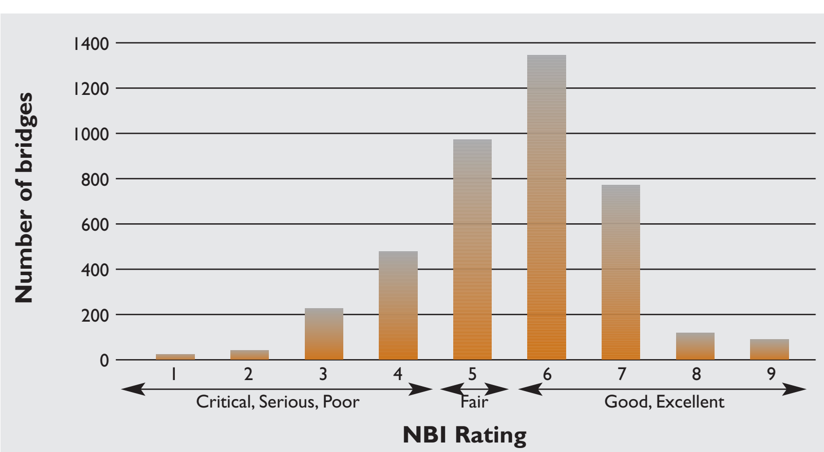


FIGURE 1 Michigan's bridge network condition (NBI = National Bridge Inventory).

Network Goals

The goal of Michigan DOT's strategic investment plan is to preserve the bridge network, ensuring safety and serviceability while optimizing available resources. Specific network goals are to

- ◆ Address the critical needs of each structure immediately;
- ◆ Improve the overall condition of the freeway bridge network, so that 95 percent of the structures are rated in good or fair condition; and
- ◆ Improve the overall condition of the nonfreeway bridge network, so that 85 percent of the structures are rated in good or fair condition.

The goals are measured in terms of the condition rating for the three major bridge elements: deck, superstructure, and substructure. If any of the three major elements is rated poor according to the National Bridge Inspection standards, the bridge is considered to be in poor condition.

The strategy incorporates four types of core activities: replacement, rehabilitation, capital preventive maintenance (CPM), and capital scheduled maintenance (CSM). Each of these activities affects the condition of Michigan's bridge network. Figure 1 shows

the number of bridges in each rating category and demonstrates the effect of each work activity.

Core Activities

Replacement

Replacement activities work to improve condition ratings from "poor" to "good" and have a direct impact on the network (Figure 2). Replacement projects are expensive; therefore few projects can be undertaken. Projects include

- Deck replacement,
- Superstructure replacement, and
- Structure replacement.

Rehabilitation

Rehabilitation activities improve the integrity of bridge elements, working to change poor or fair bridge condition ratings to good. Rehabilitation activities also have a direct impact on the network (Figure 3). These projects are less expensive than replacement projects—typically, two rehabilitation projects can be completed at the cost of one replacement project. Rehabilitation projects include

- Deep concrete overlay,
- Shallow concrete overlay,
- Superstructure repair,
- Extensive substructure repair, and
- Substructure replacement.

Epoxy sealer applied to bridge deck cracks, an early capital scheduled maintenance measure.

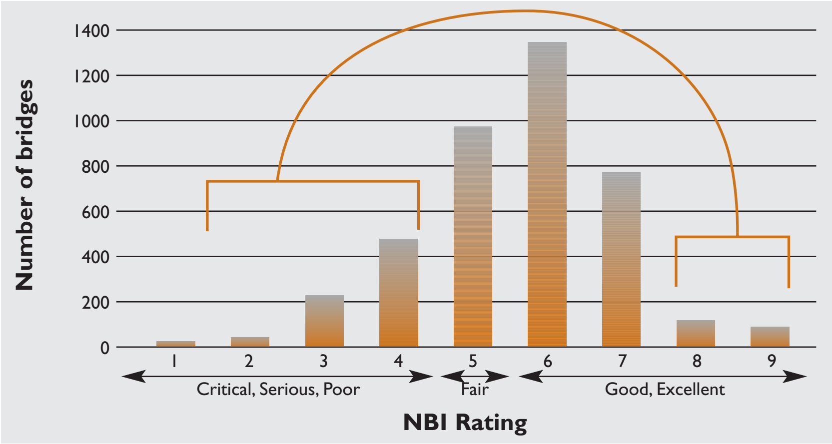


FIGURE 2 Replacement projects.

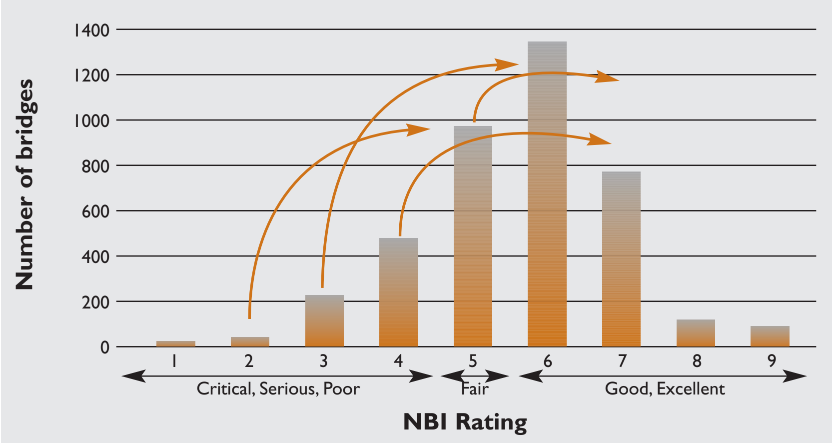


FIGURE 3 Rehabilitation projects.

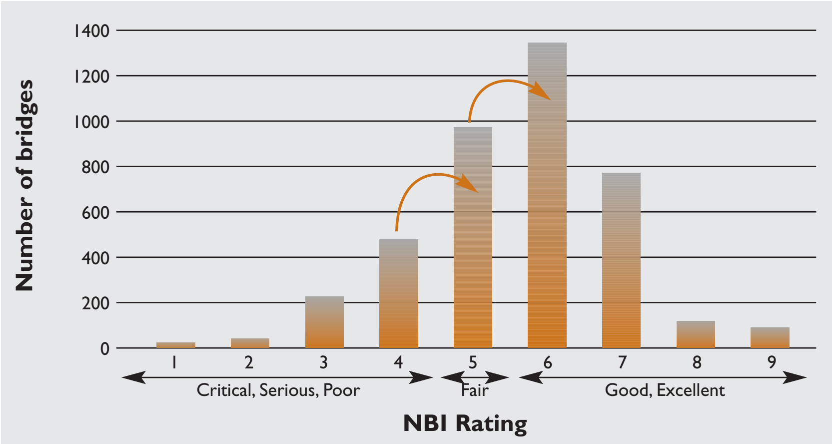
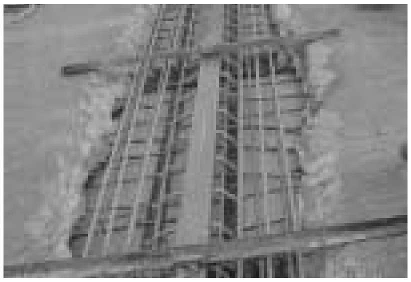


FIGURE 4 Capital preventive maintenance.



Concrete repair adjacent to a strip seal expansion joint, heading off extensive repairs.

Deck area prepared to receive structural repair patch, which can last up to 8 years.

Workers spreading epoxy and applying aggregate for thin epoxy overlay; the overlays can protect the surface for 10 to 15 years.

Concrete removed to 3/4 inch below top mat of rebar for deep concrete overlay.

Hot-mix bituminous overlay applied to bridge deck in poor condition.

Capital Preventive Maintenance

Maintenance, whether scheduled or reactive, supports serviceability. Historically, maintenance has focused on reactive responses; however, failure to perform scheduled maintenance accelerates bridge deterioration. Figure 1 shows a large number of bridges rated 5 and 6—fair and good, respectively. Michigan's strategic plan approaches preventive maintenance activities as key to success.

CPM involves scheduled work to restore the integrity of bridge elements. CPM prevents structures in fair condition from declining to poor (Figure 4). Approximately six CPM projects can be completed for the cost of one replacement project. CPM projects include

- Pin and hanger replacement,
- Complete painting of steel beams,
- Zone painting of steel beams,
- Epoxy overlays of bridge deck,
- Deck patching,
- Scour countermeasures,
- Hot-mix asphalt (HMA) overlay with waterproofing membrane, and
- Minor substructure patching.

Capital Scheduled Maintenance

CSM consists of scheduled work to sustain the bridge's current condition. CSM maintains serviceability and reduces the rate of deterioration. For example, CSM prevents good-rated structures from lapsing to fair. CSM projects include

- Superstructure washing,
- Vegetation control,
- Drainage system cleaning and repair,
- Spot painting,
- Joint repair or replacement,
- Concrete sealing,
- Minor concrete patching and repair,
- Concrete crack sealing,
- Approach pavement relief joints, and
- Slope paving repair.

Mix of Fixes

Various combinations of the work activities were compared to determine the best mix of fixes to achieve the state's goals. A combination of 30 percent of annual funding for CPM, 25 percent for rehabilitation, and 45 percent for replacement was most effective. The state distributes the CSM budget of $10 million according to the number of bridges in each region.

Several years of implementing the strategy, however, showed that the targeted proportion of CPM was too high, generating more projects than could be addressed. The strategy therefore was adjusted to 20 percent CPM, 30 percent rehabilitation, and 50 percent replacement. Moreover, because the state's seven regions have differing bridge conditions, each region required a different strategy.

Preserving Bridge Decks

Maintaining bridge decks is important to Michigan DOT's strategy. The deterioration of a bridge deck begins soon after construction, with shrinkage cracks. As the concrete undergoes freeze-and-thaw cycles, and truck traffic continually presses on the bridge deck, the cracks slowly propagate. Salt-laden moisture reaches the rebars through the cracks and causes corrosion. Eventually surface delaminations and potholes appear.

Michigan's strategy to preserve bridge decks starts early, with CSM. Deck cracks are sealed with epoxy-based, low-viscosity sealers.

In a recent informal survey, Michigan DOT bridge engineers and inspectors stated that maintaining the expansion joints is the primary activity that prolongs a bridge's life. Expansion joints prevent chloride-laden moisture from reaching the superstructure (for example, the beam ends, end diaphragms, bearings, and pins and hangers) and the substructure below the deck.

Extensive damage occurs if the expansion joints are not maintained. Therefore, expansion joint repair and replacement are included as CSM to halt the leaks as soon as possible.

Michigan DOT is making an effort to locate every leaking expansion joint, to develop a strategy for mitigating or eliminating the problem. A few regions have made substantial progress in the task.

Patching is done when delaminations are localized and constitute less than 5 percent of the bridge deck. A deck patch less than 5 square feet and less than 4 inches deep is classified as a surface repair. A prepackaged, fast-setting, repair mortar is applied.

Delaminated areas greater than 5 square feet require a structural repair patch. Contractors use mobile mixers to produce latex-modified concrete. The cure time before traffic is allowed on the bridge deck is 96 hours: 48 hours of continuous wet cure, followed by 48 hours of air cure. Structural repair patches are expected to last 8 years.

Thin epoxy polymer overlays are often applied when less than 5 percent of the bridge deck area has deficiencies. The overlays are expected to last 10 to 15 years.

The deep overlay is used most frequently in Michigan and is applied when the bridge deck surface is poor, but the underside is in good condition. The expected life of a deep concrete overlay is 25 to 30 years.

Bridges to Innovation

Scanning Tour Gains International Pointers

IAN M. FRIEDLAND

Automated systems are assisting in the inspection and management of the nation's transportation infrastructure—particularly in the design, inspection, maintenance, and operation of highway bridges and other highway structures. More can be learned, however, from the systems and technologies that other nations employ for bridge inspection and management.

From March 28 through April 13, 2003, the American Association of State Highway and Transportation Officials (AASHTO)–Federal Highway Administration (FHWA) Panel on Bridge System Preservation and Maintenance traveled to Africa and Europe, visiting South Africa, Switzerland, Denmark, and England, meeting with representatives from those nations, as well as from Germany, France, Sweden, Finland, Norway, and Wales. The tour was part of the Joint AASHTO-FHWA International Scanning Program, cosponsored by TRB's National Cooperative Highway Research Program and FHWA. The ten panel members—representing AASHTO, FHWA, state departments of transportation (DOTs), the National Association of County Engineers, and academia—met with highway agency representatives and with researchers and practitioners in the areas of bridge management and inspection technology.

The international scanning tour addressed the following topics:

- Organization and administration—including the relationship between national and local agencies; the organization of bridge activities (such as design, construction, operation, and inspection); the ownership and management of the bridge inventory; inventory characteristics (such as number, type, materials, and span lengths); and the type, frequency, and rigor of inspections.
- Bridge management systems—including the applications of economic modeling and forecasting, deterioration modeling, and information technology (such as databases, architecture, input, data transfer, and updating).
- Inspection—including typical practices, innovative methods, use of nondestructive evaluation technologies, use of load testing, designing for inspection accessibility, and "smart" bridges incorporating high-tech features.
- Operations—including vehicle permits, load rating and posting, indicators of performance, relationship to design and other activities, maintenance, repair, and enforcement.

The panel identified many policy and operational issues that could have an impact on U.S. bridge management and system preservation practices. Among the topics to be evaluated further and discussed with U.S. bridge-owning and -operating agencies are

- Inspection frequency according to bridge type and risk consequence;
- Qualifications and training for bridge inspectors;
- Integrated management approaches for highway structures, including bridges, tunnels, free-standing retaining walls, and sign and light fixtures; and
- Application and use of appropriate waterproofing systems for bridge decks.

The AASHTO–FHWA Panel is drafting a report documenting the scanning tour findings. The report will be ready for dissemination and technology implementation by the end of the year.

The author is Bridge Technology Engineer, Office of Bridge Technology, Federal Highway Administration, Washington, D.C.

Lengthening the Span of Bridge Service Life

RAYMOND McCORMICK

According to the National Bridge Inventory (NBI), the average age of the more than 590,000 bridges on public roads in the United States is 40 years. Approximately 28 percent of the bridges are considered deficient, but funding is not available for replacement or rehabilitation. The Federal Highway Administration (FHWA) therefore is focusing on rational, systematic processes to extend the useful service life of the nation's bridge inventory, relying in large part on state bridge management systems.

In January 2002, FHWA notified state transportation agencies that funds from the Highway Bridge Replacement and Rehabilitation Program (HBRRP) could be used for systematic preventive maintenance on bridges in the federal-aid highway system. This policy has assisted states in managing bridge funds to extend the service life of less critical bridges and to focus on the bridges most in need of replacement or rehabilitation.

FHWA has been reviewing its policies and regulations on bridges, to provide additional assistance to the states. A notice of proposed rulemaking to clarify and strengthen the National Bridge Inspection Standards was issued on September 9, with the goal of improving bridge inspection programs nationwide.

Comments on a proposed rulemaking on the HBRRP expressed the need for increased flexibility in state use of bridge funds, particularly for preventive maintenance. FHWA is developing a notice of proposed rulemaking, to be issued later this year or in early 2004, that will address many of the concerns.

FHWA also has formed a working group of state and federal bridge personnel to develop a new coding guide for bridge inspection and reporting that will clarify and explain the items coded by bridge inspectors and entered into the NBI. A draft of the updated coding guide will be ready in late 2003 for review and comment by the states.

The author is Senior Structural Engineer, Office of Bridge Technology, Federal Highway Administration, Washington, D.C.

HMA overlays are used for decks in poor condition. The overlays improve ride quality and add service life before more extensive work is necessary. The expected life of an overlay with a waterproofing membrane is 8 to 10 years. An HMA overlay is placed without a waterproofing membrane only if the deck is scheduled for replacement within 5 years.

Sustaining the Program

Maintaining a bridge preservation program is sometimes difficult because of the competing demands for highway repairs and the need to address the functional problems of bridges, such as inadequate widths and underclearance.

Michigan DOT has learned that different strategies are needed for different regions—some regions have many freeway bridges in poor condition while other regions already have achieved the goals for bridge network conditions. If a region's bridges are predominantly in poor or serious condition, a greater amount of rehabilitation and replacement is needed. As the network of bridges improves, CPM and CSM can receive more emphasis. The "siege mentality" of managing bridges by crisis must be abandoned to achieve the transition from poor to good condition.

Benchmarking is important for any bridge management system. Michigan DOT performs benchmarking to monitor the condition of the bridge network and to ensure that improvements are being made. The condition of the state's bridge network has been stabilized but must continue to improve.

Advanced management programs, forecasting, and benchmarking are tools for assessment and strategy, but the real improvement of the network depends on the bridge engineers, inspectors, designers, and system managers who must make the right decision for each bridge. The network improves one bridge at a time.

Tried-and-True Infrastructure in Canada

Guide Assembles Best Practices for Municipalities

NORMAND LEVAC, JERRY HAJEK, AND DAVID HEIN

Levac is Technical Manager, Canadian National Guide to Sustainable Municipal Infrastructure; and Hajek and Hein are with Applied Research Associates, Inc., ERES Consultants Division, Toronto, Ontario, Canada.

Canada has prepared a unique management and technical tool to help municipalities preserve infrastructure—the National Guide to Sustainable Municipal Infrastructure: Innovation and Best Practices. The guide deals with planning, management, and construction issues for all major components of municipal infrastructure, including roads, potable water distribution systems, sewers, and transit systems.

Preserving the pavement infrastructure ensures the transportation of people and goods but requires ever-increasing investments because of the increasing size of the roadway network and the increasing loads of commercial vehicles. New approaches are needed to maintain and improve the infrastructure effectively.

Because the U.S. and Canadian economies are closely interlinked, both countries have similar infrastructure needs. Similarities also arise in the technological approaches to infrastructure preservation. Canadian provinces participate in, and benefit from, many joint initiatives such as the Strategic Highway Research Program and the Long-Term Pavement Performance (LTPP) program. LTPP and the complementary Canadian-LTPP program, along with other research and development activities, have led to significant advances in asphalt and concrete material technologies and in pavement design and management, resulting in longer-lasting pavements at lower service costs. The challenge is to translate these developments into practice.

Assisting Municipalities

The pressure to preserve pavement infrastructure amid ever-increasing needs and to adopt new technologies and improved management procedures is greatest at the municipal level. Municipalities, however, have limited powers of taxation and often lack in-house technical expertise.

Canada's more than 5,000 municipalities are responsible for the management of approximately

Nearly 85 percent of Canada's population is located in major urban centers, and municipalities are responsible for management of more than 70 percent of all Canadian roads.

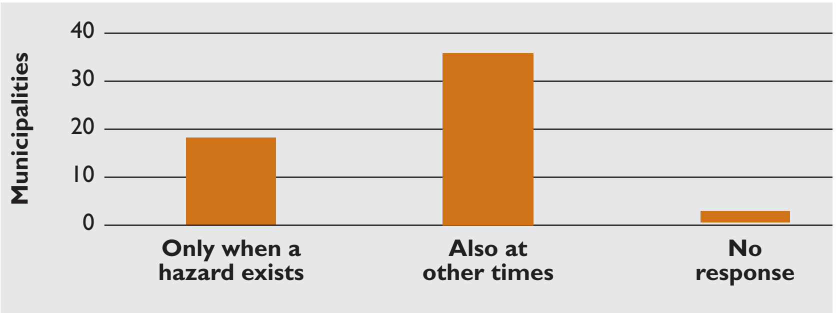


FIGURE 1 Response of Canadian municipalities to a recent survey question: "Is pavement maintenance initiated only when a perceived hazard exists?" The results of the survey indicate that pavement maintenance is often reactionary, not proactive.

750,000 two-lane-equivalent kilometers of public roads—not including local streets—ranging from multilane expressways to gravel roads. These represent more than 70 percent of all Canadian roads. Federal and provincial agencies manage the remaining 30 percent.

The provincial agencies and a few large municipalities, however, have undertaken the majority of the research and development activities in pavement preservation. With more funds and staff, provincial agencies and larger municipalities can afford to operate pavement management systems and to be innovative.

Smaller municipalities often depend on the knowledge of a local municipal or county engineer. Pavements often receive maintenance or rehabilitation on a worst-first basis (Figure 1).

A recurring lament from many municipalities, large or small, is the lack of a single authoritative reference for infrastructure preservation. Although useful for all practitioners, a single reference would be most beneficial to those in smaller municipalities.

Practical Tool

Infrastructure Canada—a federal agency—and the Canadian National Research Council have provided financial support for the development of the *National Guide to Sustainable Municipal Infrastructure: Innovation and Best Practices*, which is administered by the Federation of Canadian Municipalities. In-kind contributions from public and private municipal infrastructure stakeholders also have supported development.

The guide aims to assist municipalities and other infrastructure owners with a decision-making and investment-planning tool, as well as a compendium of technical best practices. The guide is also a focal point for the Canadian network of practitioners, researchers, and municipal governments involved in infrastructure operations and maintenance.

The guide addresses six key areas:

- Decision making and investment planning;
- Roads;
- Production and distribution of potable water;
- Collection, treatment, and disposal of stormwater and wastewater;
- Environmental protocols; and
- Urban transit.

The technical guidelines are communicated as best practices in each area. A best practice is an outline of recommended state-of-the-art methods and technologies that address a specific topic in infrastructure management or construction. Eight best practices have been developed in the subject area of municipal roads:

- Timely preventive maintenance for municipal roads, a primer;
- Priority planning and budgeting for pavement maintenance and rehabilitation;
- Sealing and filling cracks in asphalt concrete pavement;
- Rut mitigation at intersections;
- The construction of utility access boxes in pavements;
- The restoration and repair of utility access boxes in pavements;
- Coordination of infrastructure works to minimize disruption and maximize value; and
- Municipal roadway drainage.

Guide Development

The guide is a collaboration involving more than 500 representatives from more than 300 municipalities, plus volunteers, financial sponsors, consultants, trade organization staff, and university researchers. Municipal representatives participated through surveys, interviews, peer review groups, and committees. The process has raised awareness of the guide among stakeholders nationwide and has facilitated contributions.

Technical committees develop the best practices, drawing on input from working groups. A best practice takes about 9 months to complete, from conception to publication.

Draft best practices are posted on a website[1] to solicit public and peer review comments before final publication. The website offers a comprehensive source of information on the guide, and features a "get involved" section, recruiting commenters, reviewers, and committee members.

[1] www.infraguide.gc.ca

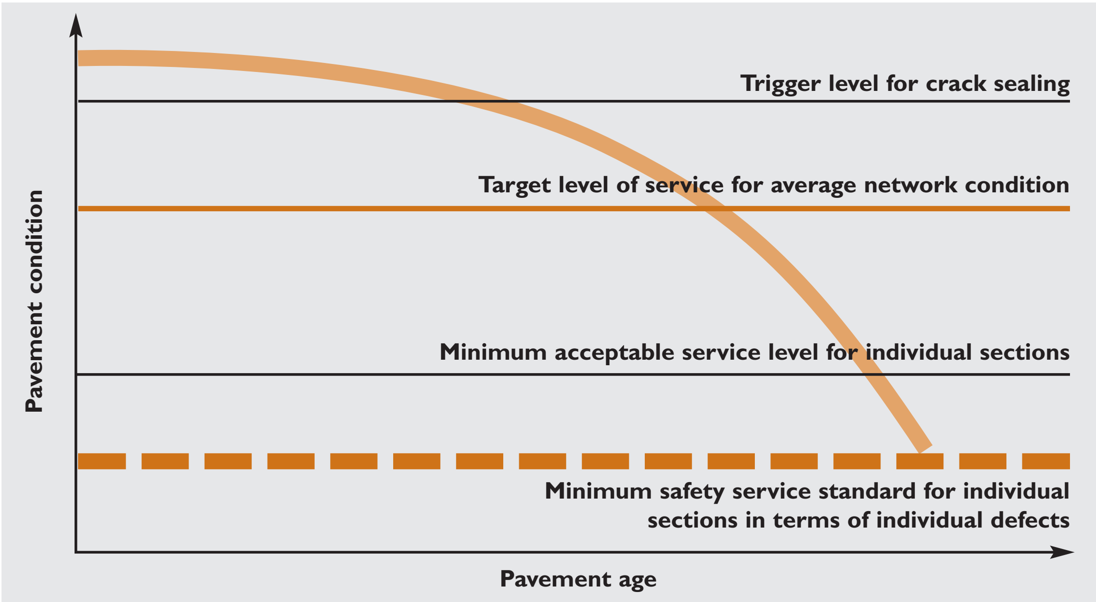


FIGURE 2 Best practices advise on how to establish required service levels to justify and quantify pavement preservation needs.

A Stitch in Time

Preventive pavement maintenance treats small problems before more expensive repairs are required. The best practice outlines the main features of a preventive maintenance program and the steps required for implementation, including the basic premises, the expected benefits, the identification of the sections for treatment, the need for ongoing support and assessment, and the importance of dedicated funding.

To be effective, a preventive maintenance program must apply the right treatment at the right time. All types of preventive maintenance and rehabilitation treatments should be part of a comprehensive, cost-effective pavement preservation program.

The key components of a successful preventive maintenance program are a pavement management system, including pavement inventory and condition assessment; performance prediction; and a framework for identifying and prioritizing preservation treatments.

Planning and Budgeting

The planning and budgeting process for pavement preservation should be systematic and easy-to-follow. The best practice provides a technically sound, business-oriented approach for taking care of the pavement infrastructure.

The planning and budgeting processes are linked and have a major effect on the condition of the pavement network and on the cost of maintenance. Planning should substantiate the budget—for example, with well-documented pavement preservation needs. In this way, budgeting combines technical and financial decision making.

The process of identifying and prioritizing needs must be consistent, transparent, and logical to be credible. The selection of the treatments must be realistic and must consider the appropriate service levels and minimum service standards. The result is not a wish list but a documented plan to meet approved and mandated standards and service levels (Figure 2).

The process presented in this best practice aims to generate objective information on pavement preservation needs for decision makers and the public. The process can quantify the link between the budget and the level of service provided to the public and can support funding requests for pavement preservation.

Crack Sealing

Crack sealing of asphalt concrete pavements is one of the most common maintenance treatments, routinely used by more than 70 percent of Canadian munici-

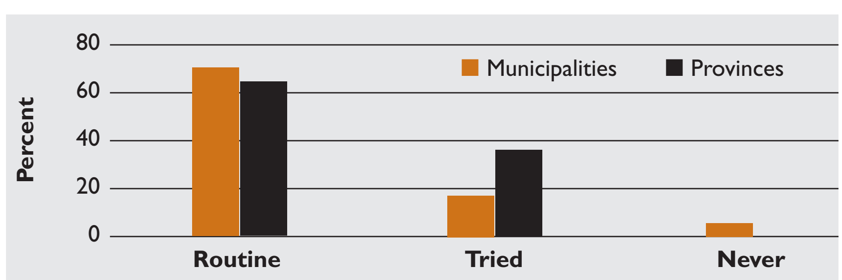


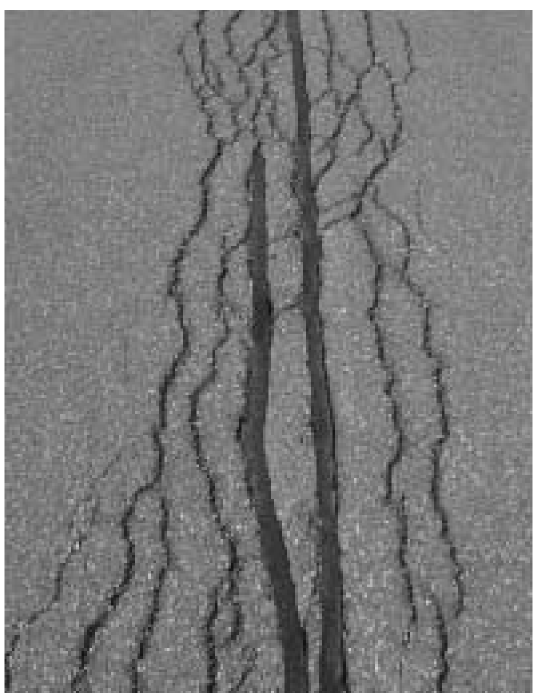
FIGURE 3 Use of crack sealing of asphalt concrete pavements by Canadian municipalities and provinces. All provinces have tried crack sealing.

Intersection rutting caused by deformation of top asphalt concrete layers. The guide includes detailed action plan to control rutting.

palities (Figure 3). An effective crack treatment program can retard deterioration and can extend the service life of a pavement by 3 to 5 years.

The success of a crack sealing program depends on the pavement condition, the sealant properties, and the method of preparation or installation. The best practice updates the guidelines for crack sealing treatment, including crack preparation and treatment (cleaning and routing), material specifications for sealants, sealant installation, and quality control procedures, along with a quality control checklist.

To rout or not to rout? Opinions vary, but routing—enlarging a crack to create a reservoir for sealant—appears to be preferred over the Band-Aid method of filling the cracks and smoothing the excess sealant. A typical rout configuration is 19 × 19 mm or 40 (width) × 10 mm and provides a reservoir for the sealant.



What went wrong? The original crack grew and was not resealed. The crack was not routed before installation of sealant. Updated guidelines address crack sealing treatments and quality controls.

Rut Mitigation

Asphalt concrete instability rutting at intersections, bus bays, and routes with considerable truck and bus traffic—particularly, slow-moving and standing traffic—is a concern for municipalities. Rutting also raises a safety concern, because water trapped in the wheel ruts can cause hydroplaning. Moreover, ice and snow in the ruts are difficult to dislodge and may reduce frictional resistance significantly. Ruts can become a nuisance to pedestrians during rainy weather, because of splashing from passing vehicles.

The best practice recommends cost-effective, technically sound treatments for mitigation of rutting and presents a detailed action plan to control rutting at critical areas through improved asphalt concrete technology. Treatments include

- Rut-resistant asphalt concrete—such as stone mastic asphalt and high-stability mixes—in the affected areas;
- Rut filling with spray patching, thin overlays, and microsurfacing;
- Localized grinding and precision milling;
- Concrete inlays—such as ultrathin whitetopping and roller-compacted concrete; and
- Interlocking concrete pavers.

Related Guidelines

Utility access boxes—such as catch basins, valve boxes, and manholes—can influence the performance of the surrounding pavement. Two best practices provide practical recommendations for the construction and rehabilitation of utility access boxes in roadways.

The best practice for coordinating infrastructure projects recommends streamlining communication about work on various components, particularly pavements and underground utilities, during rehabilitation and construction. The practice also addresses the consequences of utility cuts on pavement performance, as well compensation to roadway agencies for pavement damage.

Future Activities

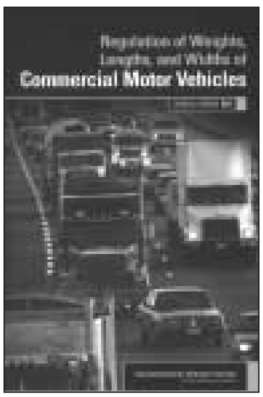
The first version of the guide comprises more than 40 best practices and should be available in 2005. The best practices will be updated periodically. The *National Guide to Sustainable Municipal Infrastructure* will consolidate a vast body of knowledge, shape best practices, and inform decision makers and technical personnel in the public and private sectors.

For additional information go to www.infraguide.gc.ca or contact the guide team at infraguide@nrc.ca.

TRB SPECIAL REPORT

Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles

JOSEPH R. MORRIS



Special Report 267: Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles is available on the web (http://gulliver.trb.org/publications/sr/sr267.pdf).

Federal and state regulations govern the weight and dimensions of trucks, buses, and trailers on U.S. highways. The regulations have economic consequences—trucking accounts for four-fifths of expenditures on freight transportation in the United States, and trucking costs are influenced by truck size and weight. Size and weight limits also influence highway construction and maintenance costs and the convenience and safety of highway travel. In addition, the regulations affect international commerce, because Canada and Mexico have different limits, and because international containers often do not meet U.S. standards.

States began to regulate vehicle dimensions before World War I. Federal limits were first enacted in 1956 in the Federal-Aid Highway Program legislation. The federal role originally was to protect the investment in roads and bridges and to allow uniformity of highway geometric design.

Extensive revisions of federal truck size and weight limits in 1983 included the first requirements that states conform to the federal standards. In 1991, federal regulations prohibited the states from expanding the operation of longer combination vehicles (LCVs)—multitrailers with a unit longer than 28 feet—on most major federal-aid roads.

The last two decades have brought changes in the use and characteristics of the highway system, as well as important structural changes in the freight industries. Congress has received proposals for revisions to the federal limits from industry groups, state governments, and others.

Proposals for changes in federal regulations governing vehicle size and weight are controversial, however, because larger trucks could increase some categories of highway costs and attract freight from railroads. Trucking firms and shippers' groups typically advocate liberalization, because larger trucks reduce costs. The railroad industry, highway safety advocacy groups, some trucking firms—especially smaller ones—and some states have opposed increases in federal size and weight limits.

Commissioning the Study

In June 1998, in the Transportation Equity Act for the 21st Century, Congress directed the Secretary of Transportation to request the Transportation Research Board (TRB) to conduct a study of the regulation of weights, lengths, and widths of commercial motor vehicles operating on federal-aid highways under federal regulation, and to develop recommendations. The National Research Council of the National Academies convened the Committee for the Study of the Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles (see box, page 37), under the auspices of the Transportation Research Board (TRB).

After reviewing past evaluations by the U.S. Department of Transportation (DOT), TRB, and others, the committee developed preliminary conclusions addressing the performance of federal size and weight regulations and the adequacy of information available for guiding regulatory decisions. The committee's recommendations involve organizational arrangements to promote reform of the federal regulations, and regulatory and management changes to improve the efficiency of freight transportation and to reduce the public costs of truck traffic.

The committee found that regulatory analyses of the benefits and costs of changes in truck dimensions are hampered by a lack of information. The uncertainty could be alleviated with a program of basic research.

Committee's Conclusions

Reform of federal truck size and weight regulations could improve the efficiency of the highway system. Reform may allow larger trucks to operate. The federal standards are poorly suited to the demands of international commerce. Special exemptions, generally granted without evaluation of the consequences, are eroding the regulations' effectiveness. Moreover, freight traffic may be bypassing Interstates to use secondary roads, generating higher public costs. Inflexible regulations also discourage private- and public-sector innovations to improve highway effi-

ciency and to reduce costs. Finally, highway users are not accountable for all the costs they generate.

Federal truck size and weight regulations should facilitate safe and efficient freight transportation and interstate commerce, establish highway design parameters, and manage consumption of public infrastructure assets. These objectives are consistent with the intentions of the Congressional legislation. Truck size and weight regulations ought to be complemented by other policies aimed at the same goals.

Changes in truck size and weight regulations with complementary changes in the management of the highway system offer the greatest potential to improve the system. The best way to control the costs of accommodating truck traffic is by coordinating practices in all areas of highway management: design and maintenance of pavement and bridges; highway user regulations, including safety-related vehicle and driver regulations; and highway user fees. When contemplating a change of policy in one of these three areas, Congress should consider complementary changes in the other two.

Past studies have not produced satisfactory estimates of the effect of changes in truck weights on bridge costs. Past studies have not evaluated how changes in truck weights affect the changes in the risk of bridge failure or a bridge's useful life. Instead, studies have estimated the cost of bridge replacement to maintain legal loads. Bridge replacement is the biggest component of the projected costs for accommodating larger trucks, but many of the replacements would achieve minimal risk reduction. Past studies have not quantitatively evaluated alternatives for attaining the same or greater risk reduction through less costly bridge management strategies.

It is not possible to predict with high confidence the outcomes of regulatory changes. Improved models are needed for analyzing the costs of operating trucks of different designs. Models and data, however, will never provide more than plausible indications of how institutions, markets, and technology will react to regulatory changes. Nevertheless, maintaining the status quo would miss opportunities to reduce the costs of transportation.

Responsible regulation is a process: the regulatory authority must do the best preliminary analysis possible, and when regulations change, the consequences must be observed systematically and the necessary adjustments must be made. The chances are greater that a regulatory change will yield a positive outcome if highway users have incentives through enforcement, user fees, and application of performance standards.

Examining the safety consequences of size and weight regulation is essential. Research and monitoring needed to understand the relationship of truck characteristics and truck regulations to safety and other highway costs are not being conducted today.

Understanding these relationships is key to the design of better highways, vehicles, and safety management and pollution control programs, and to providing a solid basis for truck size and weight regulation. Also important are information systems that record the performance of regulations and the consequences of changes.

Promising techniques are available to improve the safety of large trucks, but little is known about the effectiveness of the techniques. This knowledge gap, along with a lack of scientific understanding about the relationship of safety to truck design, road features, and other risk factors, makes it likely that opportunities to reduce accidents are being missed and that resources are being wasted on ineffective actions.

Although violations of size and weight regulations may be an expensive problem, monitoring of compliance is too unsystematic to allow estimates of the costs involved. Direct and systematic observation of the frequency and impacts of oversize and overweight vehicles—as well as of legally operated overweight vehicles—is needed, to determine the costs of violations and to evaluate the effectiveness of enforcement methods. The technology for low-cost monitoring is available.

Recommendations

Commercial Traffic Effects Institute

Congress should create an independent public organization, the Commercial Traffic Effects Institute, to observe and evaluate commercial motor vehicle performance and the effects of size and weight regulation. The institute would develop federal size and weight standards and related highway management practices, recommend regulatory changes, evaluate the results of the implementation of new regulations, and support state implementation of federal regulations. The institute would enter into agreements with private-sector entities to conduct joint programs of data collection, research, and evaluation.

Functions

The institute's objective would be to reduce the public and private costs of truck freight and passenger coach transportation by developing proposals for changes in size and weight regulations, as well as changes in related highway system management and operating practices, including user fee policies. The institute would promote innovation by providing a means to evaluate and implement private-sector or state proposals for new motor vehicle or highway operating practices that require federal regulatory accommodation.

The scope of the institute's activities would include

- ◆ Pilot studies of proposed new vehicles and related operating practices, as well as research on the relationship of vehicle characteristics to highway transport costs.
- ◆ Monitoring and program evaluation in three areas: truck and coach traffic volumes, as well as the distributions of vehicle dimensions and configurations; the administration of regulations, including enforcement and fees; and the costs of truck traffic to highway agencies and to the public.
- ◆ Support for state implementation of federal size and weight regulations.

The institute would recommend changes in federal regulations when evidence shows that the changes would further the objective of reducing the public costs of commercial highway transport. The institute also would recommend ways to harmonize areas of federal highway policy in size and weight regulation and truck costs, including safety regulation, enforcement, infrastructure design and management, and user fees.

Organization

The institute would be governed by a board with members drawn from the federal and state governments and the private sector. Funding for core and continuing activities would come from federal highway user fees. Private sponsors of proposed new vehicles or regulations would participate in funding the evaluations of their proposals. A professional staff with diverse expertise would be essential.

The board would prepare a business plan and a technical plan for the institute. The business plan would specify the form of cooperative relationships with the states, the private sector, and other federal agencies. The technical plan would set forth a process that could become an essential part of the government's management of the highway system. The institute would be subject to a sunset review by Congress after a specified time, possibly 6 years.

Pilot Studies

Congress should authorize the Secretary of Transportation to approve pilot studies involving temporary exemptions from federal motor vehicle size and weight regulations for vehicles operating within alternative limits and operated by motor carriers that agree to participate in evaluation of the safety, infrastructure cost, and other impacts of the alternative limits. U.S. DOT would approve pilot studies recommended by the institute, which would be responsible for planning the studies, carrying out the evaluations, observing that carriers comply with the conditions of the studies, and making recommendations to U.S. DOT and Congress if changes in federal regulations are warranted.

Immediate Regulatory Changes

Federal law should allow any state to participate in a federally supervised permit program for the operation of vehicles heavier than the present federal gross weight limit, if U.S. DOT has certified, on the advice of the institute, that the state meets all requirements. The institute would be responsible for monitoring the consequences of the federally supervised permit program, which would rationalize the present, largely uncontrolled and unmonitored system of state-issued exemptions.

With the permit program, the federal government would have diminished involvement in defining dimensional limits, but greater responsibility for ensuring that state regulations governing the use of vehicles on federal-aid highways are contributing to

Committee for the Study of the Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles

James W. Poirot (*Chair*), Chairman Emeritus, CH2M HILL, Mukilteo, Washington

Kenneth D. Boyer, Professor, Department of Economics, Michigan State University

Robert G. Dulla, Senior Partner, Sierra Research Inc., Sacramento, California

Nicholas J. Garber, Professor and Chairman, Department of Civil Engineering, University of Virginia

Thomas D. Gillespie, Research Scientist and Adjunct Professor, University of Michigan

Ezra Hauer, Professor, Department of Civil Engineering, University of Toronto

James H. Kopf, Deputy Executive Director and Chief Engineer, Mississippi Department of Transportation

Sue McNeil, Director, Urban Transportation Center, University of Illinois, Chicago

Eugene E. Ofstead, Assistant Commissioner for Transportation Research and Investment Management (retired), Minnesota Department of Transportation

John R. Pearson, Program Director, Council of Deputy Ministers Responsible for Transportation and Highway Safety, Ottawa, Ontario, Canada

F. Gerald Rawling, Director of Operations Analysis, Chicago Area Transportation Study

James E. Roberts, Chief Deputy Director (retired), California Department of Transportation

John S. Strong, Professor of Finance and Economics, School of Business Administration, College of William and Mary

C. Michael Walton, Ernest H. Cockrell Centennial Chair in Engineering, Department of Civil Engineering, University of Texas at Austin

the attainment of national objectives. In effect, federal oversight would tend toward performance standards: states would propose solutions to problems, and the federal government would assess whether the proposals met qualitative objectives. Federal regulation would provide a buffer for state highway programs against local, short-term economic pressures to depart from best management practices.

Size and Weight Provisions

States would be allowed to issue permits so that the following vehicles could operate on any road from which they are now prevented by federal law:

- Six-axle tractor-semitrailers with maximum weight of 90,000 pounds; and
- Double-trailer configurations with each trailer up to 33 feet long; seven, eight, or nine axles; and a weight limit governed by the present federal bridge formula.

After a transition period, all trucks operating under grandfather exemptions or state-specific exemptions from federal rules would be subject to the monitoring and evaluation requirements of the proposed permit program. Reliable information on the impacts of grandfather operation would allow Congress to decide whether to alter the grandfather provisions or to extend additional permitting flexibility to all states.

The recommended permit vehicle specifications are not presented as optimal. The definitions of the vehicles eligible for permitting would be subject to revision.

Implementation Provisions

Enforcement. A legislatively defined joint federal–state program for enforcement under the permit program would establish

- Formal and effective performance monitoring of enforcement functions;
- Application of new enforcement tools, which may include federal penalties for violation of federal limits;
- Adequate enforcement funding, including federal contributions from user fee revenues; and
- A program to advance the application of information technology as an enforcement tool.

User Fees. Legislation creating the permit program should specify a quantitative test for the revenue adequacy of the permit fees. As far as possible, fees should be structured to deter the use of truck configurations that incur public costs exceeding private benefits. Fees should cover estimated administrative and infrastructure costs for the program at a minimum; however, state proposals for fees that reflect other external costs or benefits would be acceptable.

Safety Requirements. As a temporary measure, equipment requirements of the most rigorous state permit programs would be imposed on permit recipients. States that apply to participate would submit requirements for review by the institute and for approval by the U.S. DOT secretary.

Bridge Management. If larger trucks are allowed under its permit program, a state will need a cost-effective plan for alleviating constraints caused by deficient bridges. U.S. DOT will need to evaluate a state's management of the bridge costs of larger trucks.

Longer Combination Vehicles

Federal law should allow LCVs to operate under the provisions of the federally supervised permit program and to participate in pilot studies.

Routes and Roads

The committee does not see justification for revising the specifications for the networks of roads subject to federal dimension regulations. In particular, there does not appear to be justification for extending federal weight regulation to the non-Interstate portion of the National Highway System, now governed mostly under state regulations. New enforcement mechanisms and a plan for evaluating the safety effectiveness of route restrictions are necessary before enactment of any new federal regulations for truck operations on restricted roads.

Research

The preceding recommendations call for three kinds of activities involving data analysis and research: systematic monitoring of truck traffic and truck costs to evaluate regulatory effectiveness, basic research on the relationship of truck characteristics to highway costs, and pilot studies to test new vehicles. The following are specific topics for research:

- Evaluation of the effectiveness of the enforcement of size and weight regulations,
- Air quality impacts of changes in truck characteristics,
- Relation of truck performance to crash involvement,
- Risk-based bridge costs,
- Freight transportation market research,
- Costs of mixed automobile and truck traffic in terms of nuisance and stress, and
- New infrastructure development and truck-only facilities.

The author, Senior Program Officer, TRB Division of Studies and Information Services, served as study director for this project.

Access Management Manual

TRB Committee Documents the State of the Art

KRISTINE M. WILLIAMS

The author is Program Director, Planning and Corridor Management, Center for Urban Transportation Research, University of South Florida, Tampa. She is a member of the TRB Committee on Access Management.

With growing congestion and traffic demand, the need for effective corridor management strategies is greater than ever. These strategies include access management, which involves the systematic control of the location, spacing, design, and operation of driveways, median openings, interchanges, and street connections, as well as median and auxiliary lane treatments and the spacing of traffic signals.

Agencies are updating or expanding access management activities to realize a variety of benefits:

- Preserving or improving public safety,
- Extending the life of major roadways,
- Reducing traffic congestion and delay,
- Supporting alternative transportation modes, and
- Improving the appearance and quality of the built environment.

In the past few decades, substantial research has advanced the state of the practice. This research, combined with new agency policies, plans, and programs, has provided insights into the impacts of access management techniques, has identified best practices, and has produced guidelines. The information, however, is dispersed across a variety of sources, making it difficult for practitioners to locate, evaluate, and apply.

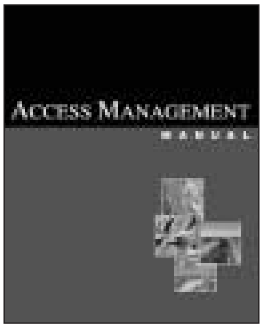
In 1996, the TRB Committee on Access Management initiated a project to compile the best information on the subject into a single, comprehensive resource documenting the state of the art. The *Access Management Manual*, published by TRB in May, is the culmination of this multiyear effort. The manual was prepared by the Center for Urban Transportation Research at the University of South Florida, with oversight and assistance from the committee and its subcommittees. The Federal

Aesthetics with access management and without (*inset*).

Why Is Access Management Necessary?

Failure to manage access is associated with the following adverse social, economic, and environmental impacts:

- Increased numbers of vehicle crashes;
- More collisions involving pedestrians and cyclists;
- Accelerated reduction in roadway efficiency;
- Unsightly commercial strip development;
- Degradation of scenic landscapes;
- More cut-through traffic in residential areas, because arterials are overburdened;
- Homes and businesses adversely affected by the widening of roads; and
- Increased commuting time, fuel consumption, and vehicle emissions, as driveways and traffic signals intensify congestion and delay along major roads.



The *Access Management Manual* is available in print and in CD-ROM from TRB [www.TRB.org/trb/bookstore/ or call 202-339-3213; book, $80 ($60, affiliates); CD-ROM, $60 ($45, affiliates); book and CD-ROM, $100 ($75, affiliates)].

Highway Administration provided funding for the project, and the Florida Department of Transportation served as project manager.

Practitioners and Stakeholders

Access management has many dimensions, cutting across jurisdictions, organizational lines, and professions. A goal of the project, therefore, was to provide information for a diverse audience.

The primary audience is the practitioner engaged in access management with a state transportation agency, local government, or metropolitan planning organization (MPO), or as a consultant in planning, engineering, or urban design. The manual offers practical information about the development and implementation of programs, including corridor access management plans, codes, and access design.

Another key audience consists of stakeholders, such as developers, elected and appointed officials, attorneys, and neighborhood groups involved in or affected by access management actions. The manual provides information to help stakeholders understand and evaluate proposed access management actions and potential alternatives. Educational information covers principles of access management, the impacts of access management techniques, regulatory best practices, right-of-way and legal considerations, and effective access design.

Techniques and Guidance

The *Access Management Manual* presents techniques for implementation, as well as guidance on how to develop and administer effective access management programs. The manual addresses a variety of circumstances that state, regional, and local agencies may encounter. The chapters offer practical information that draws on the knowledge of the many experienced practitioners who participated in development of the manual.

In particular, the manual presents detailed information on

- Principles and effects of access management;
- Steps in developing an access management program or corridor access management plan;
- Access management techniques and their potential advantages, disadvantages, and applications, with examples;
- How to develop and assign access categories to roadways;
- The role of states, MPOs, and local governments;
- The interrelationship with land development and how to address access management in the context of comprehensive planning and land development regulation;
- The rationale for spacing standards and how to choose appropriate standards for connections, signals, corner clearance at intersections, and interchange areas;
- Information on the location and design of access features, such as driveways, medians, auxiliary lanes, and service roads (Figure 1);
- When to choose a median instead of a continuous two-way left-turn lane;
- Case examples of agency policies, plans, practices, and programs;
- State statute and regulatory prototypes;
- The permitting and administrative processes and how to handle deviations from standards;
- How to work with the public on access management issues; and
- Legal considerations that guide program development and implementation.

Updating and Advancing

The manual is part of an ongoing effort by the TRB Committee on Access Management to disseminate useful, high-quality information on the state of the art. Plans are under way to promote access management research and to identify best practices; case studies and field studies are being encouraged.

Other initiatives look to integrate access management into traditional transportation processes and programs. The committee plans to update the manual regularly, to incorporate the latest research findings and agency experiences.

Access Management Manual Table of Contents

1 Introduction and Concepts
2 Effects of Access Management
3 Developing a State Access Management Program
4 Local and Regional Programs
5 Roadway Classification and Access Categories
6 Corridor Access Management Plans
7 Land Development and Access
8 Access Location
9 Access Spacing
10 Access Design
11 Medians and Continuous Two-Way Left-Turn Lanes
12 Access Permitting
13 Internal and Intergovernmental Coordination
14 Public Involvement in Access Management
15 Right-of-Way and Legal Considerations
Appendix A: Access Management Techniques
Appendix B: Case Examples of Access Categories
Appendix C: Access Management Statute Prototypes and Regulatory Elements
Appendix D: Glossary

CALENDAR

TRB Meetings

2003

November

12–15 6th Rail Passenger Caucus
San Francisco, California
Peter Shaw

16–18 9th National Light Rail Transit Conference*
Portland, Oregon
Peter Shaw

19–22 International Symposium on Road Pricing
Key Biscayne, Florida

2004

January

10 Pavement Performance Data Analysis Forum
Washington, D.C.
A. Robert Raab

11–15 TRB 83rd Annual Meeting
Washington, D.C.
Mark Norman, Linda Karson

April

13–17 5th International Conference on Case Histories in Geotechnical Engineering*
New York, New York
G. P. Jayaprakash

May

5–8 5th International Conference on Cracking in Pavements: Risk Assessment and Prevention*
Limoges, France
Frank Lisle

23–26 10th International Conference on Mobility and Transport for Elderly and Disabled People (TRANSED 2004)
Hamamatsu, Japan
Claire Felbinger

June

7–9 6th International Symposium on Snow Removal and Ice Control Technology
Spokane, Washington

27–30 North American Travel Monitoring Exposition and Conference (NATMEC) 2004
San Diego, California

July

21–24 Highway Capacity and Quality of Service Committee Midyear Meeting and Conference
State College, Pennsylvania
Richard Cunard

27–31 Modeling Unsaturated Soils for Transportation Projects*
Los Angeles, California

August

29–Sept. 1 6th National Meeting on Access Management
Kansas City, Missouri
Kimberly Fisher

September

13–17 Structural Materials Technology (SMT): NDE/NDT for Highways and Bridges*
Niagara Falls, New York
Stephen Maher

22–24 9th National Conference on Transportation Planning for Small and Medium-Sized Communities: “Tools of the Trade”
Colorado Springs, Colorado
Kimberly Fisher

25–29 2nd International Conference on Accelerated Pavement Testing*
Minneapolis, Minnesota
Stephen Maher

October

19–22 2nd International Conference on Bridge Maintenance, Safety, and Management (IABMAS’04)*
Kyoto, Japan

19–24 6th International Conference on Managing Pavements*
Brisbane, Queensland, Australia
Stephen Maher

2005

January

9–13 TRB 83rd Annual Meeting
Washington, D.C.
Mark Norman, Linda Karson

June

3rd International Symposium on Highway Geometric Design
Spokane, Washington

July

17–20 6th International Bridge Engineering Conference
Boston, Massachusetts

Additional information on TRB conferences and workshops, including calls for abstracts, registration and hotel information, lists of cosponsors, and links to conference websites, is available online (www.TRB.org/trb/calendar). Registration and hotel information usually is available 2 to 3 months in advance. For information, contact the individual listed at 202-334-2934, fax 202-334-2003, or e-mail lkarson@nas.edu/. Meetings listed without TRB staff contacts have direct links from the TRB calendar web page.

*TRB is cosponsor of the meeting.

HIGH-CAPACITY PILES

Confirming the Viability of Cost-Efficient Bridge Designs

BRIAN A. LIEBICH

The author is Senior Transportation Engineer, Foundation Testing Branch, Geotechnical Services, Division of Engineering Services, California Department of Transportation, Sacramento.

On many bridge projects, the California Department of Transportation (Caltrans) has achieved substantial cost savings and has reduced construction time by using large-diameter, high-capacity piles. With the region's high seismic loads, many bridges have column loadings of 3,000 to 6,000 kips (13 to 26 meganewtons). Designers prefer single piles instead of pile groups to carry the loads, especially in deep scour sites, where drilled shafts are not feasible. In some circumstances, high-capacity piles have produced savings estimated at up to 25 percent of the total structure cost and at up to 75 percent of the foundation construction time.

Problem

Engineering estimates of cost and time savings interested Caltrans in the use of high-capacity piles. Questions about pile capacity, however, deterred the implementation.

The static design of high-capacity piles is problematic, because the design procedures were developed for smaller piles. The calculation of pile capacities with the various static formulae yields significant variations—and questions about reliability. Selecting the most conservative value has led to constructability problems, with contractors attempting to drive piles deeper than is feasible, to meet the design tip elevations. The resulting damage and wasted time and effort have led to successful contractor claims of up to $1,300,000 on individual projects.

In addition, measuring and analyzing dynamic information in the field to confirm driven pile capacity has been unreliable, whether using simple dynamic formulae or sophisticated computer analysis software and site-specific information.

Generally, use of high-capacity piles results in fewer piles and little or no redundancy; verification of capacity, therefore, is essential. The information on the behavior of high-capacity piles was not definitive, but the potential for significant cost savings encouraged further investigation. If the performance of high-capacity piles could be determined, then Caltrans could use the piles with confidence and could benefit from the savings.

Solution

Static pile load testing is the most definitive method for determining pile capacity. Caltrans purchased a $1.03 million static pile load test system with an 8,000,000-pound (35 meganewtons) capacity to test high-capacity piles. The components for the 8,000,000-pound capacity system matched the size and weight that could be transported safely and easily on the state's highways.

The objective of the research was to verify pile capacities on individual projects and to provide information about load-deflection behavior characteristics that could enhance designer knowledge of—and confidence in—static design procedures for high-capacity piles. The research results encourage designers to consider high-capacity piles whenever the economic benefits of use outweigh the cost of testing.

The pile load test system has a large steel reaction frame to transfer load from hydraulic jacks atop the test pile to four reaction piles. The main beam of the reaction frame is 64 feet (19.5 meters) long, 6 feet (1.8 meters) wide, and 9.3 feet (2.8 meters) high, and is composed of 160,000 pounds (72,500 kilograms) of Grade 70 high-performance steel.

Caltrans crew applies 8-million-pound load to test pile at Santa Clara River Bridge, U.S. 101.

Four 24-inch (61-centimeter) stroke high-pressure hydraulic jacks, each capable of applying 2,000,000 pounds, apply the load on the test pile. Electronic load cells measure the force applied to the test pile, and electronic displacement transducers measure the deflection. Each load test costs approximately $30,000 (including crane rental, transportation, and labor), and the four reaction piles installed for each test cost $225,000.

To quantify the capacity of high-capacity piles, Caltrans tested the first piles installed on several trial projects. An additional pile also was tested if the geologic conditions were variable. Experienced Caltrans technicians and engineers performed the testing and analysis.

The load-deflection information from the test was combined with pile stress and hammer energy information, measured during installation, to provide site-specific pile acceptance criteria. The test results verified that high-capacity piles could be designed and installed. Caltrans also intends to develop a large database of quality load tests to assist in developing improved static and dynamic pile models.

Application

The replacement of the Santa Clara River Bridge on Interstate 5 in Northern Los Angeles County in 2002 was the first project to specify high-capacity piles. The load test system tested piles up to the maximum capacity of 8,000,000 pounds.

Static design methods indicated that the pile would be minimally adequate, and the observed pile-driving behavior predicted that the pile capacity was insufficient without lengthening the pile. The field test, however, showed that the capacity of the installed pile was well above the design requirements and that shorter piles would suffice. The length of the piles was reduced by 10 feet. Two load tests on another Santa Clara River bridge on Highway 101 also resulted in significant savings.

Benefits

The new 8,000,000-pound pile load test program is an ongoing research project with immediate and quantifiable benefits. The program has proved that high-capacity piles can be adequately designed and constructed.

On the two Santa Clara River bridge projects, the pile testing permitted use of high-capacity piles, with an estimated savings of $14 million. In addition, high-capacity pile installation realized significant time savings in the construction schedule, compared with alternative methods.

Pile load testing confirmed that the length of the piles could be shortened and yet meet the required capacity. Testing also alleviated concerns about the lack of redundancy.

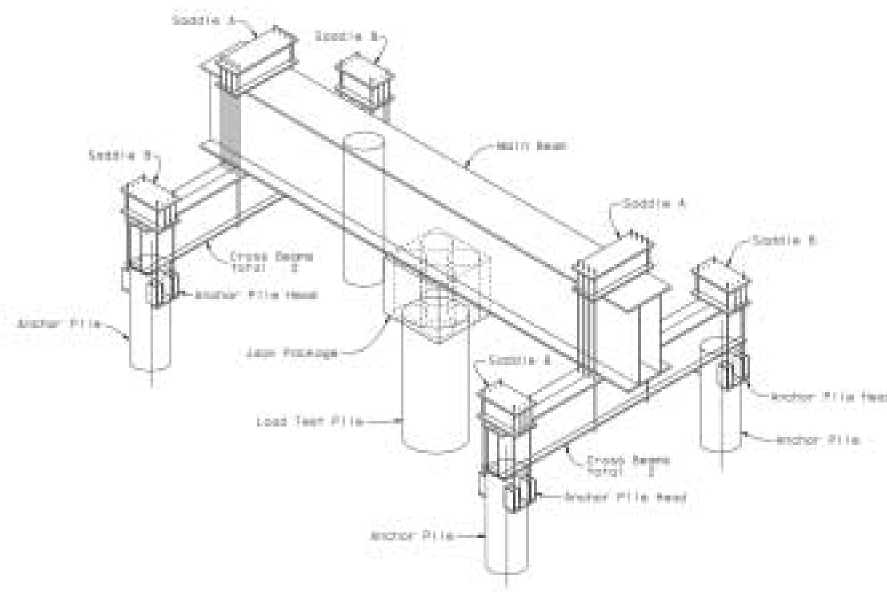
Six tests are scheduled in the next two years, and some tests of large drilled shafts are being planned. High-capacity piles allow designers to avoid pile caps that require deep excavations, especially watertight cofferdam enclosures, saving time and money. The piles allow designers to optimize the span lengths of bridges and to maximize the economic efficiency of the entire structure.

The high-capacity driven piles have produced fewer claims than alternative foundation methods. As more information is gathered from pile load tests, foundation designers will be able to take advantage of more rational static design of piles, increasing the efficiency of the design, as well as confidence in the constructed product.

For further information contact Brian A. Liebich, Geotechnical Services, Division of Engineering Services, California Department of Transportation, 5900 Folsom Boulevard MS#5, Sacramento, CA 95819-4612 (telephone 916-227-7164, e-mail brian.liebich@dot.ca.gov).

EDITOR'S NOTE: Appreciation is expressed to G. P. Jayaprakash, Transportation Research Board, for his efforts in developing this article.

Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001 (telephone 202-334-2952, e-mail gjayaprakash@nas.edu).



Schematic identifying major components of pile load system (isometric view).

William A. Hyman

William Hyman & Associates

"I was an undergraduate in economics at Berkeley in the late 1960s, when air quality problems were at their worst in California," William A. Hyman recalls. "By the summer of 1968, air quality had declined so badly that sometimes I couldn't see the huge bell tower on the Berkeley campus from 500 yards away. People do not realize how quickly air quality and other aspects of environmental quality can degrade."

After receiving a bachelor's degree from the University of California–Berkeley, Hyman went on to earn a Ph.D. in economics from the University of Wisconsin–Madison. "My commitment to transportation and environment-related problems is rooted in my student days," Hyman notes. In graduate school he signed up for a course in transportation policy, taught by John W. Fuller, who was at that time Director of the Bureau of Environmental and Policy Analysis at the Wisconsin Department of Transportation (DOT).

"I would say to young people starting in the field: embrace teamwork and enjoy the discovery process inherent in interesting projects."

Shortly after completing the course, Hyman was offered a job at Wisconsin DOT. He worked on a variety of projects, including a study on the social cost of the automobile and on several multimodal environmental studies.

"Fuller had assembled an extraordinary group of creative people and developed an exciting environment to work in," Hyman recalls. At the DOT, he honed key professional skills valuable throughout his career: contributing economic and environmental perspectives to project teams, communicating with engineers, and serving as a liaison between researchers and practitioners.

In 1984 Hyman joined the staff of TRB, where he managed a Congressionally requested study on transportation professional needs. He also helped with the preimplementation planning for the Strategic Highway Research Program.

His next position was with Austin Research Engineers (ARE), as coprincipal investigator in a project to investigate the feasibility of incorporating benefit-cost analysis into the Highway Performance Monitoring System. Later Hyman contributed to the development of the Federal Highway Administration's (FWHA) original Highway Economic Requirements System (HERS), largely based on his work at ARE.

Hyman is recognized as a leader in the fields of asset management, multimodal planning, and environmental analysis. Among the most significant studies he has managed are an environmental analysis of Wisconsin DOT's Six-Year Highway Investment Program, the development of a Multimodal Corridor Capacity Analysis Manual, and the development of a computer simulation model for determining cost-effective bridge repair for Wisconsin's state highways. Considered one of the first bridge management systems, the model is described in a paper that won Hyman the D. Grant Mickle Award from TRB in 1984.

Partly as a result of the successful bridge simulation model, Hyman was engaged by FHWA to help develop a bridge management system demonstration program and to establish the feasibility of an economic analysis of a network-level assessment of bridge needs. For a federally funded project managed by California DOT, Hyman served as a key member of the development team for Pontis, a comprehensive bridge management system, and later coauthored the AASHTO Guidelines on Bridge Management Systems.

Throughout his career, Hyman has conducted research and served as principal or coprincipal investigator for many National Cooperative Highway Research Program (NCHRP) projects. As coprincipal investigator, he helped draft a blueprint for integrated maintenance management systems and assisted with the Environmental Information Management and Decision Support System.

From 1988 to 1994, Hyman worked at the Urban Institute in Washington, D.C., as a Senior Research Associate and, for three years, as Director of the Transportation Studies Program. Hyman has authored more than 100 transportation reports and studies, in asset management, environmental analysis, human resource management, multimodal transportation planning, and research program development.

Over the past eight years, Hyman has worked for management consulting firms, as a principal of Cambridge Systematics in Washington, D.C., and in a similar position at Booz Allen Hamilton in McLean, Virginia. Clients have included NCHRP; FHWA; the Minnesota, California, and Wisconsin DOTs; and the Maryland State Highway Administration.

Hyman's TRB committee membership includes the Committees on Maintenance and Operations Management; Maintenance Personnel; Hazardous Wastes; and Bridge Management Systems. He currently chairs the Subcommittee on Environmental Maintenance.

"Two key factors have contributed to my success: Curiosity and always including on my team people who are smarter than I," Hyman muses. "I would say to young people starting in the field: embrace teamwork and enjoy the discovery process inherent in interesting projects."

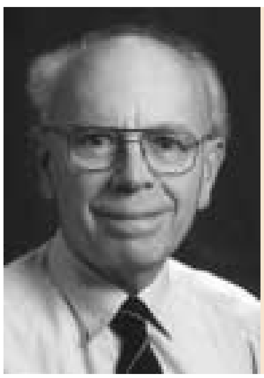
John B. Metcalf

Louisiana State University

In the mid-19th century most roads in Europe and many in the United States were paved with macadam, the novel, revolutionary layering technique developed by Scottish engineer John L. McAdam. Large stones placed under crushed stones and gravel allowed for drainage and assured runoff, ultimately providing faster and safer travel.

Times have changed, recounts Englishman John B. Metcalf, professor of civil engineering at Louisiana State University. "We now have to replace McAdam's 'drainage, drainage, drainage' with a quantified understanding of environmental effects—principally moisture movement, so we can design explicitly for the local condition."

After receiving a bachelor's degree with honors and a doctorate in civil engineering from Leeds University in England, Metcalf began his career at the Transport and Road Research Laboratory (TRRL) in London in 1958, where he acquired "an excellent understanding" of experiment planning and reporting. Several decades later, Metcalf discusses research in absolute terms: "The nature of transport is dependent upon, and must be designed for, local conditions. Yet any research program must be based on long-term fundamental studies and must also satisfy the immediate needs of its community and provide short-term, locally relevant results."



"Any research program must be based on long-term, fundamental studies and must also satisfy the immediate needs of its community and provide short-term, locally relevant results."

Metcalf soon moved to Australia to help compile a national database of soil engineering properties linked to the Northcote soil classification system, which groups soils into discernible profile forms with alphanumeric codes. The experience gave him new perspective on "the role of road transport in remote and developing regions."

In the 1970s he began work as the materials engineer for the Queensland Main Roads Department, generating an interest in construction quality control and a second stint at TRRL. Returning to the Australian Road Research Board, he initiated the Australian accelerated pavement testing program, known as ALF (Accelerated Loading Facility). ALF subsequently was sold to China and the United States and is considered by the Austroads Pavement Research Group as "the most productive accelerated loading program in the world."

Concurrently, Metcalf became involved with the Permanent International Association of Road Congresses (PIARC) and the Road Engineering Association of Asia and Australia, serving as Australia's technical representative. He gained what he calls "unmatched opportunities" to observe the many transportation problems in developing countries. "These experiences led me to take a broader interest in the role of roads and road transport with particular focus on low-volume road issues," he notes.

Metcalf continued to concentrate on low-volume roads in the 1980s, visiting New Zealand, Brazil, Indonesia, Burma, Saudi Arabia, China, and India as adviser or university instructor. In 1980, he worked with the Ministry of Communications in Indonesia to establish road roughness measuring equipment. In 1983, he advised the Organisation for Economic Cooperation and Development on economic design standards for low-traffic roads. He was a consultant to the Ministries of Communications in Burma in 1987 and in Saudi Arabia in 1988. He also has acted as adviser to the United Nations Department of Technical Cooperation for Development, the World Bank. In addition, he assisted the Federal Highway Administration in reestablishing ties with PIARC.

In 1992 Metcalf moved to Baton Rouge, Louisiana, to take the Freeport-McMoran Chair of Engineering at Louisiana State, a tenure broken only by visiting professorships worldwide. He has authored more than 120 papers, a test, and chapters in several books and has edited conference proceedings, addressing his primary areas of interest: technology transfer, low-cost roads, nonstandard materials, pavement design, and quality control. In 1997 Metcalf was awarded "Doctor Honoris Causa" from the G. Asachi Technical University in Iasi, Romania, and in 1998 he was named Researcher of the Year at Louisiana State University's Department of Civil and Environmental Engineering.

Metcalf is a member of several TRB committees, including Performance in Pavements, Superpave, International Activities, Low-Volume Roads, the Task Force on Accelerated Pavement Testing, and Chemical and Mechanical Stabilization, which he chairs. He was named emeritus member of the Committee on Low-Volume Roads in January 2003. Metcalf recently completed an NCHRP project on language and translation issues in technology transfer.

Today Metcalf says he "seeks work of practical application but that is supported—especially for road pavements—by full-scale experimentation of sufficient duration to encompass the effects of climate." He adds, "New developments in these areas will require more attention to real-world conditions. This in turn will require long-term commitment to the observation and recording of real-world phenomena over extended periods of time."

Deen Lecture To Cover Legal Issues in Design

Richard O. Jones, retired Regional Counsel for the Federal Highway Administration, is the 2004 recipient of TRB's Thomas B. Deen Distinguished Lectureship Award, which calls on career leaders to present overviews of their technical fields. Jones will receive the award and present his lecture, "Context-Sensitive Design: Will the Vision Overcome Liability Concerns?," on Monday, January 12, 2004, at the Marriott Wardman Park Hotel, Washington, D.C., during the TRB 83rd Annual Meeting. The text of the lecture will be published in the *Annual Meeting Compendium of Papers* CD-ROM distributed to meeting registrants and in a 2004 volume of the *Transportation Research Record: Journal of the Transportation Research Board.*

For more information about the Annual Meeting program, check the regularly updated postings at www.TRB.org/meetings. Reduced rates for advance registration are available until November 30; hotel reservations should be made as soon as possible before December 13.

COOPERATIVE RESEARCH PROGRAM NEWS

Guide for Pavement Friction

A Guide for Pavement Friction is needed to identify technologies, processes, and practices for designing and constructing pavements with good friction characteristics and to address the effects of friction on noise generation. The guide would update *Guidelines for Skid-Resistant Pavement Design*, published by the American Association of State Highway and Transportation Officials (AASHTO) in 1976, to reflect changes in vehicle characteristics, methods of collecting data, construction techniques, and materials that affect friction characteristics. In addition, new guidelines are needed to address legal, economic, and noise pollution issues associated with pavement friction.

ERES Consultants, a division of Applied Research associates, Inc., of Champaign, Illinois, has received a $349,805, 24-month contract (NCHRP Project 1-43, FY 2003) to develop a Guide for Pavement Friction for consideration and adoption by AASHTO. The guide will address the frictional characteristics and the performance of pavement surfaces and will review related tire–pavement noise. The research will examine highway pavements with asphalt and concrete surfaces but will not include roads with unpaved surfaces or with nonhighway pavements. The guide will help engineers to identify appropriate options for pavement surfaces.

For more information contact Amir N. Hanna, TRB (telephone 202-334-1892, e-mail ahanna@nas.edu).

Recycled Aggregates in Unbound Pavement Layers

Although much research has examined the properties of material reclaimed from hot-mix asphalt (HMA) and portland cement concrete (PCC) pavements and aggregates, limited research has addressed the use of recycled aggregates in unbound pavement layers. Nonetheless, many state highway agencies have used recycled aggregates in unbound pavement layers and have realized technical and economic benefits.

In reclaiming materials from highway pavements, however, tests intended to evaluate virgin aggregates could be compromised by binders and by contaminants from deicing chemicals and from vehicular traffic spills or from exposure to the elements. In addition, recycled materials may pose problems in construction that require evaluation. Research is needed to assess the validity of aggregate tests and, if necessary, to modify available tests or to develop new tests for evaluating and selecting recycled HMA and PCC materials for use as aggregates in unbound pavement layers.

ERES Consultants, a division of Applied Research Associates, Inc., of Champaign, Illinois, has received a $299,999, 24-month contract (NCHRP Project 4-31, FY 2003) to recommend procedures for performance-related testing and selection of recycled HMA and PCC materials for use as aggregates in unbound pavement layers, exclusively or in combination with other materials. This information will guide highway agency decision making about the use of recycled HMA and PCC materials as aggregates in unbound pavement layers.

For more information contact Amir N. Hanna, TRB (telephone 202-334-1892, e-mail ahanna@nas.edu).

Environment-Friendly Culvert Flows

Culverts are designed and constructed for hydraulic efficiency, to prevent flood flows from overtopping road embankments. Flows should contract and accelerate within a relatively smooth culvert barrel. Increased velocities, however, can cause increased outlet erosion, as well as problems for many migratory animals and for resident fish. High velocities in culverts, for example, may create barriers to juvenile salmon moving upstream or downstream in response to population pressures and changes in food sources.

To minimize the impact on the natural environment, culvert designs are maintaining natural flow velocities and minimizing turbulence, allowing migratory species to pass through the culvert barrel. The designs may add baffles on the invert, bury the invert, or use bottomless culverts for a natural stream invert. Other designs for larger and wider culverts—for example, arch, pipe arch, and bottomless shapes—reduce the contraction and acceleration of the flow.

The principles and methods for hydraulic assessments and design of culvert crossings, however, are inexact and evolving. Hydraulic loss coefficients and hydraulic equations range from semira-

Groups Honor TRB Staffers

Three TRB staff members have received awards for professional achievement and contributions:

◆ Robert Reilly, Director, Cooperative Research Programs, received the President's Transportation Award for Research from the American Association of State Highway and Transportation Officials (AASHTO). The citation noted Reilly's service to the nation through leadership on the AASHTO Standing Committee on Research and the Research Advisory Committee.

◆ Mark Norman, Director, Technical Activities, gained the Achievement Award from the Intelligent Transportation Systems (ITS) Council of the Institute of Transportation Engineers, for outstanding contributions to the advancement and implementation of ITS technologies.

◆ Richard F. Pain, Transportation Safety Coordinator, received the Distinguished Service to Safety Award, the highest individual honor of the National Safety Council, for career contributions to safety.

"These awards confirm the high-quality, professional contributions of staff in pursuing the mission of TRB," said Executive Director Robert E. Skinner, Jr.

Mark Norman receives award from John R. Freeman, Jr., International President, ITE.

tional to empirical; some are based on laboratory experiments and supported by limited prototype testing. As a result, hydraulic analyses and predictions for culverts are approximate. To design culverts that maintain natural velocities and that minimize impacts to the natural stream environment, therefore, hydraulic loss coefficients must be evaluated and made more accurate.

The Utah State University Water Research Laboratory in Logan has received a $325,000, 30-month contract (NCHRP Project 15-24, FY 2003) to refine and develop hydraulic loss coefficients for analysis and design of culverts for conventional and nontraditional, environmentally sensitive installations.

For further information contact Tim Hess, TRB (telephone 202-334-2049, e-mail timhess@nas.edu).

Backfill Materials for Retaining Walls

High-quality, free-draining, granular backfill, required in AASHTO specifications for the construction of mechanically stabilized earth (MSE) retaining walls, is becoming less available in many areas. As supplies decrease, costs most likely will increase. Research and practice, however, indicate that many soils in addition to those classified as AASHTO A-1-a have high strength (friction angles greater than 34 degrees) and are suitable as backfill within the reinforced zone of MSE retaining walls.

A Federal Highway Administration (FHWA) report (*Mechanically Stabilized Earth Walls and Reinforced Soil Slopes: Design and Construction Guidelines*, FHWA-SA-96-071) and a paper by G. Keller (Experiences with Mechanically Stabilized Structures and Native Soil Backfill, in *Transportation Research Record 1474*, pp. 30–38) indicate that other backfill materials have performed adequately for reinforced soil slopes and MSE retaining walls. In addition, the National Concrete Masonry Association has approved the use of other backfill in MSE retaining walls.

AASHTO requirements for plasticity and for the percentage of material passing sieve No. 200 preclude soils not classified as A-1-a for use as backfill in the reinforced soil zone for MSE walls. But the successful performance of reinforced slopes and retaining walls with other backfill necessitates investigation of the use of a wider range of soil types.

GeoTesting Express, Inc., of Boxborough, Massachusetts, has received a $600,000, 48-month contract (NCHRP Project 24-22, FY 2003) to develop selection guidelines, soil parameters, testing methods, and construction specifications that will allow a wider range of backfill materials for use within the reinforced zone of MSE retaining walls.

For further information contact Tim Hess, TRB (telephone 202-334-2049, e-mail timhess@nas.edu).

Soil-Nailed Structures in Bridge Design

The soil-nailing method of earth retention is the preferred option for retaining walls in many cut applications. The advantages of soil-nailed retaining structures include lower cost, speed of construction, construction flexibility, and aesthetics. FHWA Demonstration Project No. 103 developed a comprehensive design and construction manual for temporary and permanent soil-nailed structures (FHWA Report SA-96-069R). The manual contains a detailed design protocol for allowable stress design and an early, but incomplete, load and resistance factor design (LRFD) approach.

The *AASHTO Standard Bridge Specifications*, the *AASHTO LRFD Bridge Design Specifications* and the *AASHTO LRFD Bridge Construction Specifications* do not include guidance on the design and construction of soil-nailed structures. Some state DOTs therefore do not use soil-nailed retaining structures, despite the advantages. Standard design and construction specifications for soil-nailed structures are needed for incorporation into the *AASHTO LRFD Bridge Design and Construction Specifications*.

GeoSyntec Consultants, Columbia, Maryland, has received a $200,000, 18-month contract (NCHRP Project 24-21, FY 2003) to develop LRFD design and construction specifications for soil-nailed retaining structures. The specifications will be submitted to AASHTO for consideration as part of the *AASHTO LRFD Bridge Design and Construction Specifications*.

For further information contact Tim Hess, TRB (telephone 202-334-2049, e-mail timhess@nas.edu)

IN MEMORIAM

L. Stanley Crane 1916–2003

Chairman and Chief Executive Officer of Consolidated Rail Corporation (Conrail) from 1981 until 1988, L. Stanley Crane, who died on July 15, 2003, was "one of the prime architects of the global rail privatization movement," according to a rail colleague. He was credited with resuscitating Conrail—formed from Penn Central and five other rail systems in the Midwest and Northeast—when the venture seemed close to failure.

At Conrail, Crane implemented sound railroad management techniques learned during his career with Southern Railway and with Pennsylvania Railroad. Southern became the second most profitable railroad in the country during Crane's tenure.

Crane opposed the Reagan administration's plan to sell Conrail to Norfolk Southern Corporation, and fought to return Conrail to private stockholders in a public stock offering. In 1986 and 1987, Crane delivered two checks to the White House, one for $200 million and one for $100 million, to emphasize Conrail's marked improvement. The sale of Conrail in a public offering in 1987 was the largest in history.

After receiving an engineering degree from George Washington University in 1938, Crane started his career as a laboratory assistant at Southern Railway. With the exception of an interlude from 1959 to 1961, when he worked for Pennsylvania Railroad, he moved steadily through the ranks at Southern, and in 1970, he became executive vice president of operations. In 1976 he was named president and chief executive.

Crane was a member of the TRB Executive Committee from 1974 to 1977, and from 1988 to 1994. He also was a member of the Steering Committee for a Conference on Railroad Research Needs; the Committee for a Study of the Effects of Regulatory Reform on Technological Innovation in Marine Container Shipping; and the standing committees on Rail Transport Activities and on Conduct of Highway Research.

Patricia F. Waller 1932–2003


UMTRI/Kathleen Crockett Richards

Patricia F. Waller, a clinical psychologist, research scientist, and advocate for policy reform in transportation safety and injury control, died on August 15, 2003, in Chapel Hill, North Carolina. She served for 20 years as Associate Director for Driver Studies and as a faculty member at the University of North Carolina (UNC) School of Public Health, Chapel Hill; was the founding Director of the UNC Injury Prevention Research Center, from 1987 to 1989; and served as Director of the University of Michigan Transportation Research Institute in Ann Arbor from 1989 until her retirement in 1999.

With special research interests in the older driver, pedestrian safety, alcohol and driving, heavy truck safety, and driver licensing, Waller worked to ensure implementation of research findings through legislation and to incorporate injury control into the national transportation agenda. Before joining the UNC Highway Safety Research Center in 1967, she gained more than 10 years of experience as a practicing psychologist at the Veterans Administration Hospital in Brockton, Massachusetts, and in Bar Harbor, Maine.

Waller was appointed by President Jimmy Carter to the National Highway Safety Advisory Committee and to the Council on Spinal Cord Injury and was a past president of the Association for the Advancement of Automotive Medicine.

Waller served on expert committees for TRB and other divisions of the National Academies, including the TRB Committee for the Study of the Benefits and Costs of the 55-mph National Maximum Speed Limit and the Institute of Medicine Committee on Injury Prevention and Control. She was a member of more than 20 TRB committees on highway safety, motor carrier transportation, aging, women's issues in transportation, truck safety, and research and technology. She chaired two Technical Activities Group Councils—the Group 3 Council (Operation, Safety, and Maintenance) and the Group 5 Council (Intergroup Resources and Issues).

Among her many honors are the American Psychological Association's Hildreth Award for Public Service; the International Council on Alcohol, Drugs, and Traffic Safety's Widmark Award for Outstanding Contributions; the National Highway Traffic Safety Administration's Special Award of Appreciation; and the National Safety Council's Distinguished Service to Safety Award. She was the 1994 recipient of the TRB Roy W. Crum Award for outstanding achievement in transportation research.

The University of Michigan has established the Patricia F. Waller Scholarship Fund in her honor, to support graduate student research in transportation science.

Louis J. Pignataro 1923–2003

Distinguished educator and transportation researcher Louis Pignataro, professor at the New Jersey Institute of Technology (NJIT), Newark, died on June 25, 2003. His textbook, *Traffic Engineering: Theory and Practice*, has been used in more than 60 universities in the United States and abroad and is considered the definitive work on the subject.

At NJIT, City University of New York, and the Polytechnic Institute of New York, Pignataro developed interdisciplinary programs in transportation. Pignataro worked with Dr. Robert W. Burchell at the Center for Urban Policy Research at Rutgers University as coprincipal investigator on two large Economic Development Administration studies, as well as studies for the North Jersey Transportation Planning Authority.

From 1967 to 1970, Pignataro was director of the Transportation Planning Division at the Polytechnic Institute of Brooklyn. He then moved to the Polytechnic Institute of New York, where he taught and served as director of the Transportation Planning and Engineering Department from 1970 to 1985. He taught briefly at City University of New York, and in 1988 he became Executive Director for the Institute of Transportation at NJIT. Pignataro was also Distinguished Visiting Professor at Nankal University, Tianjin, China.

Among his honors and awards are the Distinguished Teacher Citation (Polytechnic Institute of Brooklyn), Engineer of the Year (New York State Society of Professional Engineers), and Transportation Engineer of the Year (Institute of Transportation Engineers, New York and New Jersey).

Pignataro chaired the TRB Transportation, Education, and Training Committee from 1992 to 1998. He served on a total of 13 TRB committees, including the Advisory Committee on Transit Performance Standards, the Selection Panel for Summer Minority Transit Internship Program, the Steering Committee for the Conference on Education and Intermodal Transportation, as well as the Committees on Highway Capacity and Future Concepts. He received TRB's D. Grant Mickle Award in 1980 for a paper on the operation and maintenance of transportation facilities.

Herbert J. Guth 1916–2003

Herbert J. Guth, who retired as director of the Office of Aviation Economics of the Federal Aviation Administration (FAA) in 1974 and then joined the TRB staff as Aviation Specialist until his second retirement in 1984, died in Washington, D.C., on August 2. Guth served as FAA representative on seven TRB committees: State Role in Air Transport, Aviation Forecasting, Airport Landside Operations, Airfield and Airspace Capacity, Air Transport Operations and Maintenance, and Aircraft–Airport Compatibility, and on the Task Force on Economics of Air Transport.

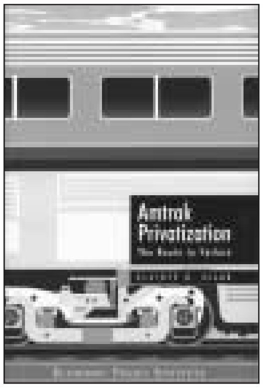
Guth received a bachelor's degree from the University of Wisconsin and a master's degree in economics from George Washington University. He served in the Army Air Forces during World War II and took part in the Strategic Bombing Survey to study the economic impact of Allied bombing on the German economy. After the war, he worked for the Office of Price Administration in Washington, D.C., before joining the staff of FAA in 1951.

Kenneth E. Cook 1933–2003

Longtime TRB staffer Kenneth E. Cook died in Baltimore, Maryland, on July 30, 2003. Cook served TRB from 1967 until 1995 as Transportation Economist, as well as liaison to state, local, national, and academic organizations. He came to TRB from the University of Virginia, where he taught economics while working for the Virginia Highway Research Council (now the Virginia Transportation Research Council).

Cook's many accomplishments at TRB include facilitating the establishment of the Intertribal Transportation Association for Native Americans, based in Stillwater, Oklahoma. He served as a TRB staff representative on more than 40 committees, including Management and Productivity, Transportation and Economic Development, Transportation Energy, Environmental Analysis in Transportation, and the Project Committee on Indirect Effects of Highway Improvements.

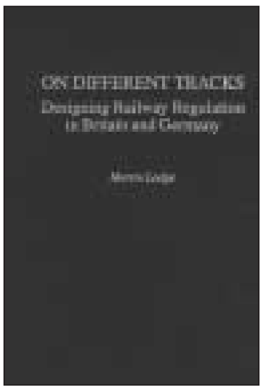
Diagnosed with cancer in 1996, Cook was active in patient advocacy groups. A graduate of Cornell University, he served as a pilot in the Air Force and was a Korean War veteran.



Amtrak Privatization: The Route to Failure

Elliott D. Sclar. Economic Policy Institute, Washington, D.C.: 2003; $8.95; paperback; ISBN 1-932066-01-2; 29 pp.

This 29-page study explains why Amtrak's highly selective business model is inappropriate. The salient point is that the benefits of rail services are not limited to those who directly patronize the system. The booklet highlights the secondary benefits of rail service to economic growth, environmental protection, and national security.

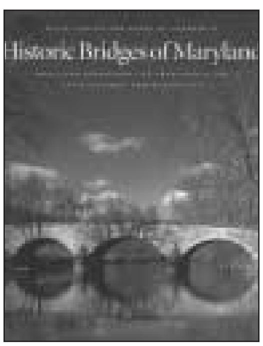


On Different Tracks: Designing Railway Regulation in Britain and Germany

Martin Lodge. Praeger Publishers, Westport, Connecticut: 2002; $64.95; hardcover; ISBN 0-275-97601-7; 219 pp.

Regulatory reform of the railway industry in Britain and Germany is examined, covering the periods after World War I, after World War II, and in the 1990s when both systems were considered to be in crisis. The primary topics of focus are government policies, regulatory policy, and operational performance.

The insulation of the regulatory process from coercive pressures, and the interaction of politics and administration in regulation, are addressed, to determine whether reforms were domain- or paradigm-oriented. The author looks at institutional isomorphism—the transformation of one unit's form into the identical or near-identical form of another—in considering policy domains and environments.



Historic Bridges of Maryland

Dixie Legler and Carol M. Highsmith. Maryland Department of Transportation, State Highway Administration, U.S. Department of Transportation, Federal Highway Administration, and Maryland Historical Trust Press: 2002, $38, hardcover, ISBN 1-878399-80-2, 136 pp.

Through photographs and descriptive text, this full-color, coffee-table book highlights the more than 400 Maryland bridges eligible for the National Register of Historic Places. The book chronicles the Maryland State Highway Administration inventory of bridges built between 1809 and 1947. Divided into five sections—Eastern Shore, Central and Southern, Northern, Western, and Historic Maryland—the book offers pictures of and insights into the bridges of Maryland's past. Many are landmarks linked to the Civil War and include bridges for the first federally funded road, rail lines, and the wagon traffic of Native American and early settlers.

Ten Principles for Successful Development Around Transit

Urban Land Institute; Washington, D.C., $10.00; 23 pp.

A 10-point outline of guidance for land development around transportation, this glossy, four-color publication advocates the following: make it better with a vision; apply the power of partnerships; think development when thinking about transit; get the parking right; build a place, not a project; make retail development market-driven, not transit driven; mix uses, but not necessarily in the same place; make buses a great idea; encourage every income level to live around transit; and engage corporate attention.

Vandalism, Terrorism, and Security in Urban Public Passenger Transport (Series ECMT–Round Table 123)

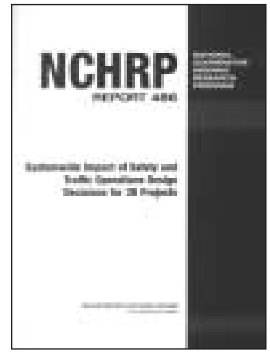
Organisation for Economic Co-operation and Development; Washington, D.C.; 2003; $35; ISBN 92-821-0301-3; 150 pp.

This compilation of reports marks the 123rd roundtable on transportation economics, held in Paris, April 11–12, 2002. Authored by transportation and security experts from Germany, France, Italy, and the United Kingdom, the reports, on countries and on cities—such as Berlin; Bochum, Germany; and Rome—address public safety and public spaces; security systems approach to public passenger transport; the causes of graffiti and vandalism; crime reduction and prevention; law enforcement; and terrorism as a threat to public transport. The roundtable participants unanimously denounce graffiti, acts of vandalism such as theft or assault, and basic qualitative factors such as lack of information for public transportation users, as "major sources of anxiety."

Local-level solutions include crime prevention, partnerships, policing, and communication with local media; at the national level, solutions depend on community and government. Actions at the international level include exchanging information and presenting safety in the context of liberalization, as well as cooperation in combating terrorism.

The books in this section are not TRB publications. To order, contact the publisher listed.

TRB PUBLICATIONS



Systemwide Impact of Safety and Traffic Operations Design Decisions for 3R Projects
NCHRP Report 486

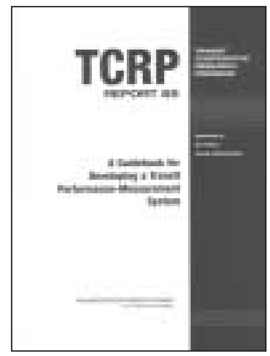
Highway agencies face a dilemma in determining the appropriate balance between resurfacing and safety improvements. This report presents a process for allocating resources to maximize the effectiveness of resurfacing, restoration, and rehabilitation (3R) projects in improving safety and traffic operations on the nonfreeway highway network. The Resurfacing Safety Resource Allocation Program, included on *CRP-CD-28*, is applicable to two-lane highways, multilane undivided highways, and multilane divided highways without control of access.

2003; 136 pp. plus CD-ROM; TRB affiliates, $24.75; TRB nonaffiliates, $33. Subscriber category: safety and human performance (IVB).

Using Customer Needs To Drive Transportation Decisions
NCHRP Report 487

Based on a review of current innovative practices, this report offers instruction on how to categorize customers into market segments, how to identify and prioritize customer needs and service expectations, and how to use that information to guide policy and investments. Case studies illustrate best practices within and outside of the transportation sector. The report concludes with guidelines for (*a*) preparing to deal effectively with customers, (*b*) gaining customer input, (*c*) applying customer needs in decision making, and (*d*) keeping customers informed.

2003; 105 pp.; TRB affiliates, $13.50; TRB nonaffiliates, $18. Subscriber category: planning and administration (IA).



A Guidebook for Developing a Transit Performance-Measurement System
TCRP Report 88

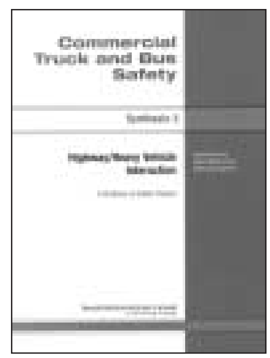
This guidebook presents a step-by-step process for developing a performance-measurement program incorporating traditional and nontraditional performance indicators that address customer and community issues. Each step includes a list of actions, how to complete them, and examples of different approaches. Detailed summaries are presented for 400 performance measures, and selection menus guide users through questions leading to specific measures. *CRP-CD-25* includes a hyperlinked version of the guidebook, allowing users to tap into related material and to navigate the selection menus, along with a background document detailing research sources.

2003; 368 pp., plus CD-ROM; TRB affiliates, $33; nonaffiliates, $44. Subscriber categories: public transit (VI); planning and administration (IA).

Financing Capital Investment: A Primer for the Transit Practitioner
TCRP Report 89

The primer evaluates financing options for public transportation capital projects. Although emphasizing approaches that take advantage of access to public capital markets, the primer addresses the tradeoffs of "paying as you go" versus borrowing against future resources. Organized for easy access to information, the primer includes sections that outline basic financing structures and that help managers decide when to apply alternative financing techniques.

2003; 172 pp.; TRB affiliates, $18.75; TRB nonaffiliates, $25. Subscriber categories: public transit (VI); planning and administration (IA).



Highway/Heavy Vehicle Interaction
CTBSSP Synthesis 3

Based on a literature review and surveys of state departments of transportation and the trucking industry, this synthesis presents the safety interactions of commercial trucks and buses with highway features and describes highway improvements that increase the safety of heavy-vehicle operations. Also addressed are the physical and performance characteristics of heavy vehicles on highways, geometric design criteria based on vehicle characteristics, traffic regulation and control devices, the use of intelligent transportation systems to improve communication with heavy-vehicle drivers, and access to real-time safety information.

2003; 94 pp.; TRB affiliates, $15.75; TRB nonaffiliates, $21. Subscriber category: highway operations, capacity, and traffic control (IVA), safety and human performance (IVB), public transit (VI), and freight transportation (multimodal) (VIII).

Impact of Red-Light Camera Enforcement on Crash Experience
NCHRP Synthesis 310

Motorists entering an intersection when a traffic signal has turned red have become a national safety issue. Traditionally, enforcement has involved police observation. However, this enforcement can now be

automated through the use of red-light cameras. The primary objective of this synthesis was to determine what impact red-light cameras have had on crashes and their related severity at intersections where a camera has been installed and, if possible, areawide for comparison. Other factors that can influence crash rates—geometry, operations, signage, public outreach—also were taken into consideration. The synthesis also reports on crash analysis procedures for evaluating the safety impact of red-light cameras.

2003; 57 pp.; TRB affiliates, $11.25; nonaffiliates, $15. Subscriber categories: highway operations, capacity, and traffic control (IVA); safety and human performance (IVB).

Performance Measures of Operational Effectiveness for Highway Segments and Systems
NCHRP Synthesis 311
During the 20th century, surface transportation programs focused primarily on the development of basic infrastructure networks. The challenge for the 21st century is managing and operating these resources to deliver services to customers under varying conditions, growing travel demands, and capacity limitations. This synthesis examines the use of performance measures by state DOTs, MPOs, and local governments for the monitoring and operational management of highway systems and segments. Specifically discussed are performance measures: the intended audience, the reporting and data collection techniques, the relative strengths and weaknesses, and examples of successful practices.

2003; 59 pp.; TRB affiliates, $11.25; nonaffiliates, $15. Subscriber categories: highway operations, capacity, and traffic control (IVA); safety and human performance (IVB).

Transportation and Public Policy 2002
Transportation Research Record 1812
Finance is the first part of this six-part volume on transportation and public policy. Topics include business relocation procedures in Virginia, toll road concessions, and highway costs. Part 2 covers pricing concerns in urban areas. Part 3 explores management, with studies on customer feedback and the forces shaping administration, among others. Part 4 focuses on designing and implementing educational programs for transportation professionals. Part 5 presents issues in economics and economic development, such as the benefits associated with mileage-based vehicle taxes, and Part 6 covers the asset management aspect of transportation investments.

2002; 227 pp.; TRB affiliates, $49.25; nonaffiliates, $66. Subscriber category: planning and administration (IA).

Construction 2002
Transportation Research Record 1813
Construction is the focus of this five-part volume of 37 papers. Part 1 considers problems in the construction and performance of portland cement concrete pavements. Part 2 examines bituminous pavements: determining air void content, detecting segregation, determining moisture in hot-mix asphalt, and more. Part 3 features topics such as the procedure for monitoring and improving the effectiveness of quality-assurance specifications. Part 4 gathers papers on concrete in bridges and structures, including smoothness provisions for bridge decks. Part 5 covers quality control and quality assurance, construction productivity, and other construction management issues.

2002; 321 pp.; TRB affiliates, $63; nonaffiliates, $84. Subscriber category: materials and construction (IIIB).

Design of Structures 2002
Transportation Research Record 1814
This eight-part volume comprises three major topics: (*a*) general structures, including beam deformations, failed traffic signal structures, and deflections on grid deck panels; (*b*) steel and concrete bridges, including field testing and seismic design; and (*c*) culverts and hydraulic structures.

2002; 261 pp.; TRB affiliates, $61.20; nonaffiliates, $72. Subscriber category: bridges, other structures, and hydraulics and hydrology (IIC).

Energy, Air Quality, and Fuels 2002
Transportation Research Record 1815
The papers in the first part of this three-part volume consider vehicle use, energy use, and greenhouse gas emissions in Delhi, India; truck efficiency strategies vis-à-vis fuel use and greenhouse gas emissions; and fuel economy gain through hybridization. The second part addresses air quality: vehicle emissions reduction; the benefits of air pollutant reduction through mandatory and voluntary programs; emissions inventories for mobile sources; environmental effects of passenger transportation; and effects on air pollution emissions from North American trade and transportation development. The final paper of the volume covers the availability of platinum for fuel-cell vehicles.

2002; 104 pp.; TRB affiliates, $25.50; nonaffiliates, $34. Subscriber category: energy and environment (IB).

To order the TRB titles described in Bookshelf, visit the TRB online Bookstore, www.TRB/org/trb/bookstore/, or contact the Business Office at 202-334-3213.

INFORMATION FOR CONTRIBUTORS TO

TR NEWS

TR News welcomes the submission of manuscripts for possible publication in the categories listed below. All manuscripts submitted are subject to review by the Editorial Board and other reviewers to determine suitability for *TR News*; authors will be advised of acceptance of articles with or without revision. All manuscripts accepted for publication are subject to editing for conciseness and appropriate language and style. Page proofs will be provided for author review and original artwork returned only on request.

FEATURES are timely articles of interest to transportation professionals, including administrators, planners, researchers, and practitioners in government, academia, and industry. Articles are encouraged on innovations and state-of-the-art practices pertaining to transportation research and development in all modes (highways and bridges, public transit, aviation, rail, and others, such as pipelines, bicycles, pedestrians, etc.) and in all subject areas (planning and administration, design, materials and construction, facility maintenance, traffic control, safety, geology, law, environmental concerns, energy, etc.). Manuscripts should be no longer than 3,000 to 4,000 words (12 to 16 double-spaced, typewritten pages), summarized briefly but thoroughly by an abstract of approximately 60 words. Authors should also provide appropriate and professionally drawn line drawings, charts, or tables, and glossy, black-and-white, high-quality photographs with corresponding captions. Prospective authors are encouraged to submit a summary or outline of a proposed article for preliminary review.

RESEARCH PAYS OFF highlights research projects, studies, demonstrations, and improved methods or processes that provide innovative, cost-effective solutions to important transportation-related problems in all modes, whether they pertain to improved transport of people and goods or provision of better facilities and equipment that permits such transport. Articles should describe cases in which the application of project findings has resulted in benefits to transportation agencies or to the public, or in which substantial benefits are expected. Articles (approximately 750 to 1,000 words) should delineate the problem, research, and benefits, and be accompanied by one or two illustrations that may help readers better understand the article.

NEWS BRIEFS are short (100- to 750-word) items of interest and usually are not attributed to an author. They may be either text or photographic or a combination of both. Line drawings, charts, or tables may be used where appropriate. Articles may be related to construction, administration, planning, design, operations, maintenance, research, legal matters, or applications of special interest. Articles involving brand names or names of manufacturers may be determined to be inappropriate; however, no endorsement by TRB is implied when such information is used. Foreign news articles should describe projects or methods that have universal instead of local application.

POINT OF VIEW is an occasional series of authored opinions on current transportation issues. Articles (1,000 to 2,000 words) may be submitted with appropriate, high-quality illustrations, and are subject to review and editing. Readers are also invited to submit comments on published points of view.

CALENDAR covers (*a*) TRB-sponsored conferences, workshops, and symposia, and (*b*) functions sponsored by other agencies of interest to readers. Because of the lead time required for publication and the 2-month interval between issues, notices of meetings should be submitted at least 4 to 6 months before the event. Due to space limitations, these notices will only appear once.

BOOKSHELF announces publications in the transportation field. Abstracts (100 to 200 words) should include title, author, publisher, address at which publication may be obtained, number of pages, and price. Publishers are invited to submit copies of new publications for announcement, and, on occasion, guest reviews or discussions will be invited.

LETTERS provide readers with the opportunity to comment on the information and views expressed in published articles, TRB activities, or transportation matters in general. All letters must be signed and contain constructive comments. Letters may be edited for style and space considerations.

SUBMISSION REQUIREMENTS Manuscripts submitted for possible publication in *TR News* and any correspondence on editorial matters should be directed to the Director, Publications Office, Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001, telephone 202-334-2972. All manuscripts must be submitted in duplicate, typed double-spaced on one side of the page and accompanied by a word-processed diskette in Microsoft Word 6.0 or Word Perfect 6.1. Original artwork must be submitted. Glossy, high-quality black-and-white photographs are preferred; if not available, we will accept color photographs. Slides are our third choice. Digital camera photographs and computer-generated images are not acceptable. A caption must be supplied for each graphic element submitted. Any graphs, tables, and line art submitted on disk must be created in Microsoft PowerPoint (do not use Harvard Graphics software). Required style for units of measurement: The International System of Units (SI), an updated version of the metric system, should be used for the primary units of measurement. In the text, the SI units should be followed, when appropriate, by the U.S. customary equivalent units in parentheses. For figures and tables, use only the SI units, providing the base unit conversions in a footnote.

NOTE: Authors are responsible for the authenticity of their articles and for obtaining written permissions from publishers or persons owning the copyright to any previously published or copyrighted material used in their articles.