Pavement Preservation Compendium II

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Table of Contents

Foreword

by David R. Geiger, P.E.

Since the release of the original *Pavement Preservation Compendium* in September 2003, there have been great initiatives taken by the State departments of transportation (DOTs), industry, and the Federal Highway Administration (FHWA) to advance the message of pavement preservation as one of several effective asset management tools. Since the last publication, FHWA has initiated a national evaluation of pavement preservation programs in the State DOTs and FHWA field offices to establish a national baseline to gain a uniform perspective on the current condition of this vital area. The message of "applying the *right* treatment to the *right* road at the *right* time" is becoming widely accepted across the country.

Even though the philosophy of pavement preservation has shown wide acceptance, there are still many challenges to be overcome before pavement preservation becomes standard practice. The concept of pavement preservation is at the crossroads. The articles and references that are presented in this compendium are a continuation of the activities to date. This compendium and other technology sharing materials serve as valuable resources for providing insight into advancements in the pavement preservation program technology and techniques. For more information, visit the following Web sites:

FHWA	www.fhwa.dot.gov/preservation
National Center for Pavement Preservation	www.pavementpreservation.org
Foundation for Pavement Preservation	www.fp2.org

David R. Geiger is the Director of FHWA's Office of Asset Management.

It's a Matter of Economics

Delaware County's chip seal program provides most economical way to preserve road system with limited budget

by Greg Udelhofen

Like many local road agencies, New York's Delaware County Highway Department has a limited budget to maintain the 270 centerline miles (two-lane roads) under its jurisdiction. According to Wayne D. Reynolds P.E., commissioner of Delaware County's Public Works, the highway department addresses those limited road dollars by preserving the existing system with an annual chip seal program—treating a fourth of the roads each year.

"We do what we can with the resources we have available," says Reynolds. "Most of the roads we're maintaining have a 'hammer stone' base and the increase in truck traffic and traffic volume has taken its toll on those roads."

Roads under the county's jurisdiction range from 4 to 7 inches of asphalt covering the large stone base. The chip seal program has been a mainstay in the county's maintenance approach to keep those roads in good serviceability. With each application, the county hopes to extend a road's service life another five to six years.

"We do some crack filling and some hot mix overlays, but our primary focus is to continue building up the roads with chip seal applications (some roads have five or six layers of chip seal)," Reynolds says. "In cases where we're experiencing heavy rutting due to the increase in truck volume, we T & L (true and level edges and excessive rutting) the road surface first before we apply a new chip seal coating."

With an annual maintenance budget of approximately $3.4 million ($1.3 million to support its own staff, $1.1 million for equipment expenditures and $1 million for outside contracts) the county's highway department tries to do as much as it can internally.

"Our staff takes great pride in being very efficient in executing the work that needs to be done," Reynolds says. "We complete our chip seal projects each summer within a three- to four-week period just after the Fourth of July."

In the case of this past summer's chip seal program, where Vestal Asphalt Inc. provided the emulsion, distributor truck and chip spreader, the county's crews trucked stone to the various road projects, provided its own traffic control and performed the required rolling after the stone was spread over the emulsion.

"We buy the stone we need in spring and begin trucking it to the various sites scheduled for chip seal," says Brian Francisco, general highway supervisor for Delaware County. "We take care of any preparation work required, like shoulders and T & L work, so that when it's time to begin applying the chip seal we're able to cover approximately 6 to 7 centerline miles a day. Our contract (with Vestal on the approximate 70 centerline road miles in 2005) called for four-tenths of a gallon of oil per square yard (application) and 22 pounds of stone per square yard. We purchased and hauled 25 pounds per square yard in case we needed to increase the application based on road conditions."

Delaware County's 2005 $300,000 contract with Vestal covered the 394,178 gallons of emulsion required, along with the cost of the distributor, chip spreader and service to operate those two pieces of equipment. Francisco says the county purchased the 12,318 tons of pre-tested stone separately from the Vestal contract.

"We've been doing it this way for a long time and seems to be the best approach in keeping our roads in good service," he says. "For the cost, it's the most economical way to get the job done, and the planning and execution of the (chip seal) program allows us to complete the work in about three weeks. The system just seems to work out well for us."

The chip seal program has been a mainstay in Delaware County's maintenance approach to keep roads in good serviceability.

Supplier, Contractor Role

Vestal Asphalt Inc, which is headquartered at Vestal, NY (near Binghamton), produces all grades of liquid asphalt emulsions—rapid setting, medium setting and slow setting—both anionic and cationic. The company utilizes these products for road construction services provided to town, county, city and village highway departments in central, western and northern New York, as well as northern Pennsylvania.

The company owns a broad selection of road construction equipment for chip seal operations, microsurfacing, slurry seal, crack filling, cold-mix production, cold-mix paving, cold patch products, dust control spraying operations (using both calcium chloride and asphalt emulsion dust oil) and full depth reclamation road rehabilitation. Vestal conducts business from two upstate locations in central New York.

For its chip seal operation, Vestal operates 20 asphalt distributors (mostly Bearcat and some Etnyre) and five chip spreaders (Bearcat and Etnyre), along with several rollers. Vestal has the capabilities to provide a turnkey chip seal operation, including traffic control, with aggregate trucking subcontracted. However, most customers choose to provide their own trucking, compaction and traffic control utilizing their municipal forces and equipment.

For the Delaware County Bid Specifications, for example, Vestal was required to quote prices for all grades of liquid emulsion and for various pieces of construction equipment (with and without operators) used in asphalt emulsion applications, including: power broom, steel wheel roller, pneumatic tire roller, variable width chip spreader, pugmill mixer, traveling plant mixer, recycler for full-depth reclamation, chip boxes, and bituminous asphalt paver. The county then purchases the needed asphalt product and contracts the needed equipment for a specific project. The specification did not include details of the construction process. Those details are worked out between Vestal and the road agency at the time of the project.

In the case of Delaware County awarding a chip seal project to Vestal, the contractor assesses the job and is allowed to make recommendations to the county regarding mix design and application rates. For the Delaware County chip seal projects this past summer, the county specified the application rates for emulsion and stone. Vestal monitored the rates and made recommendations for changes in the field where road conditions warranted deviations from the county's specified application rates.

"We've been working with Delaware County for a long time and we've been very flexible in providing the services they want us to provide," says Peter Messmer, technical services engineer for Vestal. Messmer, who handles the application and inspec-

With each application, the county hopes to extend a road's service life another 5 to 6 years.

tions on projects like Delaware County's chip seal program, says Delaware County typically solicits bids on the liquid asphalt it needs for targeted projects and then specifies the additional services and equipment it would like the winning bid to provide.

"We try to match our capabilities with their needs," Messmer says. "We can provide as much support as needed to complete the project or as little as required based on what they want to do themselves. When we are awarded the bid for the emulsion, the county is receptive to recommendations we may offer to successfully execute what they want, but we're always willing to mix and match our services with their own capabilities."

In 2005, Vestal produced and applied 750,000 gallons of emulsion, both cationic rapid set #2 (CSR2) and anionic rapid set #2 (RS2).

"In New York, emulsion manufacturers are applicators as well, and the key to working with road agency customers like Delaware County is having the capability to provide all the services they require and the flexibility to provide only what they want," Messmer says."We've been very fortunate to have a long relationship with Delaware County and that relationship has allowed both of us to work together in delivering the right solution for the county's road maintenance needs."

Reprinted from the *Asphalt Contractor,* February 2006.

Partnering for Pavement Preservation in California

Pavement preservation is receiving a new level of emphasis in California with the formation of the Pavement Preservation Task Group (PPTG). Comprised of representatives from the California Department of Transportation (Caltrans), local government, industry, and the Federal Highway Administration (FHWA), the group's goal is to be proactive about promoting pavement preservation initiatives. "Pavement preservation is the most cost-effective approach," says Shakir Shatnawi of Caltrans and co-chair of the task group. "Prevention is like found money."

The PPTG has numerous subtask groups that each focus on a different facet of pavement preservation, including education, innovation, recycling, strategy selection, binders, microsurfacing and slurry seals, chip seals, thin overlays, crack and joint seals, and the integration of pavement preservation with pavement management systems. Each of the subtask groups is co-chaired by Caltrans and industry representatives. "This is truly a partnership where people share expertise and resources and everyone is committed to its success," says Shatnawi.

The PPTG's initiatives to date range from creating technical guides and Web-based training to planning for a State pavement preservation center. The new *Caltrans Maintenance Technical Advisory Guide* (MTAG), for example, is a comprehensive reference guide on pavement preservation strategies, including materials and application requirements, field guidance and troubleshooting, and strategy selection. The final draft of the guide is available online at www.dot.ca.gov/hq/maint/roadway.htm. In addition, the PPTG is working with FHWA to develop a Web-based training and certification course based on the MTAG. This course will be made available to transportation agencies and contractors nationwide. Users will be able to tailor the training to their specific needs. The interactive training is expected to debut late this spring.

Caltrans, FHWA, and industry are also developing training courses on various pavement preservation concepts, strategies, and techniques for State, county, and city workers. "These courses are aimed at pavement workers at all levels, from highly trained engineers to maintenance workers without a technical background," says Shatnawi. Some classes have already been held, with more scheduled in conjunction with the Southern California Pavement Preservation Conference, which will be held April 25–26, 2006, in Diamond Bar, California.

Another PPTG initiative is the development of warranty specifications for construction projects. "With the use of warranties, the contractor takes on more of the risk and responsibility of the project, guaranteeing its life for a predetermined amount of time," says Shatnawi. Caltrans is currently testing the use of warranties with standard, prescriptive specifications, as well as those that are more performance-based, where Caltrans provides the minimum specifications and the contractor is free to add whatever it feels can improve the project.

> "Pavement preservation is the most cost-effective approach. Prevention is like found money."

In the planning stages is the development of a west coast pavement preservation center. The center would focus on such areas as policy, specifications, field investigations, applied research, materials, and training. "This will create a

site on the west coast for Western States to share in pavement preservation advances and research," says Jason Dietz of FHWA. Additional new pavement preservation centers being developed for different regions or States include ones in Colorado, Texas, and Louisiana. Partners in these efforts include Texas A&M University and the Texas Transportation Institute and Louisiana State University and the Louisiana Transportation Research Center. Iowa State University's Center for Portland Cement Concrete Pavement Technology is also working to advance concrete pavement preservation.

For more information on California's pavement preservation initiatives or the PPTG, contact Shakir Shatnawi at Caltrans, 916-227-5706 (email: shakir.shatnawi@dot.ca.gov), Jason Dietz at FHWA, 916-498-5886 (email: jason.dietz@fhwa.dot.gov), or PPTG co-chair Gary Hildebrand at SemMaterials, 916-798-0455 (email: ghildebrand@semgrouplp.com). For more information on the MTAG Web-based training, contact Christopher Newman in FHWA's Office of Asset Management, 202-366-2023 (email: christopher.newman@fhwa.dot.gov).

Reprinted from *Focus,* January/February 2006

A Nationwide Boost for Preserving the Highway Infrastructure

Since launching its Pavement Preservation Technical Assistance Program earlier this year, the Federal Highway Administration's (FHWA) Office of Asset Management has worked with highway agencies around the country to evaluate their pavement preservation programs and offer assistance in developing and expanding their current practices. "We are learning a lot about what is being done at the State level, the variety of levels of experience in pavement preservation, and the different approaches to preserving highway assets," says Christopher Newman of FHWA. These peer evaluations are being carried out by FHWA through a contract with the National Center for Pavement Preservation (NCPP).

Pavement preservation is a network level, long-term strategy that enhances pavement performance by using a variety of cost-effective surface treatments that extend pavement life. These treatments must be carefully selected and must be applied before the pavement sustains structural damage.

The 3- to 4-day reviews have been held to date in Alaska, Idaho, Indiana, Kentucky, Louisiana, Nebraska, Nevada, New Jersey, New Mexico, and Rhode Island. In coordination with each individual State, the NCPP staff, together with a representative from the State department of transportation and local FHWA division office, conducted interviews with key highway personnel involved in developing, implementing, evaluating, and managing the State's pavement maintenance, evaluation, and preservation programs. These key personnel have included materials, design, planning and programming, and maintenance staff, as well as senior agency officials. The review team has also visited field offices in each State. "This peer exchange approach has resulted in detailed discussions involving all levels of the department, from the director to the maintenance technicians. It's been a very positive process," notes Larry Galehouse of the NCPP.

FHWA has worked with highway agencies around the country, including New Mexico (pictured above), to evaluate their pavement preservation programs and offer assistance in developing and expanding their current practices.

Topic areas covered by the review team include:

- Business process.
- Program implementation.
- Project selection.
- Treatments.
- Materials.
- Quality control.
- Performance monitoring.
- Pavement management systems.
- Training.
- Research.
- Public/Key decisionmaker/Legislator relations.

"The review was a very good process that helped us to formalize our internal procedures for pavement preservation. We were also able to expand the knowledge base of our employees," says Dean Weitzel of the Nevada Department of Transportation. "We're looking forward to finding out more about what other States are doing as FHWA compiles the information from the reviews."

"This will give us something to benchmark against," notes Tom Raught of the New Mexico State Highway and Transportation Department. "It was particularly helpful that the review team visited our district offices also, in addition to meeting with Headquarters staff."

Reports summarizing observations and recommendations will be issued for each review. FHWA will also hold a closeout meeting with the participants from each State to discuss the observations and suggested enhancements or improvements. Comments from the review team will be combined with feedback from the States and FHWA division offices to identify areas where transportation departments can enhance system performance at reduced cost. "It's about maintaining and preserving our transportation investment," says Jim Sorenson of FHWA.

Information gathered during the assessments will be used to create a database so that pavement preservation practices and trends can be tracked nationally. The database will provide a benchmarking tool for sharing best practices, as well as examining variables that can adversely affect pavement preservation treatments, such as application timing, environmental factors, and traffic loads.

Ten more State reviews are currently scheduled for 2006. "We have also received requests from cities and counties for reviews," says Galehouse. FHWA and the Local Technical Assistance Program managers are evaluating various ways to respond to the local requests.

For more information or to schedule a review, contact your local FHWA division office or Christopher Newman at FHWA, 202-366-2023 (email: christopher.newman@fhwa.dot.gov).

Reprinted from *Focus,* December 2005.

Pavement Preservation: Techniques for Making Roads Last

by Tom Kuennen

Pavement preservation is a planned system of treating pavements at the optimum time to maximize their useful life, thus enhancing pavement longevity at the lowest cost.

Typically, pavements perform well under loads until a particular point in their life spans, at which time they deteriorate precipitously and rapidly to failure. Experience shows that spending $1 on pavement preservation before that point eliminates or delays spending $6 to $10 dollars on future rehabilitation or reconstruction costs.

Ideally, pavement preservation can mean maintenance of a pavement even when there is nothing apparently wrong with it. "The number one fault of agencies is that they wait until a problem develops before they address it," said Larry Galehouse, P.E., executive director of the National Center for Pavement Preservation (NCPP) at Michigan State University. "Instead, successful pavement preservation demands a pavement that's not in bad shape to start. If the structure is good, we can keep water out of the pavement, prevent oxidation of the asphalt, and maintain good skid resistance. With pavement preservation techniques, we will improve their performance and extend their life."

That approach is directly opposed to the politically popular road management method of "worst-first," in which scarce maintenance dollars are used to provide band-aid repairs to pavements which have gone too far and are failing. Soon after repairs are made, base or pavement failures are reflected through to the surface and the effort has been wasted.

Strong FHWA Support

In May 2005, the FHWA came out strongly in support of pavement preservation. "Each highway agency faces different challenges in applying pavement preservation treatments and establishing an effective preservation program," said David R. Geiger, P.E., director, FHWA Office of Asset Management. "Preservation involves a paradigm shift from worst-first to optimum timing. Preservation programs must focus on demonstrating benefit, securing commitment of top agency management, convincing the public, and selecting the right treatment for the right pavement at the right time."

According to Tom Deddens of the FHWA's Construction and System Preservation Team, "The goal is to help states assess where they are and provide comments and recommendations on what they can do to further develop and enhance their pavement preservation programs." Those preventive maintenance treatments include crack sealing, chip seals, slurry surfacings and hot mix asphalt (HMA) thin overlays that will bolster ride quality, provide surface drainage and friction, and correct surface irregularities.

Preservation with Asphalt Treatments

As NCPP's Galehouse implied, a big part of pavement preservation is keeping water out of pavements, and the water-proofing properties of asphalt surface treatments and liquid asphalt mean they take top billing in pavement preservation techniques.

Such pavement preservation practices include crack sealing, patching, fog seals (a combination of mixing-type emulsion and approximately 50 percent water, used to seal shoulders and patches), rejuvenation (application of a rejuvenator agent in a procedure similar to fog sealing), and chip seals (surface treatment in which the pavement is sprayed with asphalt emulsion and then immediately covered with aggregate and rolled).

Also included are slurry seals (an application of mixing-type asphalt emulsion, sometimes with additives, mineral aggregate and proportioned

water, mixed and spread on clean pavement free of dirt and loose gravel); microsurfacing (polymer-modified asphalt emulsion, mineral aggregate, mineral filler, water, and other additives, properly proportioned, mixed, and spread on a pavement); cape seals (application of slurry seal to a newly constructed surface treatment or chip seal); and thin and ultrathin hot mix asphalt overlays (HMA overlay with one lift of surface course, generally with a thickness of 1.5 in. or less).

Three varieties of liquid asphalts are used in conventional surface treatments:

- Liquid asphalt cement is used to construct chip seals in regions that have very hot weather. The asphalt cement is shot at high temperatures where it flows well and accepts chips readily. A fairly warm pavement surface is required so the asphalt does not cool off too quickly before placement of the chips.
- Cutback asphalts are blends of asphalt cement with solvents, which make the asphalt cement fluid for spraying or mixing. The solvents then evaporate, leaving the base asphalt cement in place to bind the rock. Solvents used include gasoline for rapid-curing, kerosene for medium-curing, and diesel fuel for slow-curing cutbacks. The use of cutback asphalts, once common for chip seals, has declined considerably because of environmental restrictions on hydrocarbon emissions from evaporating solvents in specific regions around the county.
- Emulsified asphalts are an emulsion of very small asphalt cement particles held in suspension in water with the use of an emulsifying agent. Like cutback asphalts, emulsified asphalts come in rapid-, medium-, and slow-setting grades for different uses. The various grades are developed through the use of different emulsifying agents and the addition of some solvents. These asphalt particles are either anionic (negatively charged) or cationic (positively charged).

The rapid-setting emulsions are used mostly for chip sealing, while the medium and slow setting grades are used for emulsion mixes or recycling and fog or tack seals. The emulsified asphalt 'sets' or 'breaks' when the asphalt particles precipitate or fall out of the water suspension and coat the aggregates. The emulsion changes color from brown to black during this process.

Ever Popular Chip Seals

Chip seals have been used for decades to preserve riding surfaces. A chip seal is a surface treatment in which the pavement is sprayed with asphalt and then immediately covered with aggregate and rolled. Chip seals are used primarily to seal a pavement with non-load-associated cracks, and to improve surface friction. They also are common as a wearing course on low volume roads.

The asphalt binder can be modified with a blend of ground tire or latex rubber, or polymer modifiers, to enhance the elasticity and adhesion characteristics of the binder. A variant of the chip seal is the fog seal, a light application of slow-setting asphalt emulsion diluted with water, and without the addition of any aggregate applied to the surface of an asphalt pavement. Fog seals are used to renew aged asphalt surfaces, seal small cracks and surface voids, or adjust the quality of binder in newly applied chip seals.

A cape seal is a combination of a chip seal and a slurry surfacing or seal. For paved roads, the chip seal is applied first and, between four and 10 days later, the slurry seal is applied. For unsurfaced roads, an application of MC-70 or SC-70 cutback asphalt is applied first as a prime coat, followed about two days later by a chip seal and about two weeks later by a slurry seal.

Joints, Cracks and Potholes

In advance of any surface treatment, pavements are prepared by sweeping and sealing the joints and cracks. "It is critical that all necessary preparation work such as crack filling, pothole repair, patching, leveling, and dig-outs be done prior to surface treatments being placed," reports the California Department of Transportation (Caltrans).

Caltrans says crack filling and sealing is its first line of defense in roadway maintenance. Caltrans urges that cracks 1/4 inch or wide be filled or sealed before rainy seasons or before the application of maintenance surface treatments such as fog seals, sand seals, slurry seals, chip seals or maintenance overlays.

Potholes are bowl-shaped holes of various sizes which are associated with pavement fatigue and poor drainage. Highway departments can minimize potholes by keeping water out of the base material. Water weakens pavement support and contributes to frost heave and cracking.

A long-term study that began under the Strategic Highway Research Program, and continued under FHWA's Long-term Pavement Preservation program, found that for patching potholes, quality of materials is more important than method or machine. The use of quality, even premium, materials is the utmost variable in effective pothole patching. The throw-and-roll technique proved as effective as the semipermanent procedure in most situations and is more cost-effective, making it a good choice, so long as quality materials are used.

Rejuvenating Pavements

Pavement rejuvenators are applied to existing aged or oxidized HMA pavements in order to restore pavement surface flexibility and to retard block cracking. Emulsified sealers, binders and rejuvenators are used in pavement preservation to protect oxidized asphalt surfaces or actually penetrate and rejuvenate them.

The oxidative aging of pavements begins at the time of construction and continues throughout a pavement's life. However, most aging occurs within the first two to four years of service life. This results in the top half-inch or so of the pavement surface becoming more brittle than the underlying material due to the actions of water and environment. This can result in raveling and/or premature cracking, which begins at the pavement surface.

Rejuvenators are formulated to penetrate into the pavement and then enhance the properties of the asphalt binder of the existing pavement. These treatments are most commonly used in the western states where ultraviolet exposure appears to promote greater oxidation. Treatments can begin immediately after construction but more typically occur many years later when some form of distress is observed.

Slurry Surfacings

A slurry surfacing, also known as a slurry seal, is not the same as a chip seal. Instead, it is a mixture of aggregates dispersed in an asphalt emulsion and applied in a slurry state. It is usually a mix of polymer-modified emulsion and fine crushed aggregate that is spread simultaneously in one pass over the street at a particular thickness. The slurry cures as the water evaporates, leaving only the asphalt to coat the aggregate.

Slurry surfacings are designed in a lab, are proportioned by a slurry machine, and laid down and cured so the asphalt-to-aggregate ratio is maintained at the optimum value to assure uniform aggregate coating and adhesion. Such friction courses use very large fractions of fine material, giving a very high surface area and a lot of microstructure, leading to a sandpaper surface and a high skid resistance while maintaining a smooth finish.

A variant of the slurry surfacing is microsurfacing, which is a mix of polymer-modified asphalt emulsion, mineral aggregate, mineral filler, water, and other additives, which is proportioned, mixed, and spread on a paved surface. Microsurfacing differs from slurry seal in that it can be used on high volume roadways to correct wheel path rutting and provide a skid-resistant pavement surface.

HMA as a Preservation Treatment

For severely distressed surfaces, thin HMA overlays will provide a like-new surface, prolong pavement structure life, and make a pavement stronger for only an incrementally higher expenditure than competing surface treatments like chip seals or slurry surfacings.

For many roads and streets the best preventive maintenance strategy may be a thin HMA overlay. This thin (0.5 to 1.5 inch) surfacing combines the best attributes of HMA's strength and smoothness with a low cost that makes maintenance dollars go farther. Aesthetically, the overall impression is of a brand-new road, at the price of a thin overlay. Other benefits include HMA's trademark quiet pavement and smooth ride.

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Tools for the Pavement Preservation Industry

by Tom Deddens, P.E.

Over the years, the Federal Highway Administration (FHWA) has changed its emphasis from construction to preservation of the National Highway System (NHS). FHWA is now providing assistance to the state DOTs and the highway industry through a number of new programs.

History

Historically, preventive maintenance activities have been excluded from federal-aid funding. When President Eisenhower initiated the construction of the Interstate System in 1956, he left the maintenance responsibility of the newly constructed roadway system squarely on the shoulders of the individual state transportation agencies. As the interstate system aged, Congress initiated the 4R Program (resurfacing, restoration, rehabilitation and reconstruction) which funded the activities to maintain the serviceability of the Interstate system. The passage of the Intermodal Surface Transportation Efficiency Act of 1991 created the Interstate Maintenance program and provided funds using the existing 4R equation. A 1993 FHWA memorandum identified any work which provided additional structural capacity, prevented the intrusion of water into the pavement, or any other work that extended the life of the highway, as being eligible for federal funding.

A 1998 memorandum gave state DOTs more flexibility in managing their federal-aid highway program. This memorandum permitted the use of "planned staged construction" for the completion of surface paving independent of other required project modifications. The memorandum simultaneously placed added emphasis on transportation systems preservation and encouraged the state DOTs to properly fund preservation programs without any additional federal assistance.

New Definition

In October of 2004, a memorandum issued by the Office of Infrastructure now makes preventive maintenance activities eligible for federal-aid funding based on a definition of pavement preservation which was consistent with the AASHTO definition: "…The planned strategy of cost effective treatments to an existing roadway system and its appurtances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system without increasing structural capacity."

The memorandum explains that "…projects that address deficiencies in the pavement structure or increase the capacity of the facility are not considered preventive maintenance and should be designed using appropriate 3R standards. Functionally, federal-aid eligibility preventive maintenance activities are those that address aging, oxidation, surface deterioration and normal wear and tear from day-to-day performance and environmental conditions."

FHWA now accepts that pavement preservation is a proactive, long-term strategy to improve pavement performance through a variety of cost effective, thin surface treatments that extend the life of a road, such as crack and joint sealing, chip seals, slurry seals, microsurfacing and thins and ultrathin hot mix asphalt overlays for flexible pavements, and partial and full depth repairs, dowel bar retrofits, and surface grindings of rigid pavements. To be effective, these treatments must be selected carefully and applied before the pavement sustains any structural damage.

Available Resources

The FHWA's shift to an emphasis on preservation

motivated the Office of Asset Management to reach out to the state DOTs and the highway industry through a number of activities. The available research and "conventional wisdom" was previously collected and assembled in a "toolbox" by the Foundation for Pavement Preservation (FP2). The Foundation collected its industry members' technical manuals, brochures, and pamphlets that described the "best practices" for the various preservation techniques. About this time, FHWA and FP2 produced two videos addressing pavement preservation entitled: *Protecting Our Pavement: Preventive Maintenance* and *Preventive Maintenance: Project Selection.* The content of these videos were consolidated later onto a single DVD.

Next, a *Compendium on Pavement Preservation* was compiled and is presently available on the FHWA's Pavement Preservation website, www.fhwa.dot.gov/preservation/. In 2003, a sequel to the toolbox entitled *Pavement Preservation State of the Practice Volume 2* was produced and distributed on CD by FP2.

Due to the popularity of these resources, all the information was compiled on a CD, which is now available from the Foundation for Pavement Preservation.

Training Efforts

Training is another significant part of this transition. Four courses specifically addressing pavement preservation issues have been developed and are available through the National Highway Institute (NHI).

131054A	*Pavement Preservation: The Preventive Maintenance Concept*
131058A	*Pavement Preservation: Selecting Pavements for Preventive Maintenance*
131103A	*Pavement Preservation: Design & Construction of Quality Preventive Maintenance Treatments*
131104A	*Pavement Preservation: Integrating Pavement Preservation Practices & Pavement Management*

A listing of these courses can be found on the NHI's website, www.nhi.fhwa.dot.gov/coursec.asp, under Pavements and Materials.

Interactive Manual

The FHWA's Office of Asset Management and the Pavement Preservation Expert Task Group are in the process of developing an interactive, online version of a manual originally developed by the California Department of Transportation entitled *Maintenance Technical Advisory Guide* (MTAG). The training will include modules on crack sealing, patching and edge repairs, chip seals, slurry seals, microseals, ultrathin bonded asphalt overlays, and thin overlays. When this project is complete in January 2006, an individual requiring training will be able to access the specific technique at his convenience.

Modules will be taught by referring the students to the corresponding section of the MTAG. Upon completing a module, the student will be tested on his understanding of the subject material. A pass or fail grade will be issued based on the test scores. If the student passes, a verification notice will be issued to his employer. If the student fails, he will be instructed to retake the module and repeat the test.

National Center for Pavement Preservation

In August of 2004, the National Center for Pavement Preservation (NCPP) was created through the partnership of the FHWA, private industry and Michigan State University (MSU). The purposes of the NCPP are to:

- Provide technical training related to pavement preservation and management
- Reach out to state agencies and provide assistance in development of specifications and be a repository for technical research related to pavement preservation issues
- Coordinate the research activities of regional or national pooled-fund studies and those research activities undertaken by other regional pavement preservation centers as they develop.

The website of the NCPP is www.pavementpreservation.org. Presently the NCPP is available to teach two courses, *Chip Seal Design* and *Pavement Preservation: Applied Asset Management.*

Voluntary Assessment Program

The most recent FHWA activity is directed toward assisting the states by providing a voluntary assessment of an agency's pavement preservation program. This assessment program is being implemented through a contract between the FHWA Office of Asset Management and the NCPP. Representatives from NCPP and/or FHWA will meet with the various components of a highway agency—upper management, contract administration, asset management, maintenance, materials and construction—involved with implementation of maintenance of the roadway system.

The assessments will be guided by a set of standard questions regarding the implementation of pavement preservation practices and policies within that state. A report will then be prepared based on the responses to these standard questions. The report will also include general suggestions for improvement, in particular, noting the best practices effectively used in other states. The information obtained from this study will be compiled and placed in a large database that can be accessed by the agencies. Each agency will be assigned a unique identifier that will permit anonymous viewing of the data for purposes of comparison with their peer agencies.

The preventive maintenance program is intended to complement expenditures made for capital improvements by providing a strategy to cost effectively prolong the life of pavement systems of the National Highway System.

Conclusion

Interpretations of the various FHWA memorandums can lead to significant differences in the manner in which programs are administered among the various agencies. In order to mitigate some confusion, the FHWA has just finalized a document standardizing the use of the various categories of roadway maintenance. It is FHWA's intent to have this "Definitions Statement" endorsed by the AASHTO's Standing Committee on Construction.

The intent of all this activity is to firmly establish pavement preservation as those activities focusing on maintenance of functional surface characteristics of a pavement. The preventive maintenance program is intended to complement expenditures made for capital improvements by providing a strategy to cost effectively prolong the life of pavement systems of the National Highway System. As the mantra says, pavement preservation is about placing the right treatment on the right pavement at the right time.

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Pavement Preservation Fights for Respect

by Tom Kuennen

Six years after the creation of the Office of Asset Management within the Federal Highway Administration, 13 years after the establishment of the Foundation for Pavement Preservation, and two years after the founding of the National Center for Pavement Preservation, the concept of pavement preservation still faces a tough climb to full acceptance.

While many county and city road agencies maintain pavement inventories and pavement management systems, not all have been able to integrate the pavement management system with a preservation program that will show where dollars will be best spent toward riding surface longevity.

Classic pavement preservation starts with a pavement inventory and condition database, which is used to establish which road surfaces are near the point at which they will begin to fail rapidly. Those pavements—not the worst pavements favored by politicians—are the ones that should be targeted with whatever funds are available, prolonging their service life to a degree not possible otherwise.

But a problem arises for the road manager. To spend money where it will do the most good, pavements that are falling apart should not receive maintenance dollars, but should be allowed to fail and then be rebuilt. That's why adhering to a pavement preservation program may put a road administrator in conflict with elected officials, who may demand quick fixes for failing pavements.

At that point, the pavement inventory and pavement management system can be exhibited to show that the road administrator is doing the right thing. The inventory and PMS provide cover for both the administrator and elected official in supporting pavement preservation principles.

"The worst way of responding to complaints is the policy of worst-first," said John O'Doherty, P.E., training coordinator, National Center for Pavement Preservation. "It's a suboptimal strategy and, if you continue to follow it, you'll eventually bankrupt your agency. When you wait for worst-first, you've waited until structural damage is being done to the road and you have to do major rehabilitation. Worst-first waits until serious damage is done, and every road in your system will have to descend to that level, making it the most expensive strategy you can think of."

Worst-first is seductive politically, though, O'Doherty told *Better Roads.* "It's very appealing politically," he said. "If you're an elected official, or department director, it's reassuring to the public to have them hear that you are doing the worst roads first, because they will get a warm, fuzzy feeling. But it's a terrible policy."

Agencies differ

"Each highway agency faces different challenges in applying pavement preservation treatments and establishing an effective preservation program," said David R. Geiger, P.E., director, FHWA Office of Asset Management, in a May 2005 memo promoting pavement preservation. "Preservation involves a paradigm shift from worst-first to optimum timing. Preservation programs must focus on demonstrating benefit, securing commitment of top agency management, convincing the public, and selecting the right treatment for the right pavement at the right time."

Those preventive maintenance treatments include crack sealing, fog seals, chip seals, thin cold-mix seals, surface recycling, and hot-mix asphalt thin overlays, including dense-, open-, and gap-graded mixes that will bolster ride quality, provide surface drainage and friction, and correct surface irregularities.

Many road agencies that are wedded to existing practice—ranging from old-fashioned cities in which an alderman or councilman decides where

the road funds are spent, to state DOTs where highway building and rebuilding take utmost priority—are disinterested or ambivalent regarding programmed pavement preservation, especially when it means shifting funds from favored programs, and there is no central authority to compel them to do otherwise.

Some states have implemented pavement preservation programs. Under a new FHWA program in 2005, the National Center for Pavement Preservation is reaching out to those state agencies that will cooperate to gauge the depth of pavement preservation in their agencies.

Mega-municipalities such as Los Angeles, down to small townships like Minisink, N.Y. have adopted pavement preservation programs. And new types of governments that merge city with county have embraced pavement preservation, such as the Metropolitan Government of Nashville & Davidson County (Metro Nashville).

One might say that pavement management + pavement maintenance = pavement preservation. The pavement preservation community is pulling out all stops to bridge that crucial gap where pavement management systems and inventories meet with maintenance activities in the field.

Too often, maintenance is not driven by pavement management, said Katie Zimmerman, P.E., Applied Pavement Technology, in a presentation at the 2003 Transportation Research Board meeting in Washington, D.C. In the presentation *Integrating Preventive Maintenance Into Pavement Management Systems,* co-authored by David Peshkin, P.E., also of APTech, Zimmerman said that, traditionally, the highest priority is given to correct safety deficiencies. "Treatments are triggered when a pavement section falls below an acceptable level," she said. "Funding for routine maintenance is typically unreliable, so treatment application cycles vary."

Turf wars within an agency can choke pavement preservation. "Maintenance and rehabilitation are often programmed by different groups within the highway agency," Zimmerman told TRB. "Maintenance activities are frequently not reported in accordance with a referencing system used by pavement management. The same maintenance treatment can be used as a preventive, corrective, or stop-gap treatment."

But more recently, road agencies are beginning to integrate preventive maintenance into planning and design activities, reducing the life-cycle cost of preserving a pavement through the use of preventive maintenance. Through planned, early application of preventive maintenance treatments, good roads are kept in good condition, validating the motto of pavement preservation being "the right treatment for the right road at the right time."

Last year, an analysis by Midwest Regional University Transportation Center, University of Wisconsin-Madison, concluded that most state agencies are ambivalent to the pavement preservation message because of sheer inertia.

"The preventive maintenance philosophy is somewhat contrary to that of traditional public administration for primarily two reasons," MRUTC said, as reported in *Better Roads* (April 2005, Making High-Volume Roads Last Longer). "First, it requires strategic rather than operational analysis on the part of agency managers and elected officials. That is, the benefits of preventive maintenance, which are best expressed in terms of future value, are intrinsically undervalued by management concerned with current operating costs."

Demonstrations of long-range savings can help alter attitudes, but it's difficult, the center said. "Although life-cycle cost analysis and other techniques have made progress toward overcoming this difference in cost-benefit perceptions, the operational mode of thought stands in the way of broader preventive maintenance implementation."

The benefits of integrating preventive maintenance with a pavement management system were described in a 2005 TRB presentation, *Potential Benefits of Integrating Preventive Maintenance into New Jersey Pavement Management System,* by Helali, Bekheet, Jackson, Jumikis, and Zaghloul.

The New Jersey Department of Transportation established a pavement preservation strategy that emphasizes preventive maintenance and moves away from the worst-first approach, they wrote. "To be able to implement the PM program and show its benefits and the merits over the existing worst-first approach, NJ DOT decided to integrate the PM program into [its] PMS."

The proposed PM program consists of two components, one short-term and one long-term. "The short-term component involves an annual crack sealing/filling program, and addresses the current needs of the network," the authors said. A long-term component involves staged treatments, in which the rehabilitation and PM treatments are combined and integrated in the form of a long-term preservation program, perhaps over two decades. The final product would be a multi-year maintenance and rehabil-

itation program for the entire network, which is based on economic analysis and optimization.

New initiative for states

To jump-start recognition of pavement preservation, the FHWA's Office of Asset Management has recently launched a Pavement Preservation Technical Assistance Program to help highway agencies define their pavement preservation programs, and to build a pavement preservation database.

The National Center for Pavement Preservation at Michigan State University in East Lansing, Michigan, is coordinating with individual states and the local FHWA division offices to conduct interviews to discuss procedures, policies, and programs associated with pavement preservation. "The goal is to help states assess where they are and provide comments and recommendations on what they can do to further develop and enhance their pavement preservation programs," said Tom Deddens of the FHWA's Construction and System Preservation Team.

"Over the next two years, the FHWA Office of Asset Management will lead an effort to conduct a series of comprehensive technical reviews and evaluations of DOTs' pavement preservation programs at the request of individual states," said FHWA's Geiger. "For each appraisal, we will conduct approximately 80 hours of program review and interviews of key personnel and provide both an oral closeout and a written report highlighting strengths, identifying gaps, and making recommendations for improvement of that DOT's program. The contract will consist of a maximum of 10 such reviews during the first year, with the likelihood that the effort will be extended by 10 more such reviews in FY 2006."

Pavement preservation is a powerful tool through which any highway agency can improve pavement condition and significantly prolong its life within existing budgets, Geiger told FHWA regional directors, administrators, and engineers. "The focus must be to keep good pavements in good condition, preserving the pavement asset while maximizing the economic efficiency. Our experience with preservation programs is showing that DOTs are gaining flexibility for funding capital needs while providing the traveling public higher level of service. Pavement preservation provides greater value to the highway system, improves safety, enhances mobility, and provides a higher level of satisfaction of highway users."

NCPP charged with outreach

To execute the outreach this year, the FHWA has turned to the National Center for Pavement Preservation. NCPP has been fighting for change in the conventional wisdom, and observes that the majority of the United States population travels through a work zone at least once per day, and that 80% of federal-aid funds go into products the public sees in work zones. NCPP wants to redirect the conventional thinking that new construction is most desirable, and that worst pavements should be fixed first. Instead, it wants to promote efficient road preservation programs for highway agencies.

For this 2005 project, NCPP is charged with working within the goals of each state, and is visiting as a facilitator and advisor. For each visit, the NCPP will visit with agency personnel involved in the development, implementation, and management of the state's preservation program.

"We have been contracted by the FHWA to conduct the state appraisals," NCPP's O'Doherty told *Better Roads.* "We have 20 states this first year with many more signing up for the second year. We will go into each state, spending a week visiting people at headquarters, districts, division and regional offices, and will be looking at some roads. We will make an appraisal that when completed can be used as a plan by the agency."

"This would include, but is not limited to, the departments of maintenance, planning, construction, research, and other areas as necessary to include all necessary organization elements," the FHWA said. "The review should be tailored to the SHA's existing programs, policies, guidance, specifications, and organizational structure. Information such as treatments used, the SHA's mix of fixes, experience of performance to date, etc. will be necessary for the review." Each review was anticipated to be 10 to 15 days over the duration of a two-month period.

Through the review of documentation, practices, procedures, economic evaluation and historical performance information, PMS information, and other sources, NCPP will assess the effectiveness of those agencies' pavement preservation programs in terms of pavement performance, life, cost-effectiveness, and other measures, and evaluate what aspects of the program or related areas of departmental operations could be refined or improved to provide a more effective pavement preservation program. NCPP will work with states to develop a roadmap of activities that can influ-

ence the success of their pavement preservation program, the FHWA said.

Los Angeles' only choice

Sometimes cash-flow problems mean a road agency has no choice but to incorporate pavement preservation principles into its program. That's what the City of Los Angeles found recently as it incorporated two strategies into its long-term pavement preservation program: Rubberized asphalt slurry seals to prolong the life of its good pavements, and foamed asphalt and asphalt emulsion base recycling for failed pavements.

It's all being driven by the need to make limited funds go farther as the city grapples with maintaining and preserving its 6,500 miles of dedicated public thoroughfares (28,000 lane miles) and 800 miles of alleys in an area exceeding 466 square miles.

L.A.'s renewed interest in pavement preservation is the result of California's famous Prop 13, which dramatically cut taxes, including resources used for street repairs and paving, said William A. Robertson, director, Bureau of Street Services.

"We quit doing maintenance," Robertson said at a conference in January. "We quit doing slurry seal. The only thing we were doing was resurfacing, and calling it maintenance. So for a number of years—although we have the largest street system in the country—we were not doing any true maintenance, and we suffered greatly. We saw a drop in resurfaced streets from 275 miles a year to 118, because the money wasn't there."

Over the last eight years the bureau has been able to convince elected officials that the city needed to take a hard look at preserving its transportation infrastructure. "We had to be innovative, and look at different ways to turn around our preservation program based on the little money that was available," Robertson said.

And that soul-searching has culminated in a new pavement preservation initiative that is based around rubberized slurry surfacings for pavements to prolong the life of pavements in better condition, and cold in-place recycling of failed pavements.

"We now are using CIP recycling and an expanded slurry seal program simply to preserve the infrastructure we have in place," Robertson said, adding the city had no choice if it was to have an adequate street system in the future. The city also continues to do asphalt overlays.

Understanding that any program savings can vanish into municipal general fund, the base recycling machine—a 2200 CR from Wirtgen America Inc., the first in the United States—was purchased by the city council with a motion stating that any savings accruing from the use of the machine must stay in the BSS budget for pavement preservation.

"The council put forward a motion instructing the CAO for the city, telling him he could not touch that money," streets director Robertson said. "Any savings created by this machine would go right back into the preservation of our street system. That was a huge, huge step for which we had been fighting for years. We have been innovative and have thought outside of the box for years, but instead of being rewarded, they have taken those savings from us and told us to do more with even less money. But we now have the elected officials behind us, helping us preserve more miles of pavement each year."

PMS drives L.A. preservation

Los Angeles uses a pavement management system to decide which streets will be reconstructed, which will be preserved with rubberized slurry seal, and which will be maintained in some other way, for example, crack-sealed, said assistant director of streets Nazario Sauceda.

"A PMS is a scientific, systematic, consistent method for selecting maintenance and rehabilitation needs for determining the optimal time of repair, by predicting future condition," Sauceda said. "In simpler words it's a methodology that allows us to be cost-effective when we manage our pavements, and a tool that we use to support our decision-making." L.A. uses the popular MicroPAVER from the U.S. Army Corps of Engineers, which uses the Pavement Condition Index method for rating pavements, complies with GASB 34, and is used by more than 600 cities, counties, airports, and consulting firms.

GASB 34 is short for Government Accounting Standards Board Statement 34, which requires that state and local governments include the value of long-lived assets, including roads and bridges, in their annual financial statements.

Pavement management "in the good old days," he told *Better Roads,* included routine maintenance cycles, priority on a worst-first basis, which would be driven by citizen complaints and political priorities, or recommendations by the old superintendent.

Modern PMS, though, are light years removed from the old days, he said. They can be used to justify different funding level requests, provide information to make efficient use of limited resources, produce quantified and accurate data, track pavement performance, identify current and future maintenance and rehab needs, select cost-effective repair strategies, and predict future pavement conditions based on different budget scenarios.

This PMS enables L.A. to determine which streets are deserving of preservation with rubberized slurry surfacings, and which are so far gone that preservation funds would be wasted. Those become reconstruction candidates for full-depth base recycling. And a pavement inspection and inventory is key.

"Our goal is to inspect all 6,500 miles in three years, so each year we view 2,200 miles of streets," Sauceda told *Better Roads.* L.A. uses two semi-automated survey vans which take digital pictures of pavements, which are analyzed for stresses. "Based on that information, we calculate the PCI of the street," Sauceda said. "Our qualified staff also will conduct investigations by hand. Sometimes you may take a picture that will not be accurate, so our guys will confirm the condition in person."

The pavement condition is predicated on how different distresses will impact street performance

Township Preserves Roads–and the Budget

A rural township west of New York City is making its limited road budget go further by rigorously preserving pavements with polymer-modified fiber-membranes and paver-placed, ultra-thin surface treatments, prolonging pavement life and satisfying its new commuter residents who demand smooth pavements.

The Town of Minisink, located just north of the New Jersey border in Orange County, about 55 miles from Manhattan as the crow flies, is a rural jurisdiction now being populated by commuters who can drive to nearby rail and bus stops for their daily journeys to New York City. As such, increased demands are being placed on the 102 lane miles of town roads which could lead to their destruction, if not for the pavement preservation practiced by the town.

In July, Minisink was surfacing what it considered to be some of the worst roads in the town, but anywhere else they would not appear to be in such bad shape. That's because the town has actively been preserving its pavements for years.

"We don't want the cracks to get any worse, and we don't want the base to fail," said Randy Filipowski, highway superintendent, Town of Minisink, New York. "We find that this surfacing process cuts reflective cracking at almost 90% over the last three years on roads where we've used it. It works out well and offers a good bang for your buck. We're the smallest town in Orange County, with the smallest budget, and we have to make our money stretch."

The fiber-membrane

In July, contractor Midland Asphalt Materials was placing FiberMat surfacing on a number of roads in Minisink. The fiber-membrane process suppresses reflective cracking, preserves the pavement, and provides a permanent riding surface that can stand on its own, or it can be surfaced later with NovaChip, or a hot-mix asphalt overlay.

"The fibers form a mesh within a double seal, which bridges the cracks," Filipowski said. "As everyone in the highway industry knows, the object is to keep water out of the base, and to keep the fines from moving around. Catching the cracks at an early stage like this, where they're only 0.25- to 0.375-inch deep, stops the road from coming apart. We want to seal before chunks start coming out of the road, so we don't have to patch."

The surfacing used there consists of 2.375-inch-long fibers that are individually cut and randomly dispersed into the first layer of a special CRS-1P type polymer-modified emulsion sprayed by the specialized trailer unit. That layer is immediately topped by another emulsion spray, which covers and encapsulates the fibers, sealing them in, all in one pass. The tanker and specialized trailer unit can move forward rather quickly, with typical speeds of 250 to 300 feet per minute. A standard chip spreader then applies the aggregate.

The FiberMat surface being placed in Minisink will be used as the driving surface until the season of 2006, when it will be overlaid with NovaChip ultra-thin surface treatment from Sem Materials; thus it will serve through the winter as a driving course, then next year as a stress-absorbing membrane interlayer.

The reason is that the town simply can't afford to do both surfacings at the same time, so it works incrementally, confident that the fiber-membrane will serve all winter until overlaid in the spring. "Use of the FiberMat followed by NovaChip costs less money than asphalt overlays, and we get the SAMI function as well," Filipowski said. "This process allows us to resurface up to 6 miles of roads a year in this fashion."

in L.A.'s mild climate, but with rigorous traffic loadings, Sauceda said. "A PCI of 70 to 100, the street will be very good to excellent," he said. "40 to 70 is fairly good. But with a PCI of zero to 40, the pavement will not be in good shape."

Rubberized slurry seals

For streets not requiring complete reconstruction, L.A. has adopted a rubberized slurry seal as a standard. This product, called FlexSeal—manufactured locally by Petrochem Marketing, Inc.—is an emulsion of oil, rubber, and fine sand. "It's a preservative application or sealant that inhibits oxidation of oils from the pavement, deters asphalt cracking, and prevents water from seeping into the sub-base," Sauceda told *Better Roads.* "It extends the street's serviceable life, thereby reducing the need for repaving."

The use of rubberized slurry seals has enabled L.A. to expand its slurry program from 100 to 300 miles per year, and hire an additional crew. The city also has fielded requests for information from counties and cities in California, and Caltrans, in addition to cities from Nevada to Texas to Wisconsin.

Despite the low cost and serviceability of conventional slurry seals, L.A. chose to get out of that program due to logistical problems. They required a base camp to be set up in local neighborhoods, of their homes or stop them from going anywhere," Filipowski said. "Very seldom will we close a road."

The application unit is improved over the configuration available just a year ago. "The fiber capacity has been increased four-fold," Koeninger said. "The fiber machine can go farther before having to reload fiber. The efficiency of the new cutting unit allows the material to be deposited more rapidly. As a result it can potentially do up to 70,000 square yards per day, depending on site conditions." The machine is towed by a tanker or an ordinary distributor. "The new machine lays the fiber out very uniformly and even," Filipowski said. "They've come a long way."

Enhanced aggregate retention

The thickness provided by the fibers and twin emulsion layers also enhances chip retention. "The chip is imbedded in the emulsion, which has bonded to the fibers," said Daniel J. Koeninger, P.E., Midland Asphalt Materials Inc. "When the aggregate chip is under stress due to traffic, the emulsion and fiber provide tensile strength to retain the chip."

The fibers make it unique, Koeninger said. "There is no other product that gives this kind of coverage. There is no comparison with non-woven/needle-punched overlay fabric, because it's usually applied in a manner where it cannot fulfill its purpose. There will be bunching, tears, and wrinkles around curves, and they all reflect back to the surface. Also, this product can be installed directly on a milled surface."

In the Town of Minisink, the FiberMat SAMI was dosed at a rate of 0.16 pounds of glass fibers per square yard. The modified asphalt emulsion was applied in two simultaneous applications which total 0.4 to 0.5 gallons per square yard depending on surface and conditions. A quarter-inch top-sized stone was placed on the sprayed membrane to blind-in the surface before an overlay is placed at a later time.

When the process is used as a wearing course seal, the glass fibers are applied at a lesser rate of at least 0.11 pounds per square yard, depending on the severity of the cracking. The membrane sandwich is followed by placement of 0.25-, 0.375-, or 0.5-inch top-sized aggregate, or a mix of those sizes as in a double dressing.

For either formulation, the chips are seated into the surface by a pneumatic tired roller, and the pavement opened to traffic in a quarter-hour. "With this process we don't keep anyone out

Voters demand a black finish

While the township has the option of using the process as a permanent, stand-alone driving surface—instead of the other overlays—Filipowski won't do it. "We're only an hour out of Manhattan, and the people moving in are used to blacktop or concrete roads, and they're really not enthusiastic about oil and chips," Filipowski said. "The NovaChip is a very good intermediate process between HMA and oil and chip, so we do the fiber process first, and place NovaChip on top later."

And because the township road superintendent is an elected position, providing good roads, surfaced the way the voters like, is paramount for Filipowski, who faces election soon. "It's our third year with the process, and we're happy," he said. "They haven't hung me yet. Until something better comes along, we're going to stick with it."

Information for this article contributed by Midland Asphalt Materials Inc.

including as much as 50 to 100 tons of sand and aggregates, plus stationing of large pieces of equipment for the duration of the project, for as long as one month. There would also be environmental issues of dust and noise pollution, noxious odors during mixing, daily equipment maintenance, and its inability to consistently pass acceptable testing standards.

"There would be a tremendous neighborhood impact with our equipment," Sauceda said. "We would store materials on-site, and large pieces of equipment, and that causes a big problem in L.A., where people are picky about their streets, their trees, and quality of life."

Instead, the private-sector-produced slurry seal is a premixed, rubberized material that is plant-mixed and delivered ready for distribution on a project site. The material is distributed through PMI applicator trucks under the direction of bureau forces. Furthermore, it's continually tested by the city's Department of General Services Materials Testing Laboratory, to ensure product compliance with spec. The testing is out of the hands of the Bureau of Street Services.

Recycling failed roads

Today, L.A.'s bureau has retrofitted its two municipal asphalt plants to increase their capacities to incorporate 20% of reclaimed asphalt pavement into the asphalt manufactured at these plants. The city also has a contract with a private sector supplier for a 50% RAP, 50% virgin plant mix, used in all phases of the city's resurfacing program.

Cost savings drive this effort. The city recognizes that RAP recycling results in a reduction in demand for virgin aggregates, reduced construction time, less truck traffic and its environmental impact, and overall reduced environmental impact.

But base recycling offers even more savings over conventional reconstruction, said assistant director of streets Thomas W. Thomas. By contrast, he said, conventional reconstruction involves excavation and removal of existing material, transport of the material to city-owned or private asphalt plants, and then importation, placement, and compaction of new base materials and new asphalt concrete, with accompanying prolonged lane closures and excessive truck traffic.

"We're concentrating on our failed streets, with an ultimate goal this year of saving $2.4 million a year based on a resurfacing program of 150 miles, with an increase of 15 additional miles in FY 2005-2006 paid for from that savings, with no increase in the budget."

L.A. is using the 2200 CR to do foamed asphalt recycling throughout the city, and will be using it for emulsion stabilization as well, Thomas said. Challenges in foamed base recycling include the need for a minimum of 48 hours of dry weather, and maintenance of liquid asphalt temperatures of 340 to 350 degrees F.

"The crew personnel assigned to the CIP program are committed to a successful program and adapted very quickly to the new technology, since they were experienced in cold milling and paving operations," Thomas said. "The division management and superintendent staff are also committed to the CIP program and a team effort by everyone is required for a successful program, including the support of the Department of General Services, which develops the mix designs and provides testing services."

Foamed asphalt is created by carefully injecting a predetermined amount of cold water into hot penetration-grade asphalt in the mixing chamber of a pavement remixing unit, and offers a cost-effective alternate for road base stabilization. Precise addition of water allows control of the rate of asphalt expansion and the amount of expansion.

The expanded asphalt has a resulting high surface area available for bonding with the aggregate, leading to a stable road base using the existing in-place materials. The benefit is substantial cost savings over use of asphalt emulsions for base stabilization, and complete elimination of the cure or break period. The foamed base then is graded and compacted, and can permit traffic—including heavy trucks—almost immediately.

L.A. got a hands-on look at foamed asphalt stabilization in the reconstruction of Mt. Lee Drive above Hollywood in 2003. Not only did the process result in a successful reconstruction, but it eliminated an estimated 864 truck trips, greatly reducing construction traffic, noise, and pollution through a mountainside residential area with narrow, winding roads. The existing pavement was recycled to a depth of 6 inches, while applying 3% foamed asphalt (by mass). The new, completed base was covered by a light tack coat, followed by surface brooming and application of microsurfacing.

"We got a really good base out of it," Thomas said in January. "It's been over a year and it's held up through all the rains we had over the winter."

Thomas estimated, in retrospect, that a conventional rebuild would have taken 44 days and cost $400,000; but the foamed asphalt rebuild was completed in just seven days at a cost of $100,000.

Nashville takes initiative

The combined city-county of Metro Nashville has gone full-throttle in adopting and justifying to the public its pavement preservation program. On its Web site, Metro Nashville defines its PMS and then says how it will use it to husband its highways and make scarce dollars go farther.

"A pavement management system is a computer-assisted process that examines all public roads and determines the best means to preserve and repair each road individually and the road system as a whole," Metro Nashville informs its citizens in a pavement preservation plan. "Decisions are based on pavement condition, ride quality, costs of treatment, benefits to the road, and benefits to the road system. Because maintenance funds are always limited, the management system recommends the optimum sequence of repairs to make the best use of taxpayer dollars. The system provides a fair and equable way to compare repair needs in all the city's neighborhoods to ensure the decisions are in the community's overall best interests."

Like L.A., Metro Nashville public works uses specially-designed digital survey vehicles to photograph every public street in Davidson County. Trained technicians then view sections of a road to determine the amount of pavement damage, using a uniform scoring method. Measuring devices

For More Information

A vast amount of information on pavement preservation is available to pavement professionals, and it's growing faster and faster. Here are some places to start:

- The Web site of the National Center for Pavement Preservation—www.pavementpreservation.org—has a growing library of technical and practical application papers. Visit the Library and also check out What's New.
- For a more in-depth look at asset management, download the Asset Management Primer (.pdf file) from the FHWA Office of Asset Management Web site, at www.fhwa.dot.gov/infrastructure/asstmgmt/amprimer.pdf/. There are many other documents on the Web site that will be of interest to readers of Pavement Preservation newsletter. Visit them at www.fhwa.dot.gov/infrastructure/asstmgmt/index.htm/.
- The International Slurry Surfacing Association has released its newest informational product, a DVD containing two videos: *Preventive Maintenance—It's a Decision, and Surfacing Systems: Pavement Performance Champions,* packaged in a printed, four-fold brochure. The package explains the advantages, benefits, and economies of pavement preservation and slurry system preventive maintenance applications for existing asphalt roadways. The brochure and videos explain in lay terms and compelling graphs and graphics, the reasons for preventive maintenance and slurry systems (microsurfacing and slurry seal). The kits are available through ISSA member companies; locate them on the ISSA Web site, www.slurry.org.
- The new National Cooperative Highway Research Program synthesis of best practice—NCHRP 35-02: *Chip Seal Best Practices*—is now available. Download it at http://trb.org/publications/nchrp/nchrp_syn_342.pdf.
- NCHRP Report 523: *TRB's National Cooperative Highway Research Program (NCHRP) Report 523: Optimal Timing of Pavement Preventive Maintenance Treatment Applications* describes a methodology for determining the optimal timing for the application of preventive maintenance treatments to flexible and rigid pavements. NCHRP Report 523 also presents the methodology in the form of a Microsoft Excel Visual Basic Application, called OPTime. It may be downloaded (at no charge) at http://trb.org/news/blurb_detail.asp?id=4306.
- All six pocket-sized, spiral-bound editions of the Pavement Preservation Checklist Series—sponsored by FP2 and the FHWA, are available from NCPP. They are No. 1, *Crack Seal Application;* No. 2, *Chip Seal Application;* No. 3, *Thin Hot-Mix Asphalt Overlay;* No. 4, *Fog Seal Application;* No. 5, *Microsurfacing Application;* and No. 6, *Joint Sealing Portland Cement Concrete Pavements.* Obtain them from www.pavementpreservation.org.
- High-performance chip seals and other surface treatments were the subject of an article earlier this year; see *Road Science: Making High-Volume Roads Last Longer,* April 2005, pp 36–53.

mounted on the vehicle also record the amount of rutting in the pavement and evaluate the ride quality. All this information is stored on a computer for processing using specialized pavement management software configured for Nashville's needs.

"MPW scores the streets in two categories—pavement stress and ride quality—to obtain an overall score for the street. Pavement distresses include cracks, potholes, and ruts," Metro Nashville says. "Ride quality is the measure of how bumpy a road is. The scores help public works officials determine the best strategy for each street. One location may need a complete overlay while another street may only need some cracks repaired and potholes filled. By tailoring the repair decision to the needs for each street, based on the data collected, MPW can stretch tax dollars further while making the best repair decision for each street." That's the very definition of pavement preservation.

"Preservation involves a paradigm shift from worst-first to optimum timing. Preservation programs must focus on demonstrating benefit, securing commitment of top agency management, convincing the public, and selecting the right treatment for the right pavement at the right time."

Echoing classic pavement preservation philosophy, Metro Nashville says, "The secret to good pavement management is repairing roads that are still in fair condition but experiencing the early stages of pavement distress, reduced ride quality, and rutting," MPW says. "By keeping those roads in good condition with lower cost repairs, MPW will still have money for reconstructing a few roads each year that are in the worst condition. A dollar in road repair spent early can give the same improvement as four dollars spent later in the road's life when repairs are more expensive. If funds are spent only on the worst roads, our community will stay in a cycle where we can afford only to reconstruct a few roads in very poor condition each year while neglecting simple, lower cost repairs on other roads. If we concentrate on the worst roads, we will never catch up."

ERES Division of Applied Research Associates, Inc., is Metro Nashville's pavement management and preservation consultant.

Reprinted from *Better Roads*, September 2005. *Better Roads* can be visited online at www.BetterRoads.com.

Moving from Goal to Reality

by Tom Deddens

Make your pavement preservation goals a reality with help from new resources available from the Federal Highway Administration (FHWA), the National Center for Pavement Preservation (NCPP), and the Foundation for Pavement Preservation.

Pavement preservation is a network-level, long-term strategy that enhances pavement performance by using a variety of cost-effective surface treatments that extend pavement life. These treatments must be carefully selected and must be applied before the pavement sustains structural damage.

The benefits of a pavement-preservation program include improved pavement performance, increased roadway safety, higher customer satisfaction and reduced overall life-cycle costs.

State and local highway agencies can gain a comprehensive understanding of pavement preservation through a new two-day course offered by NCPP, "Pavement Preservation: Applied Asset Management." The course covers the components of preservation, benefits of undertaking a pavement preservation program and asset management principles and how they can be used to manage highway pavements. Also covered are data inventories, pavement distress identification and analysis, network and project level management and pavement preservation strategies. The course features hands-on group exercises as well, where participants can develop network-level preservation strategies and select treatments to complement the preferred overall strategy.

A new course from FHWA's National Highway Institute, meanwhile, offers strategies for incorporating a pavement preservation program into an overall pavement-management system so that work is coordinated and cost effective. The two-day course, "Pavement Preservation: Integrating Pavement Preservation Practices and Pavement Management" (Course No. 131104A), demonstrates how pavement-management tools can be used to support project-, network-, and strategic-level decision making and details the benefits of including pavement-preservation strategies in the pavement-management process. These benefits include being able to better assess the cost effectiveness of preventive maintenance activities and determine if pavement preservation goals can be met with existing funding levels.

The course is designed for pavement and maintenance engineers who manage pavement preservation programs, as well as planning and programming personnel.

Additional pavement-preservation courses available from NHI are:

- The Preventive Maintenance Concept (No. 131054A);
- Selecting Pavements for Preventive Maintenance (No. 131058A); and
- Design and Construction of Quality Preventive Maintenance Treatments (No. 131103A).

For states who would like assistance in developing or expanding their pavement-preservation programs, FHWA's Office of Asset Management has launched a Pavement Preservation Technical Assistance Program. The NCPP will work with the individual state department of transportation and the local FHWA division office to conduct interviews with key personnel and assess pavement-preservation procedures and policies.

A closeout meeting will be held with the participants from each state to discuss the assessment and any recommendations or suggested improvements for the future.

To learn more, visit www.fhwa.dot.gov/infrastructure and click on "Pavement Preservation Technical Assistance Review and Evaluation."

Information gathered during the assessments will also be used to create a database that can track

Pavement preservation treatments must be carefully selected and must be applied before the pavement sustains structural damage.

pavement preservation practices and trends across the country.

Collecting this data nationally will provide information on the expected service life of various preservation treatments and on variables that can adversely affect treatments, such as application timing, environmental factors, and traffic loads. These state evaluations will establish a much needed baseline and will serve as a sound benchmark for states seeking improvement.

Deddens is a system preservation engineer for FHWA's Construction and System Preservation Team.

Reprinted from *Roads & Bridges,* August 2005.

*The FHWA contact for current information on this topic is Joe Gregory, 202-366-1557 (email: joseph.gregory@dot.gov).

Anticipation is Sweet

Research Examines Results of Preventive Maintenance on Pavements After 14 Years in Service

by Larry Galehouse, P.E., P.S., and John O'Doherty, P.E.

When applied early, preventive maintenance treatments used as part of a sound pavement preservation strategy will cost less than the reconstruction and rehabilitation of highways that are allowed to deteriorate. Michigan, which has been active in implementing pavement preservation programs, has experienced as much as a 10:1 return on preventive maintenance investments.

Network pavement quality improvements also have rewarded states with preservation programs. Since instituting a pavement preservation program in the early 1980s, the Kansas Department of Transportation has seen its good pavements increase from less than 50% in 1983 to approximately 95% in 2003. Yet, despite advances in materials and clear benefits gained over the past 14 years, we still need to gain a better understanding of the optimal timings for the application of the various preventive maintenance treatments.

While we all want highways to improve using available funding, it takes time for a preservation strategy to produce readily observable results. Despite the plethora of professional courses, training workshops, seminars, CDs and video programs promoting pavement preservation for agencies and industry, a lack of good, real-world data tends to inhibit the understanding and general acceptance of the concept. Here, we want to further document the effectiveness of pavement preventive maintenance treatments, some of which have far exceeded their expected service lives.

Sections to the test

The Specific Pavement Study-3 (SPS-3) project titled, "Preventive Maintenance Effectiveness of Flexible Pavements," part of the Strategic Highway Research Program's (SHRP) Long Term Pavement Performance (LTPP), compared the effectiveness and mechanisms for selecting maintenance treatments to preserve and extend flexible pavement service life, safety and ride quality. The overall goal was to assess the benefits of treating test sections rather than scoring the relative performances of various treatments. Study factors included climatic zone, subgrade type, traffic, initial condition and structural adequacy. Treatments tested were slurry seal, chip seal, crack seal and thin hot-mix asphalt (HMA) overlay.

SHRP administered the LTPP project for its first five years, after which it was managed by the Federal Highway Administration (FHWA). The FHWA's DataPave Internet site contains performance data collected on individual projects. The FHWA's Pavement Division formed Regional Expert Task Groups to conduct periodic field performance reviews of the treatments.

Although some of the SPS-3 projects were later overlaid, 48% were still operating in 2004 when the seven projects had been visited, photographed and analyzed for performance after 13 or 14 years of service—long past their expected design lives. DataPave data also were analyzed.

The SPS-3 research sought to define the most effective treatment application timings, evaluate treatment effectiveness for prolonging pavement lives and share information and experience among highway agencies and industry. SPS-3 projects comprised five test sections: an untreated control, a thin HMA overlay, an emulsion slurry seal, a crack-seal section and an emulsion chip seal. Some states also tested other sections. Eighty-one SPS-3 sites with 486 test sections were placed in the U.S. and Canada in 1990 and 1991. All sections were monitored for performance by LTPP.

The Expert Task Groups developed site-specific construction specifications and coordinated construction. To reduce variability, the same placement crews and supervision were used throughout each of

the four LTPP regions for slurry and chip seals. The same slurry seal emulsion was used for all projects, as was a single chip seal emulsion. Aggregates varied by state. The crack sealing materials and crews were the same in each region. Thin HMA overlays were provided by local agencies, with a different HMA and placement crew at each site. For the seven projects described here, the HMA overlay lift thickness varied from 0.7 in. in Texas to 1.8 in. in Missouri.

Under scrutiny

LTPP and the regional Expert Task Groups evaluated section performances through the first five years. Some deteriorated sections were overlaid and abandoned. State monitoring continued on several of the remaining sections. Evaluation tools included the following:

- Distress surveys using the SHRP P-338 Identification Manual;
- Deflection using a falling-weight deflectometer;
- Ride quality, or longitudinal profile, using the K.J. Law-type profilometer; and
- Rut depth using PASCO data and Dipstick.

After the planned five-year evaluation period, several reports were written, and the Expert Task Groups formed the following general conclusions:

- Preventive maintenance treatments generally outperformed control sections;
- Treatments applied to good pavements gave good performance;
- Traffic and structural adequacy did not appear to affect performance;
- Crack seals performed best when cracks were pre-routed and provided the most benefit when applied to good pavements;
- Slurry seals were best in no-freeze climates, outperformed controls and were most effective on good pavements;
- Chip seals performed well except when placed over pavements in poor condition in wet-freeze zones;
- Thin overlays consistently outperformed untreated controls; and
- Generally, preventive maintenance treatments exceeded expectations.

Although the North Atlantic region sections were abandoned by the end of the five-year experiment, after 14 years, 39 of the original 81 SPS-3 test sections were still operational. The seven projects, representing a broad cross section of environmental zones, were constructed in 1990 and evaluated in 2003 and 2004. The selected projects represent wet, no-freeze and wet, freeze zones; southern, north-central and western regions; and 1990 annual equivalent single-axle loads between 11,000 and 307,000.

The LTPP DataPave analysis for the seven projects revealed:

- The International Roughness Index showed no observable trend;
- Thin HMA overlay sections had slightly better overall rut performance than other treatments. (This may have been affected by pre-existing rutting in the wheel paths.);
- Chip seals provided the best overall cracking performance. This observation is consistent with a Texas DOT report of a study of 14 SPS-3 Texas projects;
- Initial cracking tended to be reflective, caused by underlying cracks or by thermal forces or both, and later by fatigue;
- Initially, cracking in the slurry and chip seals diminished, only to resume when the slurry seals began to wear off;
- Except for thin overlays, the treatments increased initial roughness; and
- Thin overlays produced the smallest changes in roughness, while the control and crack seal sections produced the largest increase in roughness.

Pay more later

Pavement preservation is a long-term strategy enhancing functional pavement performance using integrated, cost-effective practices that extend pavement life, improve safety and motorist satisfaction while achieving sustainable, manageable condition levels for pavement networks. Pavement preservation includes routine and preventive maintenance and minor rehabilitation.

Reconstruction replaces an existing pavement structure with an equivalent new pavement structure. Rehabilitation, including restoration treatments and structural overlays, enhances an existing pavement's structure to restore its load capacity. Resurfacing applies additional pavement material (typically more than 1.5 in.) to provide more structural integrity or improved rideability. The reconstruction, rehabilitation and resurfacing costs in Figure 1 are from FHWA's "Highway Statistics 2001" (the most recent available) publication and do not

include adding lanes to increase capacity. The annualized numbers assume a 20- to 30-year (average 25-year) life for reconstruction, 10- to 20-year (average 15-year) life for rehabilitation and 10- to 15-year (average 12.5-year) life for resurfacing. Costs vary regionally.

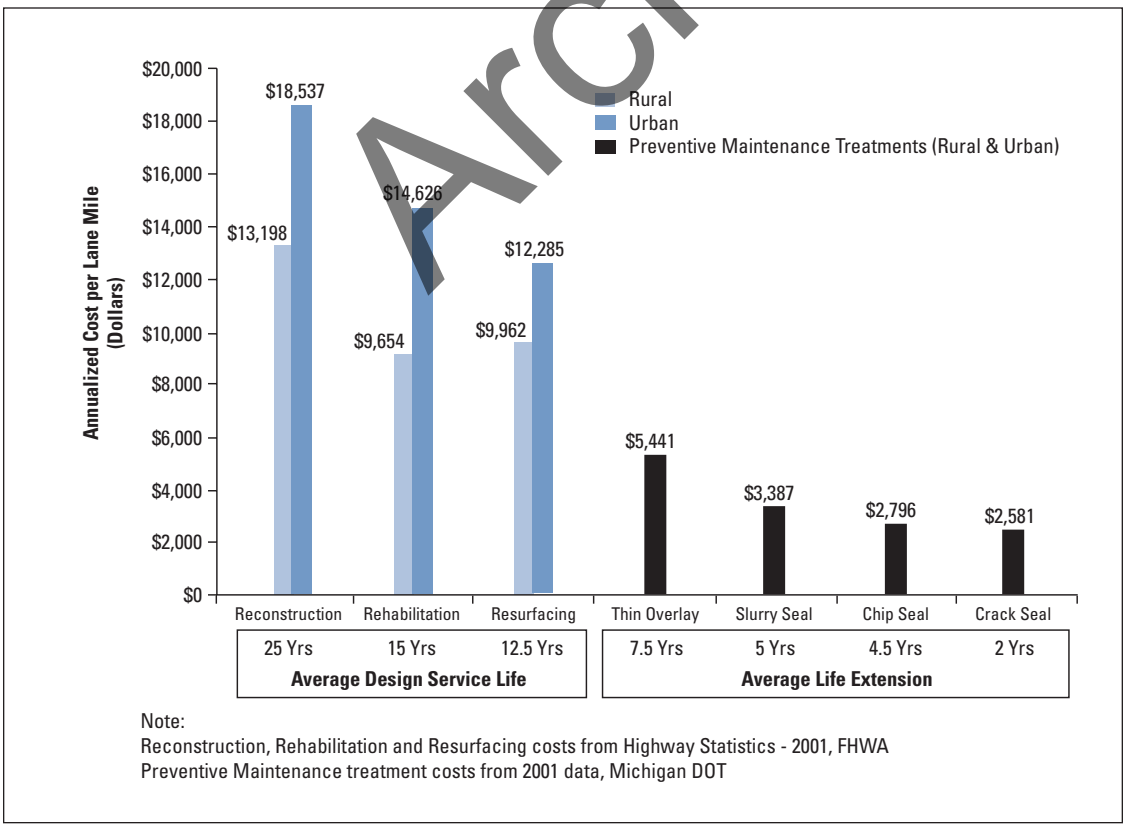
SPS-3 project construction costs were atypical. Figure 1 exhibits typical preventive maintenance costs averaged from 66 projects of the same type placed in Michigan in 2001. They include mobilization, traffic control and required warranty bonds. They have been annualized for the average life extension to the underlying pavement, not the treatment life. Michigan assumed an average 7.5-year life extension from thin HMA overlays, 5 years from slurry seals, 2 years from crack seals and 4.5 years from chip seals.

Agencies should determine treatment performances for their specific conditions. Figure 1 shows potential savings in a program emphasizing preventive maintenance. The annualized cost could be $2,600 for a crack seal or $2,800 for a chip seal to keep a good road in good condition (distinct from extending its useful life) at a mere fraction of the reconstruction cost. In fact, a simplified analysis shows that lane-mile costs for four slurry seal treatments applied over a 25-year period would be approximately $68,000, while without maintenance, the reconstruction cost would be $330,000. With performance similar to that of the projects examined here, even greater savings could be expected.

LTPP DataPave website data were used to evaluate the seven SPS-3 projects after 13 or 14 years of service. These conclusions are only for the seven projects and may not apply to the 52% of SPS-3 projects no longer in service.

Significantly, after 14 years, chip seal sections are generally performing longer than expected, reducing longitudinal, transverse and fatigue cracking, and have been especially effective in sealing and protecting center-line joints. DataPave cracking results generally mirror the visual surveys. Slurry seals are showing signs of wear, but did provide sealing protection for most of their service lives, and their underlying pavements were generally in better condition than the crack sealed and control sections. Crack sealing results were mixed, confirming earlier conclusions by Expert Task Group observers

Figure 1



Note:
Reconstruction, Rehabilitation and Resurfacing costs from Highway Statistics - 2001, FHWA
Preventive Maintenance treatment costs from 2001 data, Michigan DOT

that routed seals perform better, and performance also may depend on pretreatment conditions. Conventional thin HMA overlays, ranging in thickness from 0.7 to 1.8 in., had the lowest International Roughness Indexes and rutting, but were then exhibiting fatigue (and other) cracking and some potholes. Some state-specific special sections did well (most notably the Bonifiber overlay in California), while others did not.

Despite being in the most severe climate, Michigan's SPS-3 project performed well, although it was in good condition before treatment. The Illinois, Michigan and Missouri original pavements were in the best condition of the studied sections, and inspections confirmed the efficacy of preventive treatments. The excellent conditions of the Michigan and other test sections clearly illustrate that preventive maintenance treatments in all climates provide protection and extend service lives when appropriately applied. Selection of the best treatment depends upon many factors including initial pavement condition, local availability of quality materials and construction, local user-delay costs, climate and traffic.

Annualized costs show preventive maintenance treatments applied early in a pavement's life are more cost-effective than allowing the pavement to deteriorate until it needs resurfacing, rehabilitation or reconstruction. A preventive maintenance strategy costs less and raises the overall quality of the road network, keeping good roads good. Preventive maintenance treatments reviewed here have performed well beyond their design lives, indicating even lower possible annualized costs and higher pavement quality. Since 1990, when these projects were initiated, we have seen many improvements in materials, construction techniques, equipment and performance-related specifications, and these improvements should extend pavement life and lower costs even more.

Galehouse is director of the National Center for Pavement Preservation (NCPP), Okemos, Mich. O'Doherty is in charge of education and training at the NCPP.

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A Helping Hand in Preserving Our Pavement Investment

State highway agencies seeking to develop, expand, or improve their pavement preservation programs now have a valuable new resource available to them. The Federal Highway Administration's (FHWA) Office of Asset Management has launched a Pavement Preservation Technical Assistance Program to work with highway agencies to evaluate their pavement preservation programs. The National Center for Pavement Preservation (NCPP) at Michigan State University in East Lansing, Michigan, will coordinate with the individual State and the local FHWA division office to conduct interviews to assess procedures, policies, and programs associated with pavement preservation. "The goal is to help States assess where they are and provide comments and recommendations on what they can do to further develop and enhance their pavement preservation programs," says Tom Deddens of FHWA's Construction and System Preservation Team.

Pavement preservation is a network level, long-term strategy that enhances pavement performance by using a variety of cost-effective surface treatments that extend pavement life. These treatments must be carefully selected and must be applied before the pavement sustains structural damage. As implementation of pavement preservation programs increases nationwide, however, each highway agency faces different challenges in applying pavement preservation treatments and establishing an effective preservation program in its State. FHWA's technical assistance program will help agencies assess their particular circumstances and address challenges that may exist. FHWA and NCPP will also benefit by obtaining data to establish a national baseline for pavement preservation practices.

Each review will include approximately 80 hours of program assessment and interviews with key highway personnel involved in the development, implementation, and management of the State's pavement maintenance, evaluation, and preservation programs. "The intent of the technical assistance will be to assess these components to identify both sound engineering practices and those practices that could be refined or improved to provide a more effective pavement preservation program," says Deddens. A closeout meeting will be held with the participants from each State to discuss observations, make recommendations, and suggest enhancements and/or improvements.

Information gathered during the assessments will be used to create a database so that pavement preservation practices and trends can be tracked nationally. "The database will provide a long-term tool for sharing best practices and assessing the success of the preservation program nationwide," says Deddens. "It will also help us examine variables that can adversely affect pavement preservation treatments, such as application timing, environmental factors, and traffic loads. These results may also answer questions regarding the expected service life of various treatments."

For more information or to schedule a review, contact Tom Deddens at FHWA, 202-366-1557 (email: tom.deddens@fhwa.dot.gov).*

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*The FHWA contact for current information on this topic is Joe Gregory, 202-366-1557 (email: joseph.gregory@dot.gov).

New Course Offers "How to" for Integrating Pavement Preservation and Pavement Management

Are you missing the data needed to determine whether your agency's preventive maintenance activities are cost effective? Have you spent maintenance funds on a road scheduled for construction work, resulting in wasted money and effort? Or have you begun a pavement preservation program without knowing if you can achieve your goals with existing funding levels? Find out how to get the data you need, incorporate your preventive maintenance strategies into your pavement management system (PMS) so that work is coordinated and cost effective, and achieve your pavement preservation goals by attending the new National Highway Institute (NHI) course, "Pavement Preservation: Integrating Pavement Preservation Practices and Pavement Management" (Course No. 131104A).

A pavement preservation program uses an integrated, cost-effective set of practices to extend pavement life, improve safety, and meet the expectations of motorists. Pavement management systems, meanwhile, aid in collecting and analyzing pavement data and making planning and budgeting decisions. Bringing the two together is the focus of NHI's new course. The course details how to integrate pavement preservation programs into an overall pavement management process. "Pavement preservation programs provide significant benefits to highway agencies, while pavement management systems provide the data that agencies need to measure the benefits. This course provides the essential tools and techniques to integrate the two," says Jim Sorenson, Construction and System Preservation Team Leader in FHWA's Office of Asset Management.

Among the topics covered are the types of management decisions that are made by transportation agencies and the data that is needed to support these decisions. The course then demonstrates how pavement management tools can be used to support project, network, and strategic level decisionmaking, and outlines the benefits of including pavement preservation strategies in the pavement management process.

"Integrating a pavement preservation program into an overall pavement management plan can help highway agencies develop a more comprehensive and coordinated road improvement plan, which includes maintenance needs as well as capital improvements," says Katie Zimmerman, President of Applied Pavement Technology, Inc., which developed the course and will be teaching it for NHI. "Times have changed," notes Tom Deddens, Preservation Engineer in FHWA's Office of Asset Management. "It is no longer about identifying roads in need of rehabilitation, repair, or reconstruction. Today we must extend our highway investments by addressing surface deterioration and functional needs to get the most life out of our roads. This is preservation: selecting the right road for the right treatment at the right time. We need a PMS that includes preservation-related distress and maintenance strategies."

"Times have changed. It is no longer about identifying roads in need of rehabilitation, repair, or reconstruction. Today we must extend our highway investments by addressing surface deterioration and functional needs to get the most life out of our roads."

The 2-day course is designed for pavement and maintenance engineers who manage pavement preservation programs, as well as planning and programming personnel. The course development was supported by an expert technical panel that included representatives from Federal, State, and local transportation agencies. Industry representatives also provided support through the Foundation for Pavement Preservation.

A pilot course was held in Raleigh, North Carolina, in August 2003. Since then, the course has been presented in Bal Harbour, Florida, for local and State highway agency personnel, and Lincoln, Nebraska, for staff of the Nebraska Department of Roads.

"It was a helpful course," says Gary Brhel of the Nebraska Department of Roads. "It gave us some tools and processes to use to help us integrate pavement preservation into our pavement management system." Jerry Sudimick of the Florida Turnpike Enterprise attended the course held in Florida. "The class was very informative," says Sudimick. "We have not implemented a pavement preservation program. However, I will be going back to the Turnpike Enterprise with considerably more information and techniques to consider in order to prolong our system's pavement life."

The new course is the fourth in a series of pavement preservation classes. Other courses in the series available from NHI are:

- The Preventive Maintenance Concept (No. 131054A)
- Selecting Pavements for Preventive Maintenance (No. 131058A)
- Design and Construction of Quality Preventive Maintenance Treatments (No. 131103A).

For more information about the course content, contact John Taylor at NHI, 703-235-0524 (email: john.taylor@fhwa.dot.gov), or Tom Deddens at FHWA, 202-366-1557 (email: tom.deddens@fhwa.dot.gov).* Information is also available on the NHI Web site at www.nhi.fhwa.dot.gov. To schedule the course, contact Danielle Mathis-Lee at NHI, 703-235-0528 (email: danielle.mathis-lee@fhwa.dot.gov).

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*The FHWA contact for current information on this topic is Joe Gregory, 202-366-1557 (email: joseph.gregory@dot.gov).

Making High-Volume Roads Last Longer

by Tom Kuennen

Preservation techniques for local roads work for high-volume pavements, too—but top-flight discipline, designs, and materials are required.

Crack sealing, chip seals, slurry surfacings, and thin overlays are part of a standard pavement preservation "tool box" for low-volume, secondary roads. Now, a growing accumulation of research indicates these same techniques also work on high-volume roads, but with a catch: success demands a disciplined approach to these techniques rather than the seat-of-the-pants, intuitive procedures that often mark work done on low-volume pavements.

Where chip seals might have been done by agency forces using tried-and-true, "hand-me-down" procedures with off-the-shelf binder and chips, today's successful chip seal for high-volume roads likely will be designed in a lab based on existing conditions, climate, and traffic loads, with a binder that is polymer-modified, and chip attributes that specify shape size, moisture content, and placement.

And, rather than being installed by an agency's general maintenance crew, it may be placed by a contractor—or a highly trained agency crew—with the quality controls and material suppliers that can assure the quality materials demanded for long-term performance. Its performance may be warranted. And in some instances, the preservation treatment may be a proprietary product that is available only through a dedicated contractor, such as an ultra-thin bonded wearing course like Koch's NovaChip.

As agencies invest more in preservation for high-volume pavements, competition for that market is growing. A case in point: Rather than conceding the prevention market to chip seal interests, the hot-mix asphalt industry has been supporting research into thin asphalt overlays and how they fit into a pavement preservation program.

And, all treatments are benefiting from new research that identifies best practices for pavement preservation for high-volume roads, and establishes valid lifecycle cost-analysis that makes the argument for increased budget emphasis on prevention more effective.

New choices

Conventionally, chip seals and other surface treatments have not been associated with high-volume arterial, collector, or interstate-type pavements. Instead, with regional exceptions, the preferred application is an asphalt overlay, following years of minimal care—typically, pothole patching and occasional crack sealing. But a variety of surface treatments for high-volume roads exists, and experts say they have the potential to prolong pavement serviceability at minimal cost.

"Historically, the agency managers felt that the high-type asphalt and concrete pavements always needed an additional section of asphalt placed on them, and that chip seals, slurry seals, and other preservation treatments would not stand up to the traffic and loadings of those high-level pavements," said Jim Sorenson, senior construction and maintenance engineer, Federal Highway Administration Office of Asset Management.

"But with the advent of SHRP [Strategic Highway Research Program], 1988-1993, it was clearly demonstrated that preservation treatments were fully viable for any volume of road," Sorenson told *Better Roads.*

"There are the right techniques to use; for example, the chip seal must be properly designed, with good embedment and traffic speed held down. But on the Tacoma Narrows Bridge, with about 178,000 ADT [average daily traffic], Washington State DOT has been putting chip seals on the deck for years" noted Sorenson. "They don't want to add a lot of extra weight but need to keep friction up. Caltrans has main-line pavements on I-5 and I-80 where they did not think surface treatments would work, but the treatment has held up to the traffic."

Such surface treatments can afford to have a higher quality aggregate in them, because other costs are lower. "As a result, their durability is much better," Sorenson said. "The surfacings are not expected to carry the load or provide structural value, but to ward off the effects of aging and oxidation that Mother Nature sends. It's a matter of putting them down right, and they will serve the pavement and traveling community in a very positive fashion."

Some preservation practitioners think that multiple treatments can preserve the structural soundness, drainage, and overall condition of roads for long periods of time. "Don't think you can only mill out and replace," Sorenson told *Better Roads.* "You may be able to use fog seals, slurry seals or microsurfacing, or chip seals, bettering the pavement performance cost-effectively, because these treatments clearly are showing a return on investment."

"A lot of people use a one-size-fits-all approach," said Larry Galehouse, P.E., director, National Center for Pavement Preservation at Michigan State University. "It's not cost-effective to do business that way. We have to look at what treatment will correct the deficiency, for the least cost, for the best performance. Pavement managers have to jump in with both feet, and gain this experience. Right now, a lot of agencies don't have the institutional knowledge to take on preservation without some intense training. They have to cultivate the knowledge base within the agency, because there is a lot of poor practice out there."

One of the worst practices is waiting too long—that is, waiting for damage to develop—before preventive measures are applied, he said. "You've got to have a good pavement structure. If the pavement structure is sufficient to carry the load, we must keep the water out, maintain good skid resistance, and provide a smooth ride for the motorist. With pavement preservation techniques we will improve pavement performance and extend its life."

Most preservation actions used on asphalt or concrete low-volume roads are also suitable for higher-volume roads, Galehouse said. "For example, on good PCC pavements we can reseal joints, and on HMA, we seal the cracks," Galehouse told *Better Roads.* "We can seal edges to avoid edge drops between the driving lane and shoulder, something that's not done enough. We can microsurface and place thin bituminous lifts without concern for changing traffic volume."

Attention to preservation

Years of research, publicity, and politicking on behalf of pavement preservation in the post-interstate era are beginning to bear fruit as closer attention is being paid to pavement preservation in national forums.

Pavement preservation has been a strong topic of research at the annual Transportation Research Board meetings since 2000. The Federal Highway Administration and American Association of State Highway & Transportation Officials are putting resources into promoting pavement preservation in the context of transportation agency asset management.

The Foundation for Pavement Preservation was founded in 1992 and now is administered out of Austin, Texas. And Galehouse's NCPP, a strong resource for pavement managers, marked its first year of operation last fall.

Also driving the interest in prevention practices for high-volume roads is a growing emphasis in government on asset management.

The Midwestern Regional University Transportation Center in Madison, Wisconsin defines asset management as "a systematic process of operating, maintaining, and upgrading physical assets cost-effectively. It combines engineering and mathematical analyses with sound business practice and economic theory. Asset-management systems are goal-driven and, like the traditional planning process, include components for data collection, strategy evaluation, program selection, and feedback."

The asset management philosophy compels government agencies to borrow private-sector concepts of inventory, initial value, and net present value and apply them to their pavement system. That, in turn, helps them allocate their limited financial resources to optimize present and future road-system value. Asset management automatically puts the emphasis on life-cycle costing and how limited expenditures now can ensure optimal value later—and that is the very essence of pavement preservation practice.

However, experts warn, high-level pavement preservation programming will only work if the bureaucracy of the highway agency supports it, and that can be tough in cultures that have traditionally focused on construction and renovation, and treated maintenance as an afterthought.

FHWA moves forward

That pavement preservation deserves highest priority at the state DOTs was borne out last October, when the Federal Highway Administration strongly affirmed that pavement preservation expenditures are desirable and reimbursable under FHWA rules. In an October 8, 2004 memo obtained by *Better Roads,* FHWA Associate Administrator King W. Gee threw the weight of the FHWA behind pavement preservation.

"Timely preventive maintenance and preservation activities are necessary to ensure proper performance of the transportation infrastructure," Gee told division administrators and field services directors. "Experience has shown that when properly applied, preventive maintenance is a cost-effective way of extending the service life of highway facilities and, therefore, is eligible for Federal-aid funding."

And preservation gives states a path to optimizing their pavements for the long-term, he said. "By using lower-cost system preservation methods, states can improve system conditions, minimize road construction impacts on the traveling public, and better manage their resources needed for long-term improvements such as reconstruction or expansion. Preventive maintenance offers state DOTs a way of increasing the return on their infrastructure investment."

Eligibility of pavement preservation grew slowly during the 1990s, as Congress incrementally broadened the applicability of Federal-aid funding to preventive maintenance activities. "Congress' acknowledgement of preventive maintenance activities as an eligible activity on Federal-aid highways is a logical step that reinforces the importance of implementing a continuing preventive maintenance program," Gee said.

Gee urged FHWA offices to work proactively with states to establish a preservation program, likely to include joint repair, seal coats, pavement patching, thin overlays, shoulder repair, restoration of drainage systems, and bridge activities such as crack sealing, joint repair, seismic retrofit, scour countermeasures, and painting.

"Many other activities that heretofore have been considered routine maintenance may be considered Federal-aid eligible on an area-wide or system-wide basis as preventive maintenance (i.e., extending the service life)," Gee said. "This might include such work items as region-wide projects for periodic sign face cleaning, cleaning of drainage facilities, corrosion protection, spray-applied sealant for bridge parapets and piers, etc."

Low-volume roads

Most pavements in North America and the rest of the world carry low traffic volumes, and there is a rich history of surface treatments being used in their management.

In a 2005 TRB paper, *Maintenance and Rehabilitation of Low-Volume Pavements in Washington State,* Muench, White, Mahoney, Sivaneswaran, and Pierce confirm that "maintenance and rehabilitation practices on these roads are vital to their continued serviceability." They also noted that such low-cost strategies are vital because "low-volume roads are typically managed by agencies with extremely limited resources."

The authors researched their state's 30-year data base for low-volume pavement maintenance to reach their conclusion. "Records indicate that over two-thirds of WSDOT's low-volume pavements are bituminous surface treatments, while almost one-third are hot-mix asphalt surfaced pavements," they said. "These pavements, many of which have lasted in excess of 35 years, are in relatively good condition and are typically subject only to periodic rehabilitation treatments every 8 to 20 years and responsive pothole patching. This evidence suggests that the concept of a long-lasting low-volume pavement is viable and, in fact, already exists."

High-volume roads

Many of those same practices can be used on high-volume roads as well. For example, chip seals can be used on interstate-type highways if done right, NCPP's Galehouse said.

"There are states that have successfully put chip seals on high-volume highways," Galehouse told *Better Roads.* "They have developed an institutional knowledge that lets them be successful. Texas, California and Montana have done them. Trucks will take their toll on any treatment, and chip seals are no exception. But if a chip seal is done right it can stand up to trucks, provided there are no structural deficiencies."

"There is no magic ADT number or threshold for chip seal use," said Steve Mueller, pavements and materials engineer, FHWA Resource Center, Denver. "Our new NCHRP Chip Seal Best Practice study shows that many countries are using chip seals on

high-volume roads, and that's one of the report's major findings. It's an outstanding report which will advance the pavement preservation industry considerably."

Such seals tend to be polymer modified, Mueller told *Better Roads* at the 32nd annual Rocky Mountain Asphalt Conference and Equipment Show in February in Denver. "Polymer modification adds to the stickiness of the material, and holds the aggregates in on high-speed roadways. Public safety is a key issue here, and we certainly don't want to damage vehicles from chip loss. The fact is that we can build chip seals with very low rates of loss, and properly designed and constructed chip seals can be used on high-volume roadways."

That properly designed surface treatments can hold up to traffic and weathering is borne out by research that now is coming to fruition. At January's TRB meeting, proponents of pavement preservation gave an overview of just how well polymer-modified surface treatments can perform in different climates, based on 14 years of field experience. Visual surveys, photos, and data mining from the Long-Term Pavement Performance study's DataPave Web site were used to evaluate the condition of seven research projects after 13 or 14 years in service.

Preventive Maintenance Treatment Performance at 14 Years was authored by NCPP's Larry Galehouse, Helen King, and David R. Leach of Koch Pavement Solutions, Jim Moulthrop of Fugro Consultants, and Bill Ballou of the Foundation for Pavement Preservation. They concluded, "Perhaps the most compelling conclusion is that, after 14 years, the chip seal sections are generally giving longer than expected performance; reducing longitudinal, transverse, and fatigue cracking; and they are especially effective in sealing and protecting the centerline joints."

The slurry seals are showing signs of wear, but did provide sealing protection for most of their service life, and the pavements protected by the slurry seals are generally in better condition than the sections that were just crack sealed and the control sections, they said. "The results on the crack sealing sections are mixed, confirming earlier conclusions by ETG [expert task group] observers that the routed seals give better performance, and their performance may also depend upon the road condition before treatment," they said.

The contention that surface treatments will keep a top-flight road in top-flight condition also was borne out by the data. "The Michigan SPS-3 project, in the most severe climate, is among the best in overall condition," they said. "It was also one of the projects in the best condition before treatment. The Illinois, Michigan, and Missouri original pavements were in the best condition of the sections studied for this report, and the photos and surveys show that the preventive treatments have kept them in the best condition.

"The excellent condition of the Michigan SPS-3 project and some of the other test sections clearly illustrates that preventive maintenance treatments in all climates do provide protection and extension of service lives when appropriately applied," they said.

Chip seal best practice

That the best-designed chip seals can be used on high-volume pavements is illustrated in a new survey and practice presented in January at TRB. The paper, *Chip Seal Program Excellence in the United States,* by Dr. Doug Gransberg, P.E., University of Oklahoma-Norman, describes a survey of public highway and road agencies that use chip seals as part of their roadway maintenance program; the paper will become a part of the new NCHRP Synthesis Report 35-02 mentioned by the FHWA's Mueller, *Chip Seal Best Practices,* (see For More Information sidebar).

The survey was conducted to identify best practices in chip seal design and construction. "The study found that successful chip seal programs had much in common," Gransberg said. "The major findings were that they used chip seals as a preventive maintenance tool applying it to roads before distress levels were classified as moderate. It also found that they require their contractors to use the latest technology and exploit advances in material science such as the use of modified binders. Additionally, most of these case study programs use chip seals on both high- and low-volume roads."

Chip seals date to the 1920s, Gransberg said. "These early uses were predominantly as wearing courses in the construction of low-volume gravel roads," he said. "In the past 75 years, chip seals have evolved into maintenance treatments that can be successful on both low- and high-volume pavements. The popularity of chip seals is a direct result of their low initial costs in comparison with thin asphalt overlays, and other factors influencing treatment selection, where the structural capacity of the existing pavement is sufficient to sustain its existing loads."

Among those agencies reporting excellent chip seal performance were Arkansas State Highway and Transportation Department; Colorado DOT; Idaho Transportation Department; Nevada, Oklahoma, Texas and Washington State DOTs; and the cities of Austin and Lubbock, Texas.

"The most striking factor [is that] they use chip seals as a preventive maintenance tool by following a specific PM cycle," Gransberg said.

Research Gransberg uncovered in Texas shows that the design of a chip seal is paramount for performance. "One group followed formal design procedures...or local empirically developed procedures and utilized some form of input parameters, based on observed surface conditions, to calculate the rates of binder and aggregate application," he wrote. "The other saw chip seal as a commodity and merely ordered an estimated amount of material and specified application rates based on past experience."

The carefully designed chip seals significantly outperformed their more casually placed counterparts. "Only one of the excellent case studies did not formally design its chip seals, and those that did utilized a procedure that has been in use for an average of 21 years," said Gransberg.

All use modified binders, with polymers and crumb rubber being the most common modifiers, he said. "They all select roads whose distress level is rated at moderate or less and whose structural cross-section is rated as fair or better, using some type of pavement condition rating as the trigger point to consider the selection of chip seal to extend the life of the pavement," Gransberg said. "This further reinforces the use of this treatment as a PM technique rather than a repair method…these programs also follow-up to maintain their seals with routine crack sealing, and sometimes fog sealing, to maintain the integrity of the asphalt membrane for the life of the seal."

Gransberg found:

- Chip seals should be viewed as a preventive maintenance tool to be applied on a regular cycle, and in doing so, reinforce the pavement preservation benefits of the technology.
- Chip seals can be successfully used on high-volume roads if the agency's policy is to install it on roads before pavement distress becomes severe or the structural integrity of the underlying pavement is breached.
- Both hot asphalt cement and emulsified asphalt binders can be used successfully on high-volume roads; binders modified by polymers or crumb rubber seem to reinforce success.
- In-house maintenance forces should be used to install chips seals in areas where the greatest care must be taken to achieve a successful product.
- Requiring chip seal contractors to use state-of-the-art equipment and to control the rolling operation enhances chip seal success.
- Chip seal success requires an aggressive QC testing program combined with careful on-site inspections.

Cracks come first

In its *Roadway Maintenance Surface Treatment Strategies* (Recommended Guidelines), Caltrans says much the same thing for both contracted maintenance and that done by state forces. "Experience has shown when proper preparation has been done in areas scheduled for surface treatments (either by contract or by state forces), the life of the surface treatments can be greatly extended and helped in reducing lifecycle cost," the California DOT said. "It is critical that all necessary preparation work such as crack filling, pothole repair, patching, leveling, digouts, etc., be done prior to surface treatments being placed."

Caltrans calls crack filling and sealing "our first line of defense in roadway maintenance." The agency recommends cracks 0.25 inch or wider be filled or sealed before rainfall seasons or before the application of maintenance surface treatments such as fog seals, sand seals, slurry seals, chip seals, or maintenance overlays.

"Cracks should be cleaned before filling or sealing," the agency says. "When moisture is present or suspected, it is recommended that hot compressed air (hot lance) be used to prepare cracks immediately before filling or sealing materials are applied. All cracks should be squeegeed during filling and sealing (if product is left above the surface) to save materials, prevent road noise, improve ride quality, prevent bleeding or masking through future surface treatments, and prevent compaction problems on future overlays."

Caltrans also says crack fillers should be placed several months before future surface treatments, depending on local climatic conditions, to assure sufficient cure time for various crack-filling products.

Premium crack-sealing products should be considered, Caltrans says. "Crack-sealing operations

can be very labor intensive," the agency advises. "A value engineering study which involved seven states (including California) concluded that 66% of the total cost for these projects was for labor, 22% for equipment, and 12% for materials. Therefore, it may be more cost-effective to use a more expensive product that will last longer."

Polymer modifiers key

Gransberg's findings of the desirability of polymer-modified binder in high-volume roadway chip seals was illustrated several years ago in South Dakota, which has had mixed success in surface sealing high-volume, high-speed roadways such as interstates.

"Chip seals and sand seals have been the treatments of choice [in South Dakota] but they have been less successful on high-volume/high-speed roadways," the FHWA said. "Chip retention is the major problem associated with these failures. The high number of broken windshields caused by loose chips has resulted in multiple claims on an individual project."

So a project was undertaken to investigate the use of chip seals for high-speed applications and to make recommendations to improve their performance. An extensive literature review was conducted to develop an understanding of the latest practices and experiences. Interviews were conducted within the South Dakota DOT to investigate chip seal practices and to determine areas for improvement.

Finally, test sections were constructed to evaluate the performance of standard and modified chip seal designs. The test sections consisted of 12 chip seal designs and included two aggregate types (quartzite and natural aggregate) and alternate chip seal designs with new gradations and other modifications and enhancements.

Recommendations were articulated in a January 2002 Transportation Research Board presentation, *Evaluation of Chip Seals on High-Speed Roadways.* Authors Daris Ormesher, P.E., South Dakota DOT Office of Research; and Monty J. Wade, P.E., and David G. Peshkin, P.E., Applied Pavement Technology, Inc., said polymer-modified binders are the key to successful chip seals on South Dakota's interstate-type, high-speed pavements. Performance can be enhanced through special considerations, such as the use of polymer-modified emulsions, precoated aggregates, or a fog seal cover.

They recommended use of a polymer-modified emulsion to obtain better adhesion, especially on high-volume roadways, and the use of a fog seal over the chip seal to help with retention.

Projects should be designed on a specific, individual project basis, and a higher emulsion application rate to achieve greater aggregate embedment should be considered, the authors said.

They also concluded that a tighter and more gap-graded aggregate gradation should be developed to ensure uniformity and provide a single layer of chips, and that the amount of fines (material passing the 0.075-mm [No. 200] sieve) in the chips should be limited. Testing should limit the amount of flat and elongated particles in the aggregate, and also should determine adhesion between the aggregate chips and the emulsion.

The authors said a surfaced pavement should be swept two hours after chip seal placement, and before opening to traffic; in the meantime, if used, the pilot vehicle should be run on the chip seal to assist chip embedment and orientation. An embedment check to ensure adequate embedment of the aggregate should be considered. And a choke stone layer of small chips over the chip seal to lock in the larger aggregate particles might be beneficial.

Microsurfacing vs. slurry seals

A major western contractor says high-performance microsurfacing is a superior choice for high-volume pavements.

"On interstates we recommend microsurfacing, because you can get traffic back on it quickly," said Brett Hone, project manager, Intermountain Slurry Seal, Salt Lake City, Utah. "Microsurfacing allows the contractor the capability to fill ruts by placing the aggregate more than one stone thick, then turn 80,000-pound trucks back on to the filled ruts within one hour. The degree of heavy truck-caused rutting is the key factor over whether microsurfacing or chip seals would be used."

Hone said chip seals still have applications for interstates. "We're still using chip seals on interstates and fog-sealing them after three days," Hone told *Better Roads.* "With the proper application they're a good solution; Utah DOT uses them every year. When you fog-seal the chip seal, it does a great job of holding the chip down, and gives the gray chips a black color for snow melt, and high contrast for striping."

For main arterial roads around town, Hone recommends slurry seals as a cost-effective maintenance product. "You would want to use a latex- or

polymer-modified Type III slurry seal," he says, "because it has better bonding capabilities and the coarser Type III aggregate gives you a more aggressive surface for keeping skid numbers up high. And Type III slurry will cure out in less than four hours in the summer, which lets you get traffic back on it quickly. There is a little more downtime that way, but the cost savings compared to microsurfacing is half as much."

Intermountain has done fog-sealed chip seal projects with quarry-sourced 0.375-inch chips on I-70 and I-15 in Utah, and reports that they last four to five years. "After three years, on some applications, they will apply a rejuvenator sealant, prior to placing another wear surface down three years after that," Hone said.

For either microsurfacing or chip seal, the highway has to be in good condition. "The highway will have to be structurally sound," Hone told *Better Roads.* "Microsurfacing can fill in ruts, so long as you are confident the pavement has stabilized and is not subject to plastic deformation. My advice to states is to sit back and look at their wallet a little closer, and see where the money is going out the door. If they can maintain an asphalt surface by utilizing surface treatments in lieu of putting an overlay on top, they will be money ahead, because they can do twice as many lane miles with surface treatments. The key, though, is getting on them relatively quick, before they have oxidized and gotten brittle, and all the cracking has taken place."

Does joint sealing work?

Pavement joint and crack sealants are designed to protect pavement by minimizing water infiltration and by preventing the accumulation of debris. "Crack sealing is an effective technique for maintaining flexible [hot-mix asphalt] pavements," said the Transportation Research Board's forward-looking state-of-the-industry forecast on the occasion of the Millennium. "Research has indicated that, in conjunction with maintenance techniques such as slurry seals and chip seals, crack sealing will extend the life of a flexible pavement."

The practice of sealing joints in rigid pavements has been subject to controversy. Research conducted by the Wisconsin DOT indicated sealing joints in concrete highway pavements was not cost effective. "Anecdotal information supports this finding," the TRB panel found, adding "other information seems to show that joint sealant materials are vital to the protection of the pavement and that unsealed pavements deteriorate rapidly."

The challenge was thrown down at the 1996 Spring Convention of the American Concrete Institute in Sacramento, and subsequently was articulated in *The Effect of PCC Joint Sealing on Total Pavement Performance,* a paper by Steve F. Shober and Terry S. Rutkowski of the Wisconsin DOT.

Their research indicated that long-term pavement performance was not significantly affected by joint sealing, or its omission, and was not worth the expenditure of precious state maintenance funds.

"WisDOT believes the burden of proof has shifted," Shober and Rutkowski wrote. "No longer can anyone tout the merits of keeping water and incompressibles out of [pavement contraction] joints. Now, the burden is on researchers to prove through total pavement performance analysis that sealing PCC joints somehow enhances performance enough to be cost effective." In a subsequent paper they found that asphaltic concrete (HMA) crack sealing was cost-effective in some cases, especially in improving winter ride.

Realizing their findings constituted heresy to an establishment that maintained pavement joint sealing was intuitively valid, Shober and Rutkowski summoned up a scientific fallacy of the past.

"Centuries ago, the concept of a spherical earth was viewed as preposterous," they wrote. "Wisconsin's research has posed a position that may be viewed similarly, that is: total highway pavement performance is not significantly affected by joint sealing or lack thereof. The challenge awaits others to provide compelling research on this issue."

Into the fray stepped New York State DOT's outspoken innovative projects engineer John Bugler, and Burgess & Niple's engineer Martin P. Burke, Jr. In their 2002 TRB paper, *The Long-Term Performance of Unsealed Jointed Concrete Pavements,* Bugler and Burke said Shober and Rutkowski had not used a long-enough time frame.

"[I]t appears that WisDOT observations of test pavement performance were based on the mistaken assumption that the performance of pavements during their first 10 years of service was somehow indicative of their long-term performance," Bugler and Burke said. "Such an assumption entirely neglects the characteristics of the pavement growth/pressure phenomenon that typically becomes more destructive with pavement age. It also neglects the adverse long-term accumulative effects of surface and subsurface water movement on pavement

pumping and step-faulting, especially for pavements without dowels serving heavy truck traffic." Unsealed pavement joints did not provide long-term cost-effective pavement performance, their research indicated. "As a result," Bugler and Burke said, "the use of unsealed pavement joints has been discontinued by many major users familiar with the long-term performance of such applications."

But joint sealing had to be done right, they said. "Care must be taken in choosing high quality sealant material, the type and size of sealant for the chosen pavement joint and panel characteristics, as well as effective installation and inspection procedures, and periodic sealant repair and replacement practices."

New Pavement Preservation Boss at FHWA

Tom Deddens, P.E., joined the FHWA's Office of Asset Management as pavement preservation and construction engineer in February. He will manage the pavement preservation program, as well as the program manager moving the FHWA's interests in performance specifications.

Deddens has 30 years' experience in the industry. He worked more than 10 years in the U.S. Army Corps of Engineers, and has since worked in the private sector for several consultants, and in industry as a district engineer for the Asphalt Institute. With the Asphalt Institute, he provided technical assistance and training opportunities to the states of Arkansas, Illinois, Kansas, Missouri, and Nebraska, including maintenance of hot-mix asphalt pavements, rehabilitation of pavements using HMA, advanced Superpave mix design, and construction of asphalt pavements.

Deddens is a qualified National Highway Institute instructor, having taught its course in Pavement Preservation: Selecting Pavements for Preventive Maintenance. He holds a bachelor of science degree (1975) from the University of Missouri-Rolla, and a master of science degree (1985) from the University of Kansas. He is a registered professional engineer in Kansas and Missouri, and has been professionally active in the Association of Asphalt Paving Technologists and American Public Works Association.

FHWA'S List of Preservation Methods

Asphalt pavements:

- Crack sealing.
- Patching.
- Fog seals (a combination of mixing-type emulsion and approximately 50% water, used to seal shoulders and patches).
- Rejuvenation (application of a rejuvenator agent in a procedure similar to fog sealing).
- Sandwich seals (application of asphalt emulsion and a large aggregate, followed by a second application of asphalt emulsion that is in turn covered with smaller aggregate and compacted).
- Sand seals (application of liquid asphalt or emulsions, covered with fine aggregate or sand, to improve skid resistance, prevent oxidation, and to seal against water infiltration).
- Chip seals (surface treatment in which the pavement is sprayed with asphalt emulsion and then immediately covered with aggregate and rolled).
- Slurry seals (an application of mixing-type asphaltic emulsion, sometimes with additives, mineral aggregate, and proportioned water, mixed and spread on clean pavement free of dirt and loose gravel).
- Microsurfacing (polymer modified asphalt emulsion, mineral aggregate, mineral filler, water, and other additives, properly proportioned, mixed, and spread on a pavement).
- Cape seals (application of slurry seal to a newly constructed surface treatment or chip seal).
- Thin and ultrathin hot-mix asphalt overlays (single-lift surface course, generally with a thickness of 1.5 inch or less).

Concrete pavements:

- Patching.
- Joint sealing.
- Joint and spall repairs.
- Load transfer retrofit.
- White topping (similar to a thin HMA overlay, but using a fast-curing, high-durability concrete mix).

For More Information

More information about high-performance pavement preventive maintenance is available from a variety of sources. Begin with these:

Chip Seal Best Practices. The long-awaited National Cooperative Highway Research Program synthesis of best practice, NCHRP 35-02: *Chip Seal Best Practices,* should be available this spring. Visit this link to see if it has been announced: http://trb.org/news/blurb_browse.asp?id=5. Alternatively, locate it with a Google search by inputting: "NCHRP 35-02."

NCHRP Report 523. *Optimal Timing of Pavement Preventive Maintenance Treatment Applications* describes a methodology for determining the optimal timing for the application of preventive maintenance treatments to flexible and rigid pavements. NCHRP Report 523 also presents the methodology in the form of a Microsoft Excel Visual Basic Application, called OPTime. It may be downloaded (at no charge) at http://trb.org/news/blurb_detail.asp?id=4306.

A Pavement Preservation Strategy. Wisconsin's carefully formulated philosophy on pavement preservation can be downloaded at www.dot.wisconsin.gov/library/research/docs/finalreports/tau-finalreports/pavpreserv.pdf.

Transportation Asset Management. Asset management is getting much play and new tools exist for pavement managers. Visit the Transportation Asset Management Web site of the Midwest Regional University Transportation Center of the University of Wisconsin-Madison, at www.mrutc.org/assetmgmt/index.htm.

Capital Preventive Maintenance. The same center offers a strategy for getting support for preventive maintenance in your agency structure. Read *Capital Preventive Maintenance,* Project 03-01, February 2004 at www.mrutc.org/research/0301/03-01final.pdf.

Asset Management. There's more on asset management at the American Association of State Highway & Transportation Officials Web site. Visit http://assetmanagement.transportation.org/tam/aashto.nsf/home.

The Great Unsealing. Steve Shober's controversial report on unsealed concrete pavement joints, *The Great Unsealing,* can be downloaded at www.dot.wisconsin.gov/library/research/docs/finalreports/tau-finalreports/unsealing.pdf. Find many other useful WisDOT reports at www.dot.wisconsin.gov/library/research/reports/pavements.htm.

The Case for Joint Sealing. Burke and Bugler's response to Steve Shober's critique of PCC joint sealing, *The Long-Term Performance of Unsealed Jointed Concrete Pavements,* can be downloaded at http://irc.nrc-cnrc.gc.ca/fulltext/trb/02-2394.pdf.

Hot or Cold. Read about Texas' experience with hot-poured vs. cold-poured sealants in *Field Performance of Hot Pour Sealants and Cold Pour Sealants,* by Yetkin Yildirim, Ph.D., and Ahmed Qatan, BSc., University of Texas-Austin, at http://irc.nrc-cnrc.gc.ca/uir/ur/trb/docs/Cold-pourVsHot-pourinTX_paper001215.pdf.

Federal Highway Administration. The FHWA supports pavement preservation; visit its Web site at www.fhwa.dot.gov/preservation.

Caltrans' Pavement Maintenance Manual. California's approach to prevention can be downloaded at www.dot.ca.gov/hq/maint/manual/maintman.htm.

National Center for Pavement Preservation. Visit this new group's site at www.pavementpreservation.org/.

International Slurry Surfacing Association. Browse their resources at www.slurry.org.

Asphalt Emulsion Manufacturers Association. Information on emulsions used in chip and slurry seals, both conventional and polymer-modified, may be downloaded at www.aema.org.

Reprinted from *Better Roads,* April 2005. *Better Roads* can be visited online at www.BetterRoads.com.

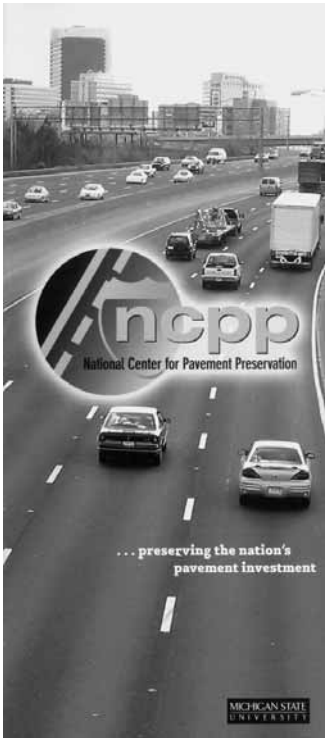
A Giant Leap Forward for Pavement Preservation

In October 2003, the National Center for Pavement Preservation (NCPP) in Okemos, Michigan, was dedicated with the goal of taking pavement preservation to a higher level across the United States. More than a year later, the center's initiatives in support of that goal range from developing new training courses to launching State pooled-fund consortiums to providing one-on-one outreach services to highway agencies. "NCPP's establishment was the culmination of a lot of hard work by several organizations and is a milestone signifying a high level of cooperation between government and industry to benefit the taxpayer," says Larry Galehouse, NCPP Director. "It will lead to better performing roads at lower cost."

"For pavement preservation, it's been a giant leap forward," says King Gee, Associate Administrator for Infrastructure at the Federal Highway Administration (FHWA).

The center was founded by Michigan State University, the Foundation for Pavement Preservation, and FHWA to lead and coordinate collaborative efforts among government, industry, and academia to advance pavement preservation. Pavement preservation is a program employing a network level, long-term strategy that enhances pavement performance by using a set of cost-effective practices that extend pavement life. Practices must be carefully selected and must be applied before the pavement sustains structural damage. "Keeping good roads in good condition has been the philosophy that gives a high rate of return for the preservation investment," says Jim Sorenson of FHWA.

The Midwest Pavement Preservation Partnership met November 30–December 1, 2004, in East Lansing, MI.



To bolster training efforts nationwide, NCPP is offering a new 2-day course for State and local agencies, "Pavement Preservation: Applied Asset Management." This course is designed to provide transportation officials, managers, and practitioners with a comprehensive understanding of pavement preservation. The course covers the components of preservation, benefits of undertaking a pavement preservation program, and asset management principles and how they can be used to manage highway pavements. Also covered are data inventories, pavement distress identification and analysis, network and project level management, and pavement preservation strategies. The workshop also features hands-on group exercises, where attendees can develop network level preservation strategies and select treatments to complement the preferred overall strategy.

A pilot for the course was held in Lansing, Michigan, in December 2004. "The pilot was very successful, with a lot of interest expressed by participants and a lot of positive feedback," says John O'Doherty of NCPP. The Michigan Asset Management Council has already scheduled three more sessions of the course.

Additional courses being developed include ones on chip seals and ultra-thin hot-mix asphalt overlays for practitioners. NCPP also intends to develop a course on a variety of treatment activities and one on network management for planners and managers. "Education on pavement preservation is needed on several different levels," notes O'Doherty. "You need it for both those in the field doing the work and those planning strategies at the network level."

Outreach is another important part of NCPP's work. "At the invitation of a State or local agency that wants to start a pavement preservation program, we can visit their agency, do a detailed assessment of their pavement practices, and advise them on ways to initiate or improve their pavement preservation efforts," says O'Doherty. The center is currently working with several State departments of transportation to develop preventive maintenance guidelines for their agencies and help establish or refine pavement preservation programs.

NCPP is also facilitating State partnerships to address pavement preservation issues. With NCPP's help, Midwestern States have formed the new Midwest Pavement Preservation Partnership. This is a pooled-fund effort to bring together local and State highway agency representatives, contractors, suppliers, and members of academia to share their pavement preservation knowledge and identify and sponsor needed research. Additional partnerships for the Southeastern, Northeastern, and Western States are now being planned. States may join a regional partnership through the NCPP at a cost of $5,000 per year.

For more information on NCPP's resources, scheduling the 2-day pavement preservation course for your State or region, or joining a regional Pavement Preservation Partnership, contact Larry Galehouse at 517-432-8220 (fax: 517-432-8223; email: galehou3@msu.edu), or visit www.pavementpreservation.org. For additional information on pavement preservation or technical support, contact Tom Deddens of FHWA's Construction and System Preservation Team, 202-366-1557 (fax: 202-366-9981; email: tom.deddens@fhwa.dot.gov).*

Reprinted from *Focus,* March 2005.

*The FHWA contact for current information on this topic is Joe Gregory, 202-366-1557 (email: joseph.gregory@dot.gov).

Preservation Partnership Promotes Preemptive Practice

by Greg Udelhofen

Convincing transportation agencies, legislators and taxpayers that a "worst first" approach to maintaining the quality and safety of road structures throughout the country proved to be an underlying theme of presentations and discussions at the recent Midwestern Pavement Preservation Partnership conference held in East Lansing, MI. Sponsored by the National Center for Pavement Preservation, MPPP's mission is to provide pavement preservation practitioners (public agencies, contractors, suppliers, academia, local and federal government officials) an ongoing regional forum to publicize and share information that promotes the benefits of pavement preservation. With insufficient funding available to address all infrastructure needs, whether it's new construction or maintaining existing roadways, preservation plays a vital role in not only maintaining the quality and safety of good road structures, but also helps to maximize available funding for maintenance, reconstruction and new construction.

Preservation proponents promote cost-effective solutions, both long- and short-range programs, by providing "the right fix at the right time in the right place."

King W. Gee, associate administrator for the Federal Highway Administration's Office of Infrastructure, told MPPP attendees that managing the nation's 3.9 million miles of roads will require a continued preservation approach. In fact, Gee issued a Preservation Maintenance Eligibility memorandum (Oct. 8, 2004) to all FHWA directors of field services, division administrators and Federal Lands Highway Division engineers stating: "The FHWA supports increased flexibility for using federal-aid funding for cost-effective preventive maintenance." The FHWA recognizes that "timely preventive maintenance and preservation activities are necessary to ensure proper performance of the transportation infrastructure."

The memorandum states: "By using lower-cost system preservation methods, states can improve system conditions, minimize road construction impacts on the traveling public, and better manage their resources needed for long-term improvements, such as reconstruction or expansion. Preventive maintenance offers state DOTs a way of increasing the return on their infrastructure investment."

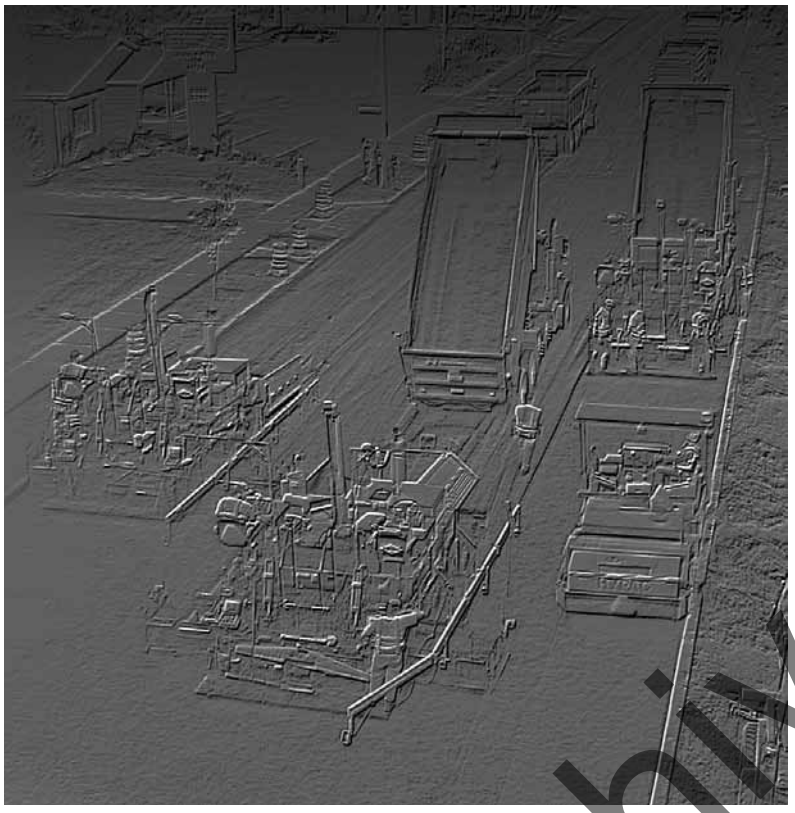
The American Association of State Highway and Transportation Officials (AASHTO) defines preventive maintenance "as the planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system without increasing the structural capacity."

According to Gee, the system preservation approach is a necessary part of the infrastructure solution because it extends the service life of roadways, maximizing the investment, while buying some time for long-term solutions. He acknowledged Kansas DOT's 20-year preservation approach and how it has improved the quality of roads throughout the state.

A preservation model

Jon Rice, P.E., managing director of Kent County Road Commission (Grand Rapids, MI), presented the approach his agency is taking to implement a preservation program that will eventually achieve higher levels of system conditions by 2015.

The Commission implemented its preservation program for all county roads in 1999. It also implemented a software program to analyze pavement conditions to determine when a preservation approach will provide the most value to the life cycle of a road. With five years of data collection, Rice said that if a road goes from fair condition to very poor condition, it will cost four to five times more to bring that structure back to fair condition.



While Kent County's road maintenance budget has remained constant over the past five years, an increase in preservation funds has been made to eliminate major rehabilitation expenditures. As the Commission evaluates major expansion, construction and reconstruction projects, it also evaluates whether or not adequate investments are being made to preserve the overall system. On an annual basis, it assesses existing and projected conditions of its roadways, and forecasts the system's level impact of alternative investment scenarios.

In 2003, 59 percent of Kent County's road system was in good (maintain) condition, with 27 percent in fair condition (requiring preservation) and 14 percent in poor condition (requiring reconstruction).

Rice and other preservation proponents know that for every $1 spent on preservation to maintain a road in fair condition, the investment can jump to $4 or $5 if the road is allowed to deteriorate to a poor condition; and they also know the drop from fair to poor condition happens quickly.

Rice and the Kent County Road Commission's preservation approach is to apply appropriate preservation treatments to roadways that are in good or fair condition to preserve the quality of the structures, as well as extend the life cycle of the structures. Preservation practices currently used in Kent County include crack sealing and patching, microsurfacing, chip seal, and thin hot mix asphalt overlays.

Since implementing a preservation program, the Commission shifted investment dollars from construction/expansion to preservation, and overall road conditions have improved significantly. In 1999, 29 percent of the county's road system required reconstructive work. In 2003, only 13 percent of the county's system was designated as a reconstruction candidate. By 2008, Rice projects that only 2 percent of the system will require reconstruction. But what's more significant about the preservation approach being used is that approximately 80 percent of the county's road system will be in good condition and remain in good condition for years to come.

'Best practices'

Currently eight of the proposed 13 Midwestern states that were invited to join MPPP have made the commitment to do so, and representatives from their respective road agencies briefed MPPP conference attendees on their current preservation efforts. Some have extensive preservation programs, like that of Kansas, while others are in their infancy in implementing a preservation approach.

Minnesota spent $32 million on pavement maintenance in 2004, covering 2,900 lane miles (10 percent of its system) with preservation surface treatments like chip seal and microsurfacing. Michigan has established a warranty program to monitor and police pavement maintenance contractors working on state-funded preservation projects.

Kansas' 20-year-old pavement management program continues to evolve as preservation proponents strive to put 72 percent of the state's road system in good condition. Kansas' preventive maintenance program is "ride oriented," which means if a preventive maintenance action can improve the ride for motorists, then it's approved.

Montana's annual $40 to $50 million preservation budget is let to projects that comply with the

state's DOT's Guidelines for Nomination and Development of Pavement Projects.

Indiana utilizes its Pavement Management Groups to provide a systematic way of recommending, reviewing and approving proposed preservation projects. While the state's pavement preservation program still requires a lot of work in getting local, district and central DOT offices to agree on what, when and where the approach makes sense, a substantial portion of the state highway construction budget is earmarked for pavement maintenance/preservation.

North Dakota, on the other hand, is just starting to develop an investment strategy that will support a preventive maintenance program as a good investment in preserving the state's infrastructure assets. Missouri is still operating in a reactive "worst first" mode in maintaining its road system. The DOT is currently trying to educate the public, as well as internal customers, on the benefits of initiating a preventive pavement maintenance program.

Illinois DOT recently initiated its pavement preservation approach by approving 27 project locations (three per each of its nine districts) to begin evaluating how preservation techniques like microsurfacing, chip sealing and slurry sealing extend the life cycle of its roads.

Moving forward

Through the Transportation Pooled Fund Program (TPF), MPPP hopes to develop national protocols for pavement preservation and publish those protocols as AASHTO standards to improve the overall quality and treatment performance.

According to Larry Galehouse, NCPP director, "two overwhelming issues" were designated as top priority by MPPP members. First, MPPP directed the NCPP to post on its web site various state specifications regarding preventive maintenance preservation techniques. The hope is to establish some standardized preservation practices that will eventually become uniformly accepted by road agencies throughout the Midwest and eventually the country.

Also, once funding has been released from TPF, which is sponsored by FHWA, AASHTO and the Transportation Research Board, the NCPP will begin to collect data on preservation research that various states have conducted to this point. The intent is to identify duplication of research efforts to better identify what type of research needs to be done.

The MPPP will continue to meet on an annual basis to discuss and exchange information on sound preservation practices, as well as provide training to implement successful preservation programs.

Two other preservation partnerships, one in the Northeast and one in the Southeast, are in a formation stage, and Galehouse anticipates the synergies to be gained by additional regional groups will benefit the overall objectives of all involved in pavement preservation.

For more information on MPPP, contact Larry Galehouse at the National Center for Pavement Preservation, 517-432-8220 or www.pavementpreservation.org.

Reprinted from the *Asphalt Contractor,* January 2005.

DC Streets: Innovation Yields Results

In July 2000, the District of Columbia embarked on the first urban, performance-based asset management project in the United States, known as "DC Streets." Under the $70 million, 5-year initiative, the District of Columbia Department of Transportation (DDOT) and the Federal Highway Administration (FHWA) contracted with VMS, Inc., to preserve and maintain approximately 121 km (75 mi) of roadway that make up the District's portion of the National Highway System (NHS). Also included in the contract is the maintenance of such assets as tunnels, bridges, curbs, gutters, sidewalks, and retaining walls. As the initiative wraps up its fifth and final year, stakeholders are reviewing both the successes and the lessons learned.

According to Edward Sheldahl, project delivery team leader for FHWA's DC division office, the contract's big advantage is that it covers all of the assets of the District's portion of the NHS, which carries the bulk of DC traffic. "Before this contract, maintenance of these roadways was the responsibility of the city, and suffered because the resources weren't there. Because this contract qualifies for Federal aid, it is 80 percent funded by the Federal Government, with a 20 percent local match," says Sheldahl. A major highlight of the program, adds Sheldahl, was the rehabilitation of two very heavily used tunnels in downtown DC that was undertaken as one of the initiative's first priorities. He also notes that the contract ensured the timely repair and replacement of peripheral assets such as lighting and guardrails.

For Rich Herlich, president of VMS, Inc., the nature of the initiative itself was the biggest success of the project. "This kind of outcome-based contract relies on close cooperation between public and private partners," he says. "We as the contractor were given great freedom to choose how to conduct routine and preventive maintenance. Overall, the process went well."

One example of innovation in action was the widespread use of spray-injection mobile pothole patcher technology for the first time in the District. The mobile pothole patcher machines can be used to quickly and efficiently fill potholes, minimizing the inconvenience to drivers and the exposure of work crews to traffic. VMS believed in the technology and used it on the NHS roads. After seeing the positive results in terms of fewer driver complaints, DDOT has now accepted the technology. "It was controversial at first, but that's the great thing about this type of contract," Herlich explains. "The contractor is free to do innovative things, and if it doesn't work, we fix it."

Simon Rennie, DDOT project manager for DC Streets, notes that change can be difficult in public agencies, and welcomes the injection of innovation that this type of contract allows. According to Rennie, the greatest advantage to such a contract is the ability to address unforeseen maintenance without the need for an additional appropriation process and the corresponding delay. For example, when Hurricane Isabel struck the District in September 2003, resulting in downed trees and submerged highways, Rennie had already consulted with VMS to arrange standby crews to address the damage. As a result, the roadways were restored within 72 hours, a feat that Rennie does not believe would have been possible before the DC Streets initiative was in place.

Rennie places a high value on this responsiveness to emergencies and citizen complaints. "Now, when someone calls our office with a report of an asset needing repair, I can call VMS, report the problem, get the schedule for when it will be fixed, and call the citizen back and tell them when the problem will be addressed, all in a short time," he says.

Despite its successes, the DC Streets program has not been without a few lessons learned on how to do a better job in future initiatives. According to Mark Robinson, program manager for Science Applica-

Work performed under the DC Streets contract has included snow removal and clearing trees and other debris after Hurricane Isabel hit the city in September 2003.

tions International Corp. (SAIC), which provided management consulting services for the DC Streets initiative, the contract has been a success, but some of the actual contract language should be adjusted in future contracts of this nature.

"Because this was the first time that such a contract was drafted for an urban area, some of the demands it stipulates were not achievable with reasonable effort," says Robinson. "For example, a few of the maintenance categories are still not up to par because there is not a well defined line between what is rehabilitation, which is covered in the contract, and what is reconstruction, which is not. So some actions required to satisfy the performance standards fall outside the scope of the contract. We've resolved these issues through a combination of general partnering agreements and item-by-item negotiations. Because this is a hybrid of a construction and a services contract, we need to better define the rehabilitation/reconstruction criteria in the future."

Herlich agrees that criteria and definitions need to be clarified in future agreements. "Some of the standards were contradictory," he notes. "For example, there is a standard for curb conditions. In some cases, tree roots have displaced the curb slabs, and the only way to fix this is to remove the trees. But another standard says that these trees should be preserved. We resolved the conflict through mediation and consultation, and kept the trees."

Rennie would like to see language in future contracts tying the meeting of performance standards to the incremental payment of the contract. Currently, VMS receives a monthly payment regardless of asset conditions. He would also like to see a greater sampling of assets to determine if performance standards have been met. The current sampling percentage is 10 percent.

Looking beyond the contract's completion in July 2005, Sheldahl expects the District to opt for smaller, follow-on asset management contracts focusing on specific types of assets, such as tunnels or bridges. He expects to see four to five such contracts, addressing the most vital components of the NHS, and possibly expanding to other District arteries that are not a part of the NHS. However, funding may not be available to issue contracts for all of the components of the DC Streets program. VMS would pursue a contract similar to DC Streets in the future without question, says Herlich, and might pursue smaller contracts if they make sense for the company.

"Performance-based contracts, when closely monitored, are definitely a good way to go," adds Rennie.

For more information about the DC Streets initiative, contact Edward Sheldahl at FHWA, 202-219-3514 (email: edward.sheldahl@fhwa.dot.gov), Simon Rennie at DDOT, 202-671-4666 (cell: 202-438-8607; email: Simon.Rennie@dc.gov), or Mark Robinson at SAIC, 703-676-2384 (email: MARK.D.ROBINSON@saic.com).

Reprinted from *Focus,* December 2004.

Preferential Treatment

by Katie Zimmerman, P.E., and David Peshkin, P.E.

Today's transportation agencies face challenges that are vastly different than those faced by the previous generation. On the one hand, improvements in technology have resulted in dramatic changes in the tools that are available today for construction, design and program development activities. On the other hand, public agency staffing and budgets are being slashed, there is more competition for available resources and there is growing demand for greater accountability for the decisions that are made.

One of the keys to success in this volatile environment lies in being able to make better use of technology so that decisions are made faster, recommendations are backed up with factual information and trade-offs between investment options can be easily evaluated.

Another key to success is to change the way transportation agencies do business. In today's environment, that means increasing the use of low-cost preventive maintenance treatments early in a pavement's life cycle to slow the rate of pavement deterioration and defer the need for more costly rehabilitation actions.

Treatment picking

The selection of an appropriate preventive maintenance treatment for a given set of conditions begins with the identification of the treatments to include in the program. Agencies vary in their selection of treatments, but most agencies include the types of treatments listed in Table 1 in their preventive maintenance program. Some agencies expand the definition of preventive maintenance treatments to include cold in-place recycling or hot in-place recycling for flexible pavements, and various patching and full-depth repair strategies for rigid pavements.

Once feasible treatments are identified, then the following considerations can be used to determine the most appropriate treatment for each situation:

- The purpose of the treatment, including an assessment of the pavement conditions that the treatment is meant to prevent or correct. For example, if moisture is getting into the underlying pavement layers, the purpose is to seal the surface. In some cases, there may be more than one purpose for applying a treatment, such as both sealing the surface and restoring surface friction;
- The applicability of each treatment to address existing distress, after considering the type, severity and extent of distress, current and projected traffic levels and environmental conditions. In some parts of the country it's appropriate to consider other factors such as the amount of snow plowing that is done each winter, the use of studded tires or chains, the availability of contractors and the amount of time available for lane closures to complete the work;
- Construction considerations, which might include the complexity of the construction of the treatment, the need for specialized equipment, the local availability of qualified contractors and the need for specialized materials;
- Performance and cost, which determine the cost-effectiveness of the feasible options. In some cases, preventive maintenance treatments are feasible under a given set of circumstances, but are not effective in terms of the level of performance that can be expected. Treatment performance and cost should be considered together to differentiate between feasible alternatives for reaching similar objectives. Comparing the ratio of expected life divided by treatment cost is a

quick and easy approach for comparing these variables; and

- Customer satisfaction, which may include characteristics that are important to the traveling public, such as noise, smoothness, safety and traffic disruptions.

A decision matrix for taking these factors into account in selecting the most appropriate preventive maintenance treatment to match specific project attributes is illustrated in FHWA Publication No. FHWA-IR-00-027, *Selecting a Preventive Maintenance Treatment for Flexible Pavements* (August 2000) and in the "Participant's Workbook" for National Highway Institute (NHI) Course No. 1311058, Pavement Preservation: Selecting Pavements for Preventive Maintenance.

The matrix is fully customizable so that an agency can consider whatever considerations are most important for the specific project being analyzed. These considerations are included in the table as rating factors. A weight is assigned to each rating factor to represent the relative importance of each in selecting the appropriate treatment.

For example, if an agency decides that traffic disruption is the most important consideration, it is assigned the highest weight among all of the rating factors.

The weights must add up to 100. The final step is to score each of the feasible treatments on each rating factor. The product of the scores and weights are summed for each feasible treatment strategy, and the treatment with the highest total score is identified as the most appropriate treatment for the given conditions.

To ensure the timely application of the selected treatment, many transportation agencies have developed pavement preservation guides that provide agency personnel with useful information for selecting the appropriate treatment to address a given set of conditions. Typically, the guides include information on the most commonly observed distress types and their severities, as well as recommendations for preventive maintenance treatments that address the specific distress. For example, Table 2 provides guidance on the types and amount of distress that can be reasonably addressed by a chip seal. In this example, roads with conditions outside the indicated ranges would not be viewed as good chip seal candidates.

An agency's guidelines should be reviewed regularly to determine whether changes in the agency's practices or policies are influencing the types of treatments being considered or the conditions under which they are considered. Since industry is constantly developing new approaches to pavement preservation, new treatments also should be considered for inclusion in the guidelines.

Table 1. Types of preventive maintenance techniques.

Bituminous-Surfaced Pavements	Concrete-Surfaced Pavements
Thin hot-mix overlays	Crack and joint sealing
(less than 1.5 to 2 in.)	Diamond grinding
Crack treatments	Diamond grooving
Microsurfacing	Undersealing
Chip seals	Load transfer restoration
Fog seals	Maintenance of drainage features
Slurry seals	
Ultrathin friction course	
Maintenance of drainage features	

Table 2. The effectiveness of preventive maintenance.

Distress Type	Characteristics
Fatigue Cracking	Low severity only; preventive maintenance is not appropriate for med-high severity fatigue cracks.
Longitudinal & Transverse Cracking	Low and medium severities only; a chip seal is not appropriate for pavements with wide cracks.
Bleeding	Any amount of bleeding can be addressed with a chip seal, but it is most effective on smaller quantities.
Raveling	A chip seal is an appropriate treatment for a pavement with raveling present.
Rutting	Rutting should not be addressed with a surface treatment.

Seeking advice

Agencies that have developed guidelines for the use of preventive maintenance treatments usually base them on observations that have been made by engineers and technicians in the field. But how can an agency develop these guidelines if they haven't used the treatments before or if the treatments have only been applied as bandages on failed pavements? In these situations, an agency must rely on informa-

tion published by other agencies with similar conditions, or seek other sources of information on treatment performance.

One of the most difficult issues to address is the appropriate timing for applying preventive maintenance treatments. In many cases, applying a treatment to a new pavement surface is probably using preventive maintenance too soon, while waiting until the end of the pavement's life to apply a treatment is too late. However, finding the right time—when the treatment is effective and it is not a waste of money—is a significant challenge.

Some agencies have begun monitoring preventive maintenance test sections as one way of determining the effect of treatment timing on performance.

The Arizona Department of Transportation, for example, has constructed test sections with varying surface thickness to represent pavements at different points in a pavement life cycle (the idea is that the thinner roads will deteriorate faster than thicker sections so they represent a pavement later in its life cycle). Preventive maintenance treatments have been applied to these sections and the performance of the treatments is being monitored so that guidelines on treatment timing can be developed.

Nationally, a study conducted under the National Cooperative Highway Research Program (NCHRP) found that there is little guidance available to agencies regarding the optimal time to apply preventive maintenance treatments. Because of the lack of available information on this topic, the study focused on the development of a tool that could be used to identify the window during which the greatest improvement in pavement condition is realized for the lowest cost.

In concept, the methodology for identifying the optimal timing is relatively simple. However, the application of the methodology can be complex without appropriate tools. A spreadsheet tool was developed to assist agencies with analyzing their preventive maintenance-related data. As part of the study it was tested in several state highway agencies.

One of the agencies included in the study was the Kansas Department of Transportation (KDOT). KDOT is in the process of developing prediction models that reflect the influence of preventive maintenance treatments for its pavement management system. Using KDOT's transverse crack models, the NCHRP tool (referred to as OPTime) was used to determine the optimal time to rout and seal cracks on a flexible pavement. The analysis showed that under the conditions modeled, it was most cost-effective to rout and seal cracks when the pavement is 11 years old.

Another example using data from the North Carolina Department of Transportation found that a seal coat was most cost-effective when applied nine years after resurfacing or reconstruction. It is worth noting that these results are very dependent on the inputs used in the analysis and should not be used by other agencies without modification.

Seeking a management position

Fundamental to applying the right treatment at the right time is the ability to forecast when the conditions are appropriate for applying a preventive maintenance treatment and making sure that the resources are available to construct the treatment then. A pavement management system can assist with these analyses as long as the preventive maintenance treatments are included in the treatments being considered.

Pavement management systems have been used for years to help agencies identify and prioritize pavement improvement needs, determine funding levels needed to meet certain pavement condition objectives and to project network conditions under various funding scenarios. In recent years, some agencies have used their pavement management systems to demonstrate the cost-effectiveness of preventive maintenance programs as a way of securing the funding needed to jump-start their preservation programs. As agencies increasingly consider the use of preventive maintenance treatments as a pavement preservation strategy, challenges are emerging associated with the integration of preventive maintenance treatments into a pavement management system. For the most part, these difficulties are arising because the pavement management system was originally structured to focus primarily on rehabilitation and reconstruction activities.

The inclusion of preventive maintenance treatments requires agencies to re-evaluate their pavement management procedures to ensure that the factors that trigger the use of preventive maintenance treatments are incorporated into the pavement condition survey procedures and are available in the database, that the performance of a preventive maintenance treatment can be effectively modeled and that treatments that have been constructed are reflected in the database and in future analyses. These activities are not always as easy as they appear.

For instance, fog seals may be considered to address pavements that have cracking, low friction numbers or oxidation. Most pavement management condition surveys do not include friction or oxidation, so these treatment triggers are not available in the pavement management database to trigger the use of a fog seal.

Other features that might be important to trigger preventive maintenance treatments include fine cracking or the differentiation between sealed and unsealed cracks.

Perhaps more complicated is the modeling of preventive maintenance treatments in a pavement management system. To appropriately match feasible treatments with pavement conditions, the pavement management system must be able to predict the changes in pavement condition with time. This implies that the performance of pavement sections can be differentiated when preventive maintenance treatments are applied so that the benefit associated with the treatment can be calculated. It also requires that rules exist to identify the appropriate performance curve for each pavement section. If an agency's pavement management system includes only asphalt and concrete surface types, for example, it will be difficult for that agency to identify different performance models for each of its preventive maintenance treatments.

Although the integration of preventive maintenance treatments into an agency's pavement management system may not be as simple as it first appears, there are steps that an agency can take to improve its consideration of preventive maintenance treatments in its pavement management system. An agency can start by establishing a single treatment in its decision trees that represents the broad category of preventive maintenance treatments and is triggered on roads that are in good condition. Over time, more sophisticated models can be developed.

Facing success

Even in the face of increasing constraints, such as smaller budgets, reductions in staff and greater accountability, there are opportunities to improve our stewardship of our transportation infrastructures. More and more highway agencies are using preventive maintenance as a way to face these constraints head-on.

When properly used—that is, when an appropriate treatment is used on a pavement that is in good condition—preventive maintenance helps to extend the life of the pavement structure, delaying the need for more extensive and costly rehabilitation and improving other desirable characteristics, such as safety and smoothness.

There are several factors that are key to successful preventive maintenance programs. These include identifying the mix of treatments that will provide the desired benefits for your pavements and developing guidelines for when those treatments should be used to obtain the greatest benefit. A recently completed NCHRP project on the optimal timing of preventive maintenance treatments offers guidance on these topics. A spreadsheet tool also is available to help in the analysis of treatment timing.

It's also important to remember that pavement management tools and systems can be extremely valuable in the successful implementation of preventive maintenance practices. The integration of preventive maintenance into a working pavement management system can help to identify pavements which are good preventive maintenance candidates and monitor their performance once the treatments have been applied. Pavement management systems also can be used to identify preventive maintenance funding needs and to illustrate cost-effectiveness.

The use of preventive maintenance treatments is an integral part of a cost-effective pavement preservation program. Employing preventive maintenance treatments effectively enables an agency to do more with less, thereby making cost-effective use of the available resources as part of a coordinated program to improve the serviceability of its road network.

Zimmerman is president of Applied Pavement Technology, Champaign, Ill. Peshkin is vice president of AP Tech, Chicago.

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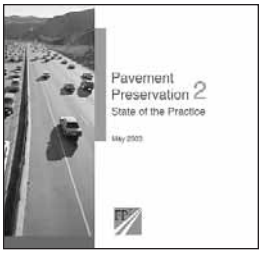
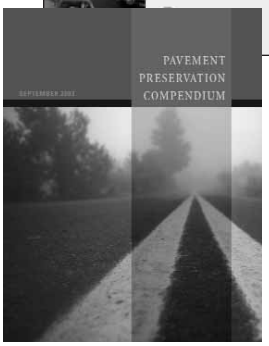
Pavement Preservation Resources Offer "How-To" Guidance





Learn more about pavement preservation practices that are working nationwide by consulting the many new resources, ranging from guidance checklists to CDs, available from the Federal Highway Administration (FHWA).

Two new CDs produced by FHWA and the Foundation for Pavement Preservation (FP2) look at pavement preservation in action across the country. The first CD, *Pavement Preservation 2: State of the Practice,* contains policies, guidance, and technical information from California, Delaware, Michigan, Minnesota, Montana, North Carolina, Ohio, and South Dakota. The CD provides a range of information, from guidelines for statewide preservation programs to examples of innovative funding approaches. Also included are "how-to" technical manuals and details on training courses, videos, fact sheets, and other useful resources.

National Pavement Preservation Forum II: Investing in the Future (Publication No. FHWA-IF-03-019), meanwhile, includes papers and presentations from the 2001 Forum hosted by the California Department of Transportation and FP2 in San Diego, California. The CD covers such topics as introducing new pavement preservation products and techniques, establishing partnerships, integrating pavement preservation into pavement management systems, and performing education and outreach.

For step-by-step guidance on the use of innovative pavement preventive maintenance processes, turn to FHWA's and FP2's series of pavement preservation checklists. Topics in the series to date are:

- *Crack Seal Application* (Publication No. FHWA-IF-02-005)
- *Chip Seal Application* (Publication No. FHWA-IF-02-046)
- *Thin Hot-Mix Asphalt Overlay* (Publication No. FHWA-IF-02-049)
- *Fog Seal Application* (Publication No. FHWA-IF-03-001)
- *Microsurfacing Application* (Publication No. FHWA-IF-03-002)
- *Joint Sealing of Portland Cement Concrete Pavements* (Publication No. FHWA-IF-03-003)

The checklists take users through such steps as project review, material checks, surface preparation, equipment inspections, weather requirements, and common problems and solutions.

For information on the scope of pavement preservation activities underway in States from California to Michigan to North Carolina, consult FHWA's *Pavement Preservation Compendium* (Publication No. FHWA-IF-03-21), which presents articles, papers, and other reference material on accomplishments to date and future needs. The Compendium also highlights the importance of taking research on innovative and effective system preservation technologies to a higher level. To date, research has lagged behind the demand for knowledge.

To obtain copies of the CDs, checklists, or Compendium, contact Steve Mueller in FHWA's Office of Asset Management, 202-366-1557 (email: steve.mueller@fhwa.dot.gov),* the National Center for Pavement Preservation at 517-432-8220 (email: hahnp@egr.msu.edu), or your local FHWA Division Office. For additional information on pavement preservation, visit the Web sites listed in the sidebar.

Reprinted from *Focus,* March 2004.

*The FHWA contact for copies of resources or current information on this topic is Joe Gregory, 202-366-1557 (email: joseph.gregory@dot.gov).

Pavement Preservation Online Resources

FHWA—www.fhwa.dot.gov/preservation

Foundation for Pavement Preservation—www.fp2.org

National Center for Pavement Preservation—www.pavementpreservation.org

Resources for a Better Future

by Jim Sorenson

With more than $1.75 trillion invested in the nation's highway system, preserving that investment is one of today's key challenges facing both state and local highway agencies across the country. To meet that challenge, agencies can now call upon a range of new pavement preservation resources. Pavement preservation is applied asset management. It is the planned strategy of treating pavements at the optimum time to maximize their useful life, enhancing pavement longevity while lowering lifetime costs. Preserving our pavements also results in increased safety and higher user satisfaction.

Preservation treatments are not the right fix for every road at any time. Treatments must be carefully selected and must be applied when the pavement is still in relatively good condition, that is with no structural damage. Pavement preservation treatments are generally lower-cost surface improvements and they offer little or no structural enhancement. They do, however, rejuvenate the roadway surface by addressing the effects of environmental aging and minor surface defects before the road deteriorates further and requires rehabilitation or reconstruction, which is much more costly and time consuming.

A significant new resource for highway agencies is the National Center for Pavement Preservation (NCPP), which was dedicated at Michigan State University in Okemos, Mich., in October 2003. Founded by MSU, the Foundation for Pavement Preservation (FP2) and the Federal Highway Administration (FHWA), the center will coordinate, administer and conduct fundamental and applied research on pavement preservation. It also will provide hands-on technical assistance and work with highway agencies and others on meeting training and education needs. The center's resources include a technical library of national studies, specifications and treatment procedures. The center is now providing technical services to several state and local agencies. To learn more about the NCPP and the assistance it can provide look online at www.pavementpreservation.org.

Two new CDs available from FHWA and FP2 also provide a wealth of information on pavement preservation practices that are working nationwide. The first CD, *Pavement Preservation 2: State of the Practice,* presents policies, guidance and technical information from California, Delaware, Michigan, Minnesota, Montana, North Carolina, Ohio and South Dakota. This information ranges from guidelines for statewide preservation programs to examples of innovative funding approaches. The second CD, *National Pavement Preservation Forum II: Investing in the Future,* contains papers and presentations from the 2001 forum hosted by the California Transportation Department and FP2 in San Diego. The forum was conducted over a pair of two-day sessions, drawing nearly 200 participants to each session. The documents on the CD cover such topics as introducing new pavement preservation products and techniques, establishing partnerships, integrating pavement preservation into pavement management systems and performing education and outreach.

To learn more about the many facets of pavement preservation activities under way in the U.S. today, consult FHWA's *Pavement Preservation Compendium,* which presents a range of articles and

Pavement preservation is applied asset management. It is the planned strategy of treating pavements at the optimum time to maximize their useful life, enhancing pavement longevity while lowering lifetime costs.

other reference material on accomplishments to date and future needs. One such need is to take research into effective system preservation technologies to a higher level. In this program area, research has not kept up with the demand for knowledge.

Also available from FHWA and its industry partner, FP2, are a series of pavement preservation checklists that provide step-by-step guidance on the use of innovative pavement preventive maintenance processes. Topics covered in the series to date are:

- Crack seal application;
- Chip seal application;
- Thin hot-mix asphalt overlay;
- Fog seal application;
- Microsurfacing application; and
- Joint sealing of portland cement concrete pavements.

To obtain copies of the CDs, checklists or compendium, contact Steve Mueller at FHWA, 202/366-1557; e-mail: steve.mueller@fhwa.dot.gov.*

Sorenson is a senior highway engineer in FHWA's Office of Asset Management.

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*The FHWA contact for current information on this topic is Joe Gregory, 202-366-1557 (email: joseph.gregory@dot.gov).

The Seven Stallers

by Katie Zimmerman, P.E. and David Peshkin, P.E.

Highway agencies are increasingly turning to pavement preventive maintenance programs. Preventive maintenance slows the rate of pavement deterioration, essentially delaying the need for pavement rehabilitation by several years (see Fig. 1). The delay in rehabilitation needs, combined with the fairly low cost of preventive maintenance treatments, can result in dramatic cost savings for pavement preservation. Other benefits of a preventive maintenance program include:

- Higher customer satisfaction with the road network;
- The ability to make better, more informed decisions on an objective basis;
- The more appropriate use of maintenance techniques;
- Improved pavement conditions over time;
- Increased safety; and
- Reduced overall costs for maintaining the road network.

Although there are significant reported benefits from preventive maintenance, starting such a program is not a trivial undertaking; implementation often requires a fundamental shift in the philosophy of the transportation agency. To a large degree, the challenges agencies face when initiating these changes are caused by misconceptions about pavement preventive maintenance. This article addresses seven of the most deadly misconceptions about pavement preventive maintenance. These misconceptions are deadly because any one of them is enough to stop a program in its tracks. Therefore, suggestions for addressing each misconception also are provided, based on the authors' experiences working with agencies that have been using preventive maintenance concepts for years as well as agencies that are just beginning to implement these programs.

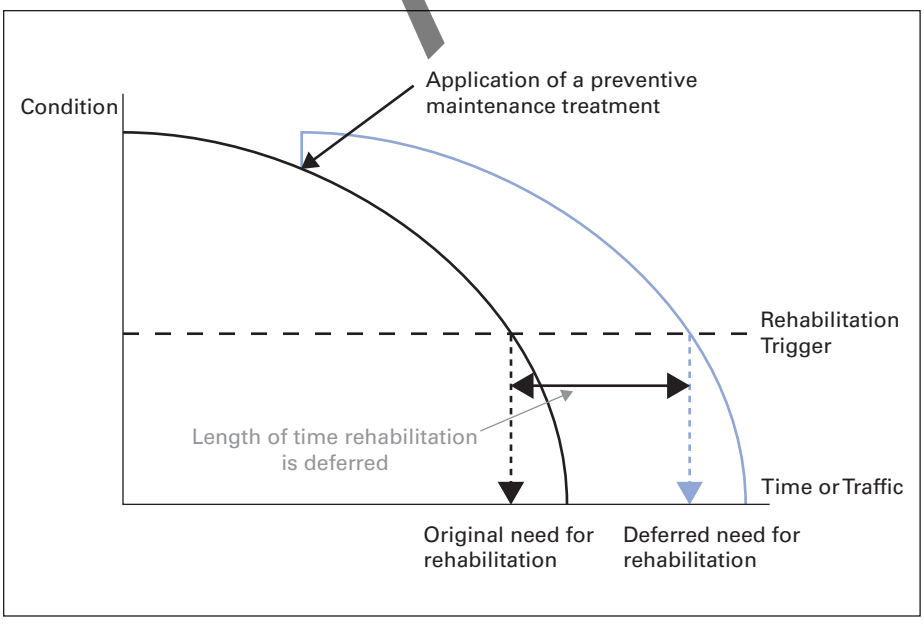

Figure 1. Use of preventive maintenance treatments to defer the need for rehabilitation.

The seven bullets

We can't start a preventive maintenance program until our backlog is gone.

Any agency that has inadequate funding to address its pavement rehabilitation and reconstruction needs is faced with the challenge of a continuously growing backlog of identified, but unfunded, projects. As long as there are roads that need rehabilitation, agencies find it difficult to move away from an improvement program that is primarily oriented towards addressing the worst roads first. This is especially true when the agency is considering dedicating a portion of its improvement funds to a program that includes the application of preventive maintenance treatments to roads in good condition.

An effective way to counter this argument is to use a pavement management system to demonstrate the effect of each improvement program (one that addresses the worst roads first and the other that includes rehabilitation and preventive maintenance treatments) on overall network conditions. Agencies that have used pavement management to demonstrate the importance of starting a preventive maintenance program to help reduce the size of an agency's pavement backlog have found that the results take time to be realized. But, as shown in Fig. 2, eventually a preventive maintenance program results in dramatically different network conditions because of the reduced rate in which the backlog grows with preventive maintenance. Since preventive maintenance treatments are applied to roads in good condition, they remain in good condition for a longer period of time; thereby reducing the rate at which the backlog grows while a portion of the program is targeted to addressing those roads already in a backlogged condition.

We're already using preventive maintenance treatments.

Many agencies report they are already using the types of treatments normally included in a preventive maintenance program, such as those shown below:

- Crack filling or crack sealing;
- Joint resealing;
- Surface treatments such as fog seals, sand seals and chip seals;
- Slurry seals and microsurfacing;
- Thin hot-mix asphalt (HMA) overlays;
- Diamond grinding;
- Undersealing;
- Joint spall repair;
- Load transfer restoration; and
- Maintenance of drainage facilities.

The key to the use of these treatments as part of a preventive maintenance program is the early application of the treatment before major structural deterioration has taken place. In most cases, this

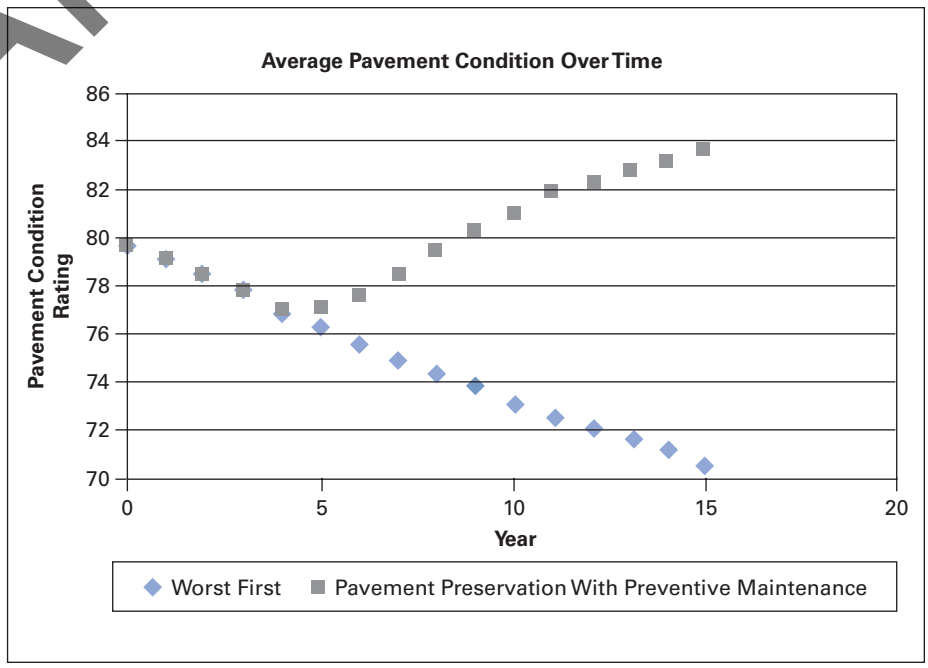

Figure 2. Impact of two preservation strategies on overall network conditions.

means applying these treatments while the roads are in fairly good condition, instead of applying the treatment as a corrective treatment until more substantial treatments can be applied.

For most agencies, the early application of pavement preventive maintenance treatments represents a marked difference in the way road networks are managed. Traditionally, most agencies have followed programs in which no treatments were applied until rehabilitation or reconstruction activities were required (after pavement conditions fell below an acceptable level). Some routine maintenance may have been performed, but the funding for the maintenance activities was usually unreliable and the highest priority for funding came from stopgap, or safety, maintenance needs.

Agencies with preventive maintenance programs in place are including preventive maintenance treatments as part of a planned strategy to slow the rate of pavement deterioration, thereby deferring the need for rehabilitation. It is this early, planned application of the preventive maintenance treatments that marks one of the primary differences from the way these treatments have been used in the past.

It can't be cost-effective if you're applying treatments more frequently.

A preventive maintenance program requires the early application of treatments, while roads are still in relatively good condition. Admittedly, the life of a preventive maintenance treatment is not as long as the expected life of a rehabilitation treatment, so can it still be cost-effective to apply more frequent treatments without causing increased disruptions to the traveling public? The answer is yes.

A life-cycle cost analysis is one way of comparing the costs associated with maintaining a pavement facility over an analysis period that includes at least one rehabilitation cycle. An example of this application is provided.

In the first application, represented by strategy A, an initial treatment is constructed at a cost of $400,000. A minor rehabilitation treatment is applied in years 8 and 16 at a cost of $80,000 for each application. Routine maintenance costs associated with this strategy are $500 per year and the salvage value associated with the last application of the year 16 treatment is $40,000 (since half of the life of the treatment is used at the end of the analysis period, half of the cost of the strategy is considered the salvage value). The expenditure stream diagram associated with this strategy is shown in Fig. 3.

The second strategy, represented by strategy B, is presented in Fig. 4. This strategy is comprised of the same initial treatment, with a $12,000 preventive maintenance treatment applied in years 4, 8, 12 and 16. Annual maintenance costs associated with this

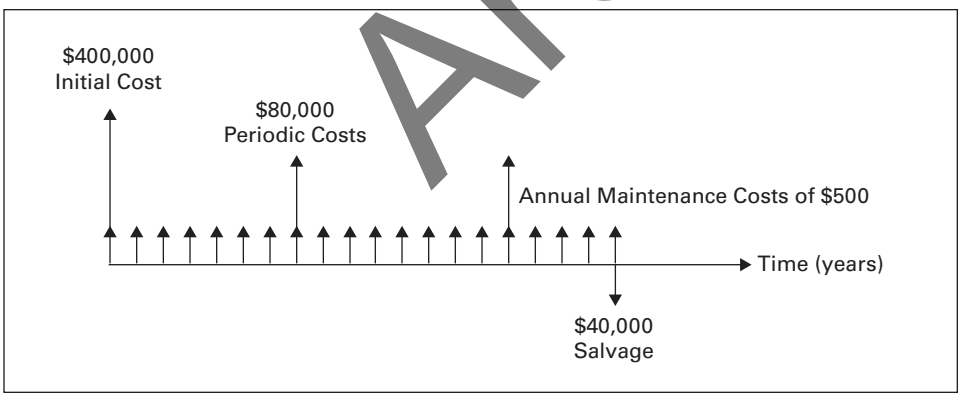

Figure 3. Expenditure stream diagram for Strategy A.

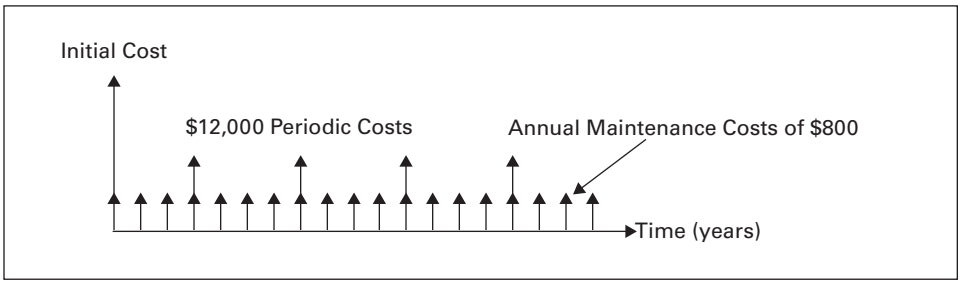

Figure 4. Expenditure stream diagram for Strategy B.

strategy are $800/year and there is no salvage value since the life of the last treatment is used up at the end of the analysis period.

The present worth values associated with each strategy are presented below. Both examples are based on a 20-year analysis period and a discount rate of 4%. The example demonstrates that strategy B, which included more frequent applications of a lower cost treatment, resulted in a lower life-cycle cost, and that preventive maintenance treatments can reduce the cost of preserving the pavement network. The more frequent application of preventive maintenance treatments typically doesn't interfere with normal traffic operations because many of the treatments can be applied at night, or during a relatively short closure.

Decision-makers will never support this type of program.

Once an agency can demonstrate the cost effectiveness of preventive maintenance to decision-makers, it is easier to convince these individuals of the benefits associated with such a program. Consider the following when promoting preventive maintenance program to management:

- Don't oversell the program: Several agencies have determined that preventive maintenance programs greatly reduce their overall cost of maintaining a pavement network. However, when reporting the cost savings to decision-makers, these agencies have been conservative in reporting the benefits that the agency will realize. As a result, the agencies are much more confident of their ability to meet their targets.
- Remember that it takes time for the benefits to be realized: Although some benefits associated with the use of a preventive maintenance program may be immediate, the improvement in network conditions and overall reduction in life-cycle costs may take time to be realized by the agency. For example, it took the Georgia DOT about 15 years to achieve a "steady state" condition for their pavement network. It is important that decision-makers understand this so that support for a program is not suspended before the results are realized.
- Communicate the preventive maintenance concept in terms that decision-makers can understand: Most of us are familiar with the use of preventive maintenance concepts in their every day life, from routine visits to the dentist to maintenance schedules for cars and other vehicles. The application of these concepts to pavements is very similar. We don't postpone maintenance on our cars until the engine seizes; why would we apply this approach to pavement preservation? Communicating the message in a way that decision-makers can understand helps to secure their support.
- Set goals for the program: An effective preventive maintenance program should be established with clearly defined, measurable goals that can be achieved within a stated timeframe. Over time, progress towards the goal should be monitored and reported to the decision-makers to continually build support for the program. An example of an effective goal is to have at least 70% of the pavement network in good condition within a five-year period. A pavement management system can be used to help establish a reasonable goal for a preventive maintenance program.

Preventive maintenance is solely the responsibility of the maintenance department.

Although in many agencies placing preventive maintenance treatments is primarily the responsibility of maintenance crews, a preventive maintenance program must be supported by individuals at

Figure 5. Present worth values associated with each strategy.

Present Worth of Strategy A	
PW (initial)	=$400,000
PW (routine maintenance)	=$ 6,567
PW (treatment 1)	=$ 58,455
PW (treatment 2)	=$ 42,713
PW (salvage value)	=$ -18,255
Total PW	=$489,480
Present Worth of Strategy B	
PW (initial)	=$400,000
PW (routine maintenance)	=$ 10,507
PW (all four treatments)	=$ 32,928
PW (salvage value)	=$ 00
Total PW	=$443,435

all levels of the organization to be successful. At the policy level, dedicated funding will support the preventive maintenance program. At this level, managers can promote the preventive maintenance philosophy within the organization, support the program among political factions and provide the resources needed to embrace the philosophy within the organization.

The preventive maintenance program also must be supported by design, pavement management, research, planning and programming, and construction. Designers should consider the effect of pavement designs on maintenance needs and pavement performance. Pavement management should incorporate preventive maintenance treatments into the analysis of pavement maintenance and rehabilitation needs for planning and programming activities. Research can provide information on the optimal timing of preventive maintenance treatments based on agency performance studies, and construction can help ensure that the quality of preventive maintenance treatments is incorporated into the construction activities. Finally, individuals in planning and programming functions can help ensure that preventive maintenance treatments are applied on a timely basis, before too much pavement deterioration has taken place. In short, preventive maintenance is not the sole responsibility of maintenance, but represents a paradigm shift within the agency that must be supported by all.

The public will never understand why we're working on good roads.

Where there is a general mistrust of government and public employees, having treatments applied to roads in good condition will only further fuel that feeling. This is especially true if there are still plenty of roads in poor condition that are not being treated.

Since the public also wants government to be accountable, perhaps the best way to fend off the anticipated negative public response is to promote preventive maintenance among civic groups, special interest groups and the general public through presentations at meetings, press releases and material placed on the Internet. This is essentially a public relations campaign. The materials that are used should illustrate the cost-effectiveness of a preventive maintenance strategy and the resulting benefits in terms of network conditions, improved safety and better levels of service. As with the decision-makers, explaining pavement preventive maintenance in terms that the public understands, such as house or car maintenance, is an effective means of conveying the agency's philosophy to the community.

Our agency can't afford this type of a program.

In reality, your agency can't afford NOT to consider a pavement preventive maintenance program as a strategy for preserving its investment in its transportation assets. Not only have preventive maintenance programs been shown to reduce the overall cost of preserving the pavement network, but additional benefits have been realized in terms of improved safety, better network conditions and higher customer satisfaction. Many agencies have funded their preventive maintenance programs with new funds obtained through increased taxes or the reallocation of funds from other sources. However, several agencies have successfully implemented preventive maintenance programs without levying additional taxes. Granted, the benefits may come a little slower without additional funds, but any level of commitment to a preventive maintenance program will eventually result in benefits to both the agency and the traveling public.

Support groups

The preservation of a pavement network is a challenge to both public and private transportation agencies. Pavement preservation strategies, including the use of pavement preventive maintenance treatments, have emerged in the last few years as a cost-effective means of maintaining the functional condition of a road network.

To be effective, a pavement preservation program requires a shift in the operations of most transportation agencies. Instead of using maintenance funds to address only stopgap measures, funds are allocated to the construction of preventive maintenance treatments while pavement is still in relatively good condition. To effectively implement this type of change within a transportation agency, the benefits of such a program must be demonstrated using available tools, such as a pavement management system.

Resources are available to assist agencies in implementing a preventive maintenance program. For example, the Federal Highway Administration's (FHWA) National Highway Institute (NHI) offers a series of training courses on pavement preservation activities such as preventive maintenance. Courses currently available or under development include topics on the preventive maintenance concept,

selecting projects that are good candidates for preventive maintenance, the construction of quality preventive maintenance treatments and the integration of preventive maintenance treatments into a pavement management system. Information on NHI training courses is available at www.nhi.fhwa.dot.gov.

Other organizations actively promoting the use of preventive maintenance treatments are supported by a combination of governmental, private and academic agencies. The Foundation for Pavement Preservation (FP2) is one such example. Through its website (www.fp2.org) and its support for pavement preservation forums and conference sessions, FP2 has been an early leader in providing resources to support agency practices in this area. In conjunction with the FHWA, the Foundation has recently supported the development of the National Center for Pavement Preservation at Michigan State University. The National Center for Pavement Preservation is expected to be involved in furthering research and training efforts in the area of pavement preservation. More information on the Center is available through its website at www.pavementpreservation.org.

Reprinted from *Roads & Bridges,* December 2003.

National Center for Pavement Preservation Opens in Michigan

A new era for pavement preservation in the United States began on October 17, when the National Center for Pavement Preservation (NCPP) was dedicated at Michigan State University (MSU) in Okemos, Michigan. "The National Center for Pavement Preservation is a first and the only one in the world," said Bill Ballou, president of the Foundation for Pavement Preservation (FP2). "Over the coming years, this center will have the opportunity to reach each transportation owner agency with technical support for pavement preservation programs."

The center was founded by MSU, FP2, and the Federal Highway Administration (FHWA) to lead and coordinate collaborative efforts among government, industry, and academia to advance pavement preservation. Pavement preservation is a planned strategy of treating pavements at the optimum time to maximize their useful life, enhancing pavement longevity while lowering lifetime costs. The key to successful pavement preservation efforts is applying the right treatment to the right pavement at the right time. Treatments must be carefully selected and must be applied when the pavement is still in good condition, i.e., with no structural damage.

"The Nation's highways are valued at more than $1.75 trillion. As responsible stewards of the highway system, present and future generations cannot allow this investment to deteriorate," said King W. Gee, FHWA Associate Administrator for Infrastructure, at the dedication. "The FHWA has undertaken a greater focus on preservation philosophy to address the significant deterioration that has been occurring to the Nation's infrastructure. Preservation extends highway service life and provides smoother, safer, and more reliable roads."

The center will coordinate and administer fundamental and applied research on pavement preservation. It will also provide hands-on technical assistance and work with highway agencies and others on meeting training and education needs. The center's resources include a technical library of national studies, specifications, and treatment procedures.

"The opening of the NCPP brings together the resources for national level research and development in the preservation area," said Jim Sorenson, senior construction and system preservation engi-

Participating in the October 17, 2003, ribbon cutting for the National Center for Pavement Preservation are, from left, Center Advisory Board chair James S. Moulthrop, Fugro-BRE, Inc.; King W. Gee, Associate Administrator for Infrastructure, FHWA; Lou Anna K. Simon, Provost and Vice President of Academic Affairs, MSU; David Porteous, MSU Board of Trustees; Bill Ballou, President, FP2; Rep. Rick Johnson, Michigan Speaker of the House; Ronald Harichandran, Chair, Department of Civil and Environmental Engineering, MSU; and Janie Fouke, Dean, College of Engineering, MSU.

"The National Center for Pavement Preservation is a first and the only one in the world. Over the coming years, this center will have the opportunity to reach each transportation owner agency with technical support for pavement preservation programs."

neer in FHWA's Office of Asset Management. The center has the long-term potential to help highway agencies at all levels support their pavement infrastructure investment, noted NCPP Director Larry Galehouse. "We will assist agencies in becoming more proactive and less reactive when addressing pavement needs, resulting in greater cost savings and satisfaction for the motorist," said Galehouse.

A Center Advisory Board will serve as a link between the NCPP and the pavement preservation community and will help determine priorities and direction for the center. For a list of board members, see sidebar.

For more information about the center and the assistance it can provide, contact Larry Galehouse at NCPP, 517-432-8220 (fax: 517-432-8223; email: ncpp@egr.msu.edu) or visit www.pavementpreservation.org.

Reprinted from *Focus,* November 2003.

National Center for Pavement Preservation Advisory Board

- **James S. Moulthrop,** *Senior Engineer,* Fugro-BRE, Inc. (Chair)
- **King W. Gee,** *Associate Administrator for Infrastructure,* FHWA
- **Gloria Jeff,** *Director,* Michigan Department of Transportation
- **Rick Johnson,** *Speaker of the House,* Michigan Legislature
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- **Jean-Claude Roffe,** *Executive Manager,* SIR/COLAS
- **Bill Temple,** *Chief Engineer,* Louisiana Department of Transportation and Development

Principles of Pavement Preservation

Definitions, Benefits, Issues, and Barriers

by Larry Galehouse, James S. Moulthrop, and R. Gary Hicks

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 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.

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, environment 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 mainte-

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

nance 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.

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.

Definition 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 borrow 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 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.

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

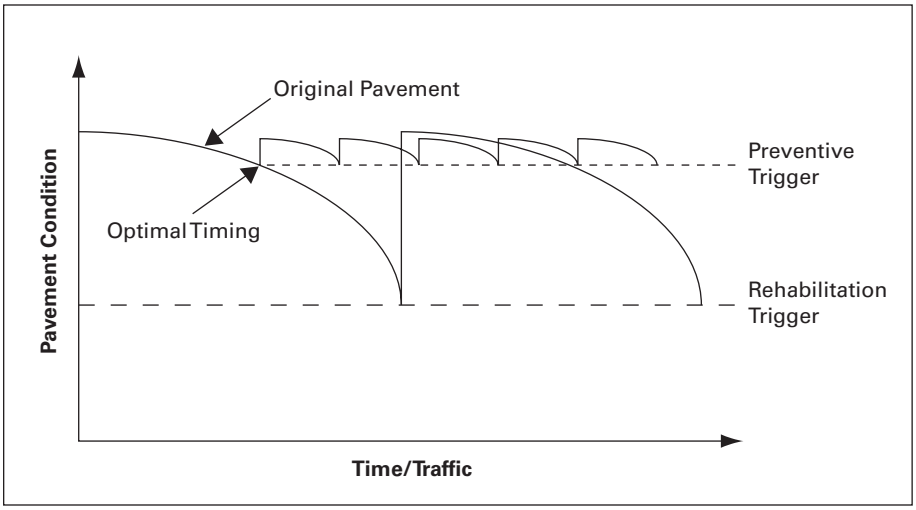

Figure 1. Pavement preservation concept.

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 Construction	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.

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.

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 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.

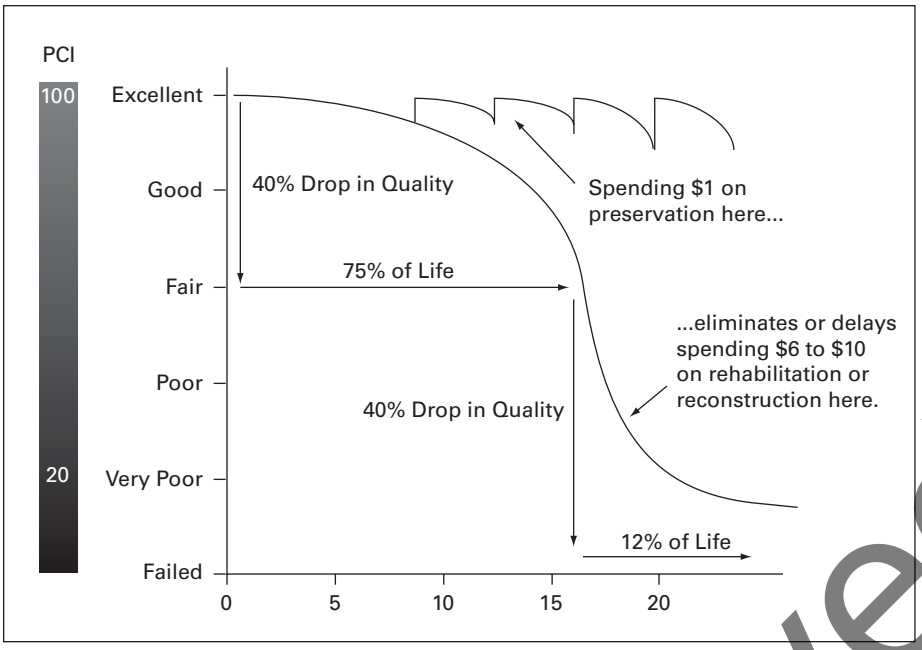

Figure 2. Pavement option curve (example). (PCI = Pavement Condition Index.)

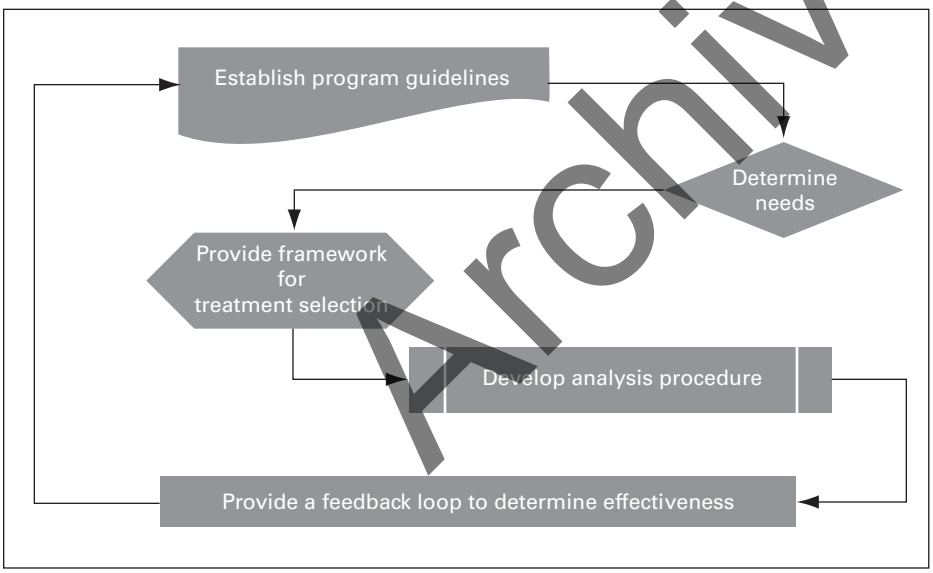

Figure 3. Pavement preservation process.

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.

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 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.

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Preserving Pavements and Budgets

California's Strategies Leverage Limited Funds

by 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 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. 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. 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.

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.

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Looking at Long-Term Results

Performance of Test Section After 13 Years

by 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.

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 conventional 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.

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.

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.

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[1] 06A300; GPS Section 061253; Butte County, California; State Route 32; PM 13.96-18.71; average annual daily traffic: 2,900 vehicles.

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Protecting Roads in the Desert

Chip Sealing over Fabric Retards Reflective Surface Cracks

by 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.

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.

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 specifica-

tions: fabric manufactured from polyester, polypropylene, or polypropylene-nylon material. The fabric is nonwoven and is heat-treated on one side.

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. 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.

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Research Frontiers in Pavement Preservation

by Roger M. Larson, Larry Scofield, and James B. Sorenson

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 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 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 the 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.

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.

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Investing in the Future of Roads

by Jim Sorenson

The goal of "Keeping good roads good" is behind a growing number of pavement preservation programs nationwide. Information on what states, industry and others have accomplished can now be found on a new CD available from the Federal Highway Administration (FHWA), *National Pavement Preservation Forum II: Investing in the Future* (Publication No. FHWA-IF-03-019).

The CD contains presentations and papers from the National Pavement Preservation Forum II, which was held in San Diego, Calif., in November 2001. The conference gave participants an opportunity to share success stories, detail challenges and discuss the future of pavement preservation. The event, which was a follow-up to the 1998 Forum for the Future, was sponsored by the Foundation for Pavement Preservation, FHWA and the California Department of Transportation (Caltrans).

"Keeping good roads good" involves the timely application of carefully selected treatments to maintain or extend a pavement's service life. These treatments may include various types of surface seals, thin lift overlays and crack sealing for asphalt pavements. Treatments for concrete pavements might include crack and joint sealing, diamond grinding and retrofit dowel bars. The key is to apply the treatments when the pavement is still in good condition, with no structural damage. Placing a treatment too late will result in poor performance, while applying treatments too early can cause other pavement problems and use up funds before they are needed. Applying the right treatment to the right road at the right time allows highway agencies to get the most out of their maintenance dollars.

Conference participants stressed the importance of education and awareness as vehicles for promoting pavement preservation. Other keys to success cited by forum participants were:

- Adequate dedicated funds;
- Effective marketing of preventive maintenance;
- Support from management;
- Legislative support;
- Training and buy-in of workers; and
- Public awareness of the financial benefits of preventive maintenance.

Conference co-sponsor Caltrans began its pavement preservation efforts in 1992 and now issues an annual Pavement Condition Report, which it uses to determine high-priority needs. The agency also developed 10-year pavement goals, which were implemented in 1998. These goals include reducing the backlog of distressed lane miles from 14,000 to 5,000 by 2008. Preventive maintenance work completed to date has included applying a 1.2-in. asphalt rubber overlay to 150 lane miles of I-5 in Fresno. The work, which was performed by the Granite Co., had to be completed in 65 days and come with a one-year warranty. The overlay "improved the ride dramatically and extended the pavement life by 10 additional years," said conference co-chair Larry Orcutt of Caltrans.

Forum participants noted that training is fundamental to spreading the word about pavement preservation.

In response to state and industry needs, FHWA has developed a series of pavement preservation training courses. Two courses are currently being offered to highway agencies through FHWA's National Highway Institute (NHI), while two more are expected to be available by fall 2003. Pavement Preservation: The Preventive Maintenance Concept is targeted toward highway agency decision makers, management, senior maintenance staff and others who have the ability to create and fund department programs and initiatives. Selecting Pavements for

Preventive Maintenance targets engineers and field supervisors who make decisions about which roads receive treatment and when. Still under development are courses on Design and Construction of Quality Preventive Maintenance Treatments and Pavement Preservation: Integrating Pavement Preservation Practices and Pavement Management.

Also important to the success of pavement preservation programs is documenting the benefits of preventive maintenance. As forum participants noted, data must be accurate and it also should be accesssible.

To obtain a copy of the Forum II CD, contact Steve Mueller at FHWA, 202/366-1557; fax: 202/366-9981; e-mail: steve.mueller@fhwa.dot.gov.*

Pavement preservation treatments for asphalt pavements can include slurry seals, which are shown here.

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When Prevention Is the Cure

by Tom Kuennen

A current pavement inventory, identification of conditions, and correct timing of pavement preservation applications are the secrets to successful preservation of hot-mix asphalt driving surfaces, according to a growing body of experts and research.

Naturally, government agencies want to keep citizens happy by providing as large an inventory of smooth streets as possible. But state, city, and county road agencies alike have to remember that maintenance techniques applied to pavements that are completely deteriorated beyond a certain point are a waste of money.

A "worst-first" pavement maintenance philosophy tosses scarce public funding at pavements that should be allowed to fail first, then be reconstructed in an orderly, programmatic manner.

Asphalt pavements will perform well and deteriorate very slowly through the first eight to 10 years of their lives, then fail rapidly as an assortment of ills does them in.

The best way, experts say, to spend scarce maintenance funds is to determine where the pavement is in its life-cycle "curve," and apply preventive maintenance techniques just before the period of rapid deterioration sets in.

Unfortunately, the public agencies responsible for pavements ultimately must answer to elected officials. It takes guts for a public works supervisor to insist to a mayor or aldermen that the municipality will get the best use of funds by allowing a street to fall apart before rebuilding, despite what the voters say.

Support for preservation

Experts agree pavement preservation is best executed in the framework of a pavement management system that will enable a road agency to identify pavement condition throughout its road inventory. Not only will such a system help allocate where funds are best spent, but it will also provide a database to prove the long-term benefits of pavement preservation and justify additional preservation spending.

"The key is to have a good pavement management system that will allow you to track the condition of your pavements over time," says Mark Buncher, Ph.D., P.E., director of field engineering for The Asphalt Institute. "The best preventive maintenance practice will be indicated by the pavement history in a pavement management system."

Today, programmed pavement preservation is gaining major support from some heavy hitters in the road and bridge community.

- The Federal Highway Administration delivers pavement preservation guidance and moral support through its Office of Asset Management.
- The Foundation for Pavement Preservation, a public/private venture, is funding and managing research into pavement preservation materials, techniques, training, and best practices—and publicizing best practices via outreach to governments and contractors. (visit at http://fp2.org).
- The American Association of State Highway & Transportation Officials recently launched a web site devoted to agency asset management and pavement preservation (visit at http://assetmanagement.transportation.org/).
- The pending GASB 34 accounting regulations now being adopted from coast to coast are compelling municipal and county governments to reconsider their philosophy toward the transportation infrastructure they possess, counting it as an asset that must be nurtured and maintained, rather than just a network of streets and highways that wears out and must be fixed.

A new way of thinking

The theme of asset management supporting pavement preservation is driving the new emphasis on preventive maintenance for the local and state transportation infrastructures of the 21st century.

"Pavement preservation is at the core of all future highway programs," says Bill Ballou, president of the Foundation for Pavement Preservation. "Without asset and system management, we can't maintain highway systems cost-effectively. We want pavement preservation to be a routine undertaking for road agencies."

"Pavement preservation is more than just a collective set of specific pavement maintenance techniques," said FHWA's Office of Asset Management Construction and System Preservation Team leader Jim Sorenson at last year's annual meeting of the International Slurry Surfacing Association. "It is a way of thinking and the guiding force behind an agency's financial planning and proper asset management."

And that leads to challenges in asphalt pavement preservation and maintenance, Sorenson said at an FP2 conference in 2000. "The vast majority (about 94%) of U.S. pavements are made of asphalt," he said. "The balance of the pavements in the high-service corridors are of portland cement concrete. We make choices, and we need the competition between the industries. But the mainstay of our pavements is black, and that's where we need to place much of our preservation focus."

Sorenson adheres to the classic definition of pavement preservation—application of the right treatment, to the right road, at the right time. "We have to get the best bang for the buck out of those asphalt pavements," Sorenson said. "That means we have to do at least something at the right time." And to be able to respond at the right time requires planning and budgeting, he said.

Asset management

Since 2000, the FHWA has promoted transportation infrastructure asset management as a best practice for state and local road and bridge owners. Asset management is a philosophy borrowed from the private sector, now being applied to government agency-owned transportation infrastructure.

"Asset management is a business process that's being introduced into the highway community to allow agency top management—our policy decision makers—to be cognizant of the investments we're making in our highway system," Sorenson says.

"Highways are a big business, and every dollar that we invest in the highway system must get a high rate of return. And in the United States, in the post-war era, we can show those returns in the way our economy has stabilized and developed."

For more information and tools to use, visit the FHWA's Office of Asset Management at www.fhwa.dot.gov/infrastructure/asstmgmt/index.htm.

Foundation for preservation

Research and educational support of long-lived pavements through preventive maintenance is being undertaken by the public/private-funded Foundation for Pavement Preservation.

Commonly known as FP2 ("FP squared"), the foundation is the nation's leading proponent of pavement preservation. Like FHWA's Sorenson, the foundation believes that proper pavement preservation means application of the right treatment, to the right road, at the right time, and communicates this principle to the top management levels of government agencies, as well as to field personnel.

FP2 funds and conducts research, coordinates development of educational courses and programs, sponsors symposia and workshops, issues external publications, and identifies research problem statements for future work.

Established in 1992, FP2 is facilitating change in the transportation infrastructure community, Sorenson says, by providing resources to advance knowledge for improved asset management for maintaining and preserving highway pavements.

"We are closely monitoring how reauthorization will support pavement preservation," says FP2's Ballou. "While we are not a lobbying group, we are acutely aware of the need to include pavement preservation research funding, as well as system preservation funding itself."

In 2001, FP2 began high-level talks with the FHWA and the American Association of State Highway & Transportation Officials to readdress pavement preservation research and policy needs, and to establish a focus for a national program. And last February, FP2 brought FHWA, AASHTO, and private sector stakeholders together into a "Strategic Partnership in Pavement Preservation Research" initiative to identify common ground as TEA-3 approaches. "We discussed reauthorization and how

we could participate and what our best options were," Ballou says.

Sealer/binder research

Ongoing research on surface sealants and rejuvenators being coordinated by FP2 likely will pay big dividends in the near and long term.

Sealers have been used in approximately two-thirds of the states, the foundation reports. Rejuvenators are formulated to penetrate into the pavement and enhance the properties of the asphalt binder of the existing pavement.

To explore which treatments will work best under which climatic conditions, the FHWA contracted with FP2 in February 2001 to evaluate the effectiveness of spray-applied emulsified sealer/binders and rejuvenators.

This was a unique approach as it brought together a partnership between industry and the FHWA. Although the FHWA provides the significant share of research funding, the pavement preservation industry also contributes to this effort through the foundation. FP2 conducts the research through its partners and contractors.

As part of this research, a workshop and field application of test sections was conducted in early autumn 2002 in southern Minnesota.

Preservation through maintenance

Preventive maintenance is a means to achieving pavement preservation.

"Preventive maintenance applies lower-cost treatments to retard a highway's deterioration, maintain or improve the functional condition, and extend the pavement's service life," says retired Michigan DOT pavement preservation engineer Larry Galehouse, P.E., L.S.

"With various short-term treatments, preventive maintenance can extend pavement life an average of 5 to 10 years," Galehouse says. "Applied to the right road, at the right time—when the pavements are mostly in good condition—preventive maintenance can improve the network condition significantly at a lower unit cost."

Beginning in 1992, Galehouse's work at the Michigan DOT provided hard evidence that preventive maintenance is a wise investment. According to a study undertaken by the DOT and confirmed by an independent consultant, in the long run Michigan's preventive maintenance strategy is more than six times as cost-effective as rehabilitation and reconstruction projects in providing acceptable driving surfaces.

In Michigan, surface treatments for flexible pavement surfaces include microsurfacing, chip seals, slurry seals, crack sealing, 0.75-inch overlays of ultrathin hot-mix asphalt, and 1.5-inch hot-mix asphalt overlays, Galehouse says.

Ills of asphalt pavements

Such procedures mitigate the degenerative problems that hot-mix asphalt pavements endure. Some asphalt pavement ills—like raveling—indicate the need for immediate pavement preventive maintenance. Others, like alligator cracking, indicate a pavement that has deteriorated too far, or a subbase that requires repair lest good money be thrown after bad.

- Raveling is the separation of the surface aggregate from the asphalt binder. As aggregate moves out of the mix, the surface becomes rougher in texture. Aggregate that has "raveled" out of the matrix can be found in gutters and close to drain inlets. The cause usually is oxidation by sun and weather, as the asphalt binder is broken down by the elements. This can begin early in a pavement's life. Surface treatments are indicated.
- Bleeding, also known as flushing, is the exuding of binder onto pavement surface; it's caused by excessive amounts of liquid asphalt binder in mix or low air void content (densification) caused by excessive traffic, and appears during hot weather. A seal coat can help, or overlay of an open-graded friction course.
- Rutting is longitudinal deformation of pavement; it's caused by high levels of repeated stress being applied to the subgrade below the asphalt course, or by an asphalt mix without enough shear strength to resist repeated heavy loads. Some say rutting can't be fixed by preventive maintenance treatments other than cold mill and overlay, or hot in-place surface recycling; others say an asphalt thin surfacing or microsurfacing will satisfactorily fill ruts while leaving a new driving surface.
- Corrugation or "washboarding" is a transverse deformation of pavement, and can be caused by poor compaction technique or a shifting of the subgrade. It can't be fixed by preventive maintenance methods.

- Fatigue, or alligator cracking, is interconnected cracking with a pattern resembling the hide of an alligator. Its primary cause is attributed to base failure, or heavy traffic loading combined with partial base failure, so it can't be cured with a preventive maintenance treatment. However, mild cases of alligatoring with minimal base involvement can be treated with seal surfacing.

New look at fatigue cracking

This spring a contract was pending for new research into fatigue cracking, as proposed by the National Cooperative Highway Research Program. Project 1-42, Top-Down Fatigue Cracking of Hot-Mix Asphalt Layers, would be a two-year, $400,000 project that will take another look at why fatigue cracking happens.

Until recently, load-associated fatigue cracking of hot-mix asphalt pavements that occur in the wheel path have been thought to always initiate at the bottom of the HMA layer and propagate to the surface, NCHRP says.

But new studies indicate that load-related fatigue cracks can also be initiated at the surface of the pavement and propagate downward through the HMA layer, NCHRP says. These studies say environmental conditions, tire-to-pavement interaction, mixture characteristics, pavement structure, and construction practices are among the factors that influence the occurrence of this cracking.

Research proposed by NCHRP would identify mechanisms that govern the initiation and propagation of top-down fatigue cracking, identify or develop methods of lab-testing HMA mixes for susceptibility to surface cracking, determine factors associated with top-down fatigue cracking, and identify predictive models.

Preservation techniques

A variety of techniques and materials can be used to preserve a pavement—if it is at the right stage in its life. These include chip seals, fog seals, cape seals, slurry seals, microsurfacing, and thin-lift hot-mix asphalt overlays. But before spending money on an application, the engineer must determine if the treatment will actually prolong pavement life.

"There are lots of different tools in the tool box to choose from," the Asphalt Institute's Buncher says. "The pavement owner will have to choose the best solution for the funds that are available."

For example, most fatigue or alligator cracking indicates a failed subgrade following years of weathering and traffic loads. The existing fatigued asphalt and base must be milled or dug out, then rebuilt prior to placement of a treatment or new lift of asphalt.

Rutted asphalt may be treated by a thin-lift HMA overlay, or by microsurfacing. But a chip seal or slurry seal will do little to improve the riding surface, much less prolong pavement life.

Simple raveling, on the other hand, may be treated by a number of surfacing solutions, including the family of surface seals.

"The application of slurry seal will significantly extend the life of existing pavements by protecting the under-surface from damage caused by water seepage," says the International Slurry Surfacing Association. "Improved surface performance is an added bonus. A pavement maintenance program using slurry seal will not only help to protect your pavement, it will help to protect your paving investment."

Simple pavement seals

There are four approaches to pavement sealing in common use today.

The classic chip seal is an inexpensive solution for an oxidized or raveling asphalt pavement. An asphalt chip seal, also referred to as a seal coat or a bituminous surface treatment, consists of sequential applications of asphalt and stone chips, applied either singly or in layers, to build up a structure that can approach 1-inch thick, according to the National Highway Institute's course of instruction, Techniques for Pavement Rehabilitation.

Rubberized asphalt chip seals are a special type of chip seal in which rubber (ground-rubber tires) is blended with the asphalt cement. "This application has been used both as a SAM (stress-absorbing membrane) and a SAMI (stress-absorbing membrane interlayer) to help reduce reflection cracking, but it has also been used without overlays," NHI says.

Fog seals are very light applications of an emulsion to the pavement surface with no aggregate, according to NHI. "These applications seal the surface and provide a small amount of rejuvenation, depending on the type of emulsion used and the condition of the existing pavement surface," NHI says.

Cape seals are a combination of chip seal and slurry surfacing or seal. "For paved roads, the chip seal is applied first and, between four and 10 days later, the slurry seal is applied," NHI says. For unsurfaced roads, an application of penetration oil (MC-70 or SC-70) is applied first as a prime coat, followed about two days later by a chip seal and about two weeks later by a slurry seal.

Slurry surfacings

A slurry surfacing, also known as a slurry seal, is a mixture of aggregates dispersed in asphalt and applied in a slurry state.

"Slurry seal is a mixture of an asphaltic oil and water (emulsion) and crushed rock aggregate that is spread over the street at about one-fourth-inch thickness," says the City of Austin (Texas) Street and Bridge Division. "The slurry 'cures' when the water evaporates, leaving only the asphalt to coat the crushed rock."

Afterward, the asphalt acts as a binder to hold the slurry together and bond to the existing pavement. The slurry seal protects the existing street surface from the effects of aging and oxidizing and increases the skid resistance.

"Slurry seals typically include some crack sealing on cracks 0.1875-inch and larger," Austin says. "Prep work may also include a minor amount of level-up and surface replacement areas depending upon conditions; however, slurry seal is typically used on streets that are in good to excellent condition."

"Slurry surfacings are designed in a lab, are proportioned by the slurry machine, and laid down and cured so the asphalt-to-aggregate ratio is maintained at the optimum value to assure uniform aggregate coating and adhesion," says Jeff Reed, president, Valley Slurry Seal Co., Sacramento.

Such surfaces use very large fractions of fines material, giving a very high surface area and a lot of microstructure, leading to a sandpaper surface and a high skid resistance, while maintaining a smooth finish, Reed says.

Microsurfacing evolved from slurry

Microsurfacing is a more advanced extension of the slurry-surfacing concept. Microsurfacing is described as a polymer-modified, cold-mix paving system that can remedy a broad range of problems on today's streets, highways, and airfields.

Like slurry seal, microsurfacing begins as a mixture of dense-graded aggregate, asphalt emulsion, water, and mineral fillers, says the International Slurry Seal Association, but microsurfacing has added capabilities, thanks to the use of advanced polymers and other modern additives.

Introduced in the United States in 1980, microsurfacing is made and applied to existing pavements by a specialized machine which carries all components, mixes them on-site, and spreads the mixture onto the road surface. These materials are continuously and accurately measured, and then thoroughly combined in the microsurfacer's mixer.

As the machine moves forward, the mixture is continuously fed into a full-width "surfacing" box, which spreads the width of a traffic lane in a single pass, the ISSA says. Also, specially engineered "rut" boxes—designed to deliver the largest aggregate particles into the deepest part of the rut to give maximum stability in the wheel path—may be used to fill ruts. Edges of the microsurface mat are automatically feathered.

Thin surfacings

The next step up from microsurfacing is a full-blown hot-mix asphalt thin surfacing. This consists of a single layer of hot-mix asphalt (minimum of 1-inch thick, but often 2-inches thick) used to level, waterproof, and restore the original street shape and ride.

Thin overlays for pavement maintenance got a big boost this year when the results of a National Cooperative Highway Research Project were revealed at the 82nd meeting of the Transportation Research Board in Washington in January.

There, a paper on NCHRP Project 20-50 (03/04)—*LTPP Data Analysis: Effectiveness of Maintenance and Rehabilitation Options*—assessed the relative performance of different pavement maintenance and rehab treatments, including the influence of pretreatment condition and other factors on treatment effectiveness.

The study was executed by Kathleen T. Hall and Carlos E. Correa, both with ProTech Engineering, Inc., and Amy L. Simpson, now with PCS-Law. Data used in the study were drawn from the Long-Term Pavement Performance Studies SPS-3 experiment.

"In terms of roughness, rutting, and fatigue cracking, the most effective of the maintenance treatments in the SPS-3 core experiment has been

the thin overlay treatment, followed by the chip seal treatment, and then the slurry seal treatment," they write. "The thin overlay treatment was the only one of the four SPS-3 maintenance treatments to produce an initial (albeit small) reduction in roughness, and the only one of the four to have a significant effect on long-term roughness, relative to the control sections."

For rougher pavements, however, there was some evidence that chip seals and slurry seals also had some effect on long-term roughness, rutting, and cracking, relative to the control sections. "Slurry seals and crack seals did not have any significant effect on long-term roughness, rutting, or fatigue cracking," the authors reported.

It should be kept in mind that the term effectiveness, as used in this paper, refers to the magnitude of effect on initial and long-term condition levels, and is not meant to imply anything with regard to the relative cost-effectiveness of the different treatments. "The most effective treatment is not always the most cost-effective treatment," the authors warn.

> "Preventive maintenance applies lower-cost treatments to retard a highway's deterioration, maintain or improve the functional condition, and extend the pavement's service life."

Options are vast

The options available to pavement engineers to help preserve pavements are vast, sophisticated, and are getting better. But perhaps the engineers' biggest challenge will be to move forward and apply true pavement preservation principles to the infrastructure under their control. Fortunately, support is building for pavement preservation, and they won't be alone.

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U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: ACTION: Pavement Preservation Definitions
Date: September 12, 2005
From: David R. Geiger, P.E.
Director, Office of Asset Management

Reply to Attn. of: HIAM-20
To: Associate Administrators
Directors of Field Services
Resource Center Director and Operations Manager
Division Administrators
Federal Lands Highway Division Engineers

As a follow-up to our Preventive Maintenance memorandum of October 8, 2004, it has come to our attention that there are differences about how pavement preservation terminology is being interpreted among local and State transportation agencies (STAs). This can cause inconsistency relating to how the preservation programs are applied and their effectiveness measured. Based on those questions and a review of literature, we are issuing this guidance to provide clarification to pavement preservation definitions.

Pavement preservation represents a proactive approach in maintaining our existing highways. It enables STAs to reduce costly, time consuming rehabilitation and reconstruction projects and the associated traffic disruptions. With timely preservation we can provide the traveling public with improved safety and mobility, reduced congestion, and smoother, longer lasting pavements. This is the true goal of pavement preservation, a goal in which the FHWA, through its partnership with States, local agencies, industry organizations, and other interested stakeholders, is committed to achieve.

A Pavement Preservation program consists primarily of three components: preventive maintenance, minor rehabilitation (non structural), and some routine maintenance activities as seen in figure 1.

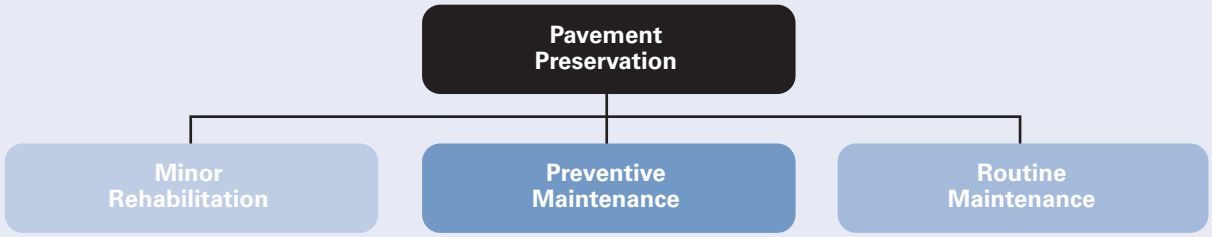

Figure 1. Components of pavement preservation.

An effective pavement preservation program can benefit STAs by preserving investment on the NHS and other Federal-aid roadways, enhancing pavement performance, ensuring cost-effectiveness, extending pavement life, reducing user delays, and providing improved safety and mobility.

It is FHWA's goal to support the development and conduct of effective pavement preservation programs. As indicated above, pavement preservation is a combination of different strategies which, when taken together, achieve a single goal. It is useful to clarify the distinctions between the various types of maintenance activities, especially in the sense of why they would or would not be considered preservation.

For a treatment to be considered pavement preservation, one must consider its intended purpose. As shown in Table 1 below, the distinctive characteristics of pavement preservation activities are that they restore the function of the existing system and extend its service life, not increase its capacity or strength.

Definitions for Pavement Maintenance Terminology

Pavement Preservation is "a program employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety and meet motorist expectations."

Source: FHWA Pavement Preservation Expert Task Group

An effective pavement preservation program will address pavements while they are still in good condition and before the onset of serious damage. By applying a cost-effective treatment at the right time, the pavement is restored almost to its original condition. The cumulative effect of systematic, successive preservation treatments is to postpone costly rehabilitation and reconstruction. During the life of a pavement, the cumulative discount value of the series of pavement preservation treatments is substantially less than the discounted value of the more extensive, higher cost of reconstruction and generally more economical than the cost of major rehabilitation. Additionally, per-

Table 1. Pavement preservation guidelines.

	Type of Activity	Increase Capacity	Increase Strength	Reduce Aging	Restore Serviceability
	New Construction	X	X	X	X
	Reconstruction	X	X	X	X
	Major (Heavy) Rehabilitation		X	X	X
	Structural Overlay		X	X	X
Pavement Preservation	Minor (Light) Rehabilitation			X	X
	Preventive Maintenance			X	X
	Routine Maintenance				X
	Corrective (Reactive) Maintenance				X
	Catastrophic Maintenance				X

forming a series of successive pavement preservation treatments during the life of a pavement is less disruptive to uniform traffic flow than the long closures normally associated with reconstruction projects.

Preventive Maintenance is "a planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system (without significantly increasing the structural capacity)."

Source: AASHTO Standing Committee on Highways, 1997

Preventive maintenance is typically applied to pavements in good condition having significant remaining service life. As a major component of pavement preservation, preventive maintenance is a strategy of extending the service life by applying cost-effective treatments to the surface or near-surface of structurally sound pavements. Examples of preventive treatments include asphalt crack sealing, chip sealing, slurry or micro-surfacing, thin and ultra-thin hot-mix asphalt overlay, concrete joint sealing, diamond grinding, dowel-bar retrofit, and isolated, partial and/or full-depth concrete repairs to restore functionality of the slab; e.g., edge spalls, or corner breaks.

Pavement Rehabilitation consists of "structural enhancements that extend the service life of an existing pavement and/or improve its load carrying capacity. Rehabilitation techniques include restoration treatments and structural overlays."

Source: AASHTO Highway Subcommittee on Maintenance

Rehabilitation projects extend the life of existing pavement structures either by restoring existing structural capacity through the elimination of age-related, environmental cracking of embrittled pavement surface or by increasing pavement thickness to strengthen existing pavement sections to accommodate existing or projected traffic loading conditions. Two sub-categories result from these distinctions, which are directly related to the restoration or increase of structural capacity.

> *Minor rehabilitation* consists of non-structural enhancements made to the existing pavement sections to eliminate age-related, top-down surface cracking that develop in flexible pavements due to environmental exposure. Because of the non-structural nature of minor rehabilitation techniques, these types of rehabilitation techniques are placed in the category of pavement preservation.
>
> *Major rehabilitation* "consists of structural enhancements that both extend the service life of an existing pavement and/or improve its load-carrying capability."
>
> *Source: AASHTO Highway Subcommittee on Maintenance Definition*

Routine Maintenance "consists of work that is planned and performed on a routine basis to maintain and preserve the condition of the highway system or to respond to specific conditions and events that restore the highway system to an adequate level of service."

Source: AASHTO Highway Subcommittee on Maintenance

Routine maintenance consists of day-to-day activities that are scheduled by maintenance personnel to maintain and preserve the condition of the highway system at a satisfactory level of service. Examples of pavement-related routine maintenance activities include cleaning of roadside ditches and structures, maintenance of pavement markings and crack filling, pothole patching and isolated overlays. Crack filling is another routine maintenance activity which consists of placing a generally, bituminous material into "non-working" cracks to substantially reduce water infiltration and rein-

force adjacent top-down cracks. Depending on the timing of application, the nature of the distress, and the type of activity, certain routine maintenance activities may be classified as preservation. Routine Maintenance activities are often "in-house" or agency-performed and are not normally eligible for Federal-aid funding.

Other activities in pavement repair are an important aspect of a STA's construction and maintenance program, although they are outside the realm of pavement preservation:

Corrective Maintenance activities are performed in response to the development of a deficiency or deficiencies that negatively impact the safe, efficient operations of the facility and future integrity of the pavement section. Corrective maintenance activities are generally reactive, not proactive, and performed to restore a pavement to an acceptable level of service due to unforeseen conditions. Activities such as pothole repair, patching of localized pavement deterioration, e.g. edge failures and/or grade separations along the shoulders, are considered examples of corrective maintenance of flexible pavements. Examples for rigid pavements might consist of joint replacement or full width and depth slab replacement at isolated locations.

Catastrophic Maintenance describes work activities generally necessary to return a roadway facility back to a minimum level of service while a permanent restoration is being designed and scheduled. Examples of situations requiring catastrophic pavement maintenance activities include concrete pavement blow-ups, road washouts, avalanches, or rockslides.

Pavement Reconstruction is the replacement of the entire existing pavement structure by the placement of the equivalent or increased pavement structure. Reconstruction usually requires the complete removal and replacement of the existing pavement structure. Reconstruction may utilize either new or recycled materials incorporated into the materials used for the reconstruction of the complete pavement section. Reconstruction is required when a pavement has either failed or has become functionally obsolete.

If you need technical support or further guidance in the pavement preservation area, please contact Christopher Newman in the FHWA Office of Asset Management at (202) 366-2023 or via e-mail at Christopher.Newman@fhwa.dot.gov.

Resources

To learn more about pavement preservation, visit FHWA's Transportation System Preservation Web site at **www.fhwa.dot.gov/preservation.** Resources on the site include fact sheets, a checklist series with details on pavement preservation applications and techniques, and information on research studies.

Information is also available on the National Center for Pavement Preservation's Web site at **www.pavementpreservation.org,** and from the Foundation for Pavement Preservation at **www.fp2.org.** An additional resource is the American Association of State Highway and Transportation Officials' Transportation System Preservation Technical Services Program, which can be visited online at **www.tsp2.org.**

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**Federal Highway
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