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TRANSPORTATION STUDIES
UNIVERSITY OF MINNESOTA



MINNESOTA LOCAL TECHNICAL ASSISTANCE PROGRAM



12th Annual

Minnesota Pavement Conference:

Session Summaries

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St. Paul Campus

Conference Sponsors:

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Hosted by:

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Conference Objective

This one-day annual conference provides information to practitioners and others in pavement design, construction, and maintenance. The emphasis of the conference is new materials and methods that can assist decision makers in providing the most cost-effective strategies for building, repairing, and maintaining Minnesota roads.

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Annual Pavement Conference Award

2008 Gerald Rohrbach Minnesota Pavement Conference Award

The 2008 recipient of the Gerald Rohrbach Annual Pavement Conference Award is Doug Schwartz, concrete pavement engineer with Mn/DOT's Concrete Engineering Unit since 1994. The 2007 recipient, retired county engineer Duane Blanck of Crow Wing County, presented the award.

Schwartz, a career Mn/DOT employee, began his service as a lab technician "who aspired to be more," Blanck said. As state concrete engineer, Schwartz updated the department's quality management program for concrete paving and developed specifications to lower the life-cycle costs of concrete pavement, among other efforts. He previously was the state's bituminous engineer, and is the past president of the Minnesota Association of Asphalt Paving Technologists. In 2007 he was named the American Concrete Paving Association's government official of the year. "He represents Minnesota quality at its best, as an individual and as an engineer," Blanck said.

Plenary Session

Moderator: Maureen Jensen, Minnesota Department of Transportation

Welcome

Lisa Freese, Deputy Commissioner, Minnesota Department of Transportation

Training events such as this conference are a great opportunity for experts from all levels of government to come together with academic and private-sector partners to learn and share experiences, said Lisa Freese. “We need to work together to make the most cost-efficient choices and find the newest and most innovative ways to do our work,” she said. Through the support of the Transportation Engineering Road Research Alliance (TERRA), the Minnesota Local Road Research Board (LRRB), Mn/DOT, MnROAD, and other groups, “We are beginning a new phase of research to today’s challenges.”

Composite Pavements: Design, Construction, and Benefits

Michael Darter, Director, Pavement Research Institute, University of Minnesota

Mike Darter described a major project that will investigate the design and construction of new composite pavements.

For the project, the University of Minnesota Department of Civil Engineering (CE), the Minnesota Department of Transportation (Mn/DOT), and the MnROAD pavement research facility will receive more than half of a \$4 million award over four years from the second Strategic Highway Research Program (SHRP 2).

The research will focus on two strategies that show promise for providing strong, durable, safe, smooth, and quiet pavements that require minimal maintenance:

- Surfacing of new portland cement concrete (PCC) layer with high-quality asphalt concrete (AC) layer(s)
- Relatively thin, high-quality PCC surface atop a thicker, less expensive PCC layer.

Darter said that although all pavements are “composite”—since they consist of layers of different materials bonded together—these two types are generally called “composite” pavements.

Urban areas in North America have built AC/PCC for many years, and European usage with AC/CRCP (continuously reinforced concrete pavement) is common on major freeways.

PCC/PCC composite pavements are also used frequently in Europe, Darter continued. PCC/PCC is built mainly to provide a cap of high-quality aggregate concrete over a thicker layer of lower quality local aggregates or recycled concrete. Some projects included porous concrete as the top layer.

The structural and functional performance of these systems is not well understood or documented, however, and models for predicting their performance need to be developed for use in design, pavement management, and life-cycle cost analysis (LCCA), Darter said. Moreover, construction techniques, guidelines, and specifications are limited and insufficient

One approach—a two-layer concrete with exposed aggregate—has become the standard in Europe for many different types of concrete projects. The functional performance of the AC surfacing ideally provides low noise, high friction, reduced splash and spray, and smoothness, Darter said. Another advantage is the ability to remove and replace the AC surfacing rapidly and reliably.

Because reflection cracking is hard to prevent, the SHRP 2 project will study saw and seal of joints in the AC surfacing over joints in JPCP (jointed plain concrete pavements) or RCC (roller compacted concrete). If joints are aligned exactly over the top, the pavement “will perform for a quite a long time,” Darter said. New York and Connecticut have used saw and seal for 30 to 40 years, and the approach has been tried on many projects across the country and found to be

highly successful. “There may be other solutions,” he added, and those too will be researched carefully in the study.

The project is expected to identify and determine the behavior of critical material and performance parameters, develop and validate mechanistic-empirical performance models and design procedures, and recommend specifications, construction techniques, and quality management procedures.

The overarching goal of the project is to investigate—and prove—the benefits of composite pavements. Will they produce long life surfacing? How will they match up with asphaltic layers in terms of noise, friction, and splash/spray? Will they be valuable for easing utility repair? “Putting it all together,” Darter summarized, “can we do these and reduce the life-cycle cost over time? Will it be competitive with regular asphalt or regular concrete pavements?”

The project “is an opportunity to bring more federal attention to the quality and depth of research in Minnesota,” Darter noted. He is the principal investigator for the work, and CE associate professor Lev Khazanovich is a co-investigator. Others on the research team include CE associate professor Mihai Marasteanu, PRI associate director Derek Tompkins, and Mn/DOT’s Ben Worel.

The University will investigate modeling and accelerated loading, while Mn/DOT will implement experimental design in MnROAD test sections.

SHRP 2 is a targeted, short-term research program created by Congress to address the challenges of moving people and goods efficiently and safely on the nation’s highways.

The Pavement Research Institute is a resource for research in pavement techniques, materials, and technologies. It develops, promotes, and carries out pavement-related research that addresses not only state and local needs, but also regional and national needs. In addition, PRI conducts outreach and education efforts related to pavement research. (See www.pri.umn.edu.)

Pavement Preservation and the Role of Bituminous Surface Treatments—A Washington State View

Joe Mahoney, Department of Civil Engineering, University of Washington

Though other options exist, most pavement preservation decisions boil down to chip seal vs. hot-mix overlay, said Professor Joe Mahoney in his keynote presentation. He compared the two resurfacing methods in terms of cost, quality, and quantity.

Cost

“The bottom line,” stated Mahoney, a professor of civil engineering at the University of Washington, “is there’s not enough money to preserve the system.” He estimated the true cost to adequately maintain Washington State’s roads at about \$10,000 per lane mile per year—but said the amount currently spent is around \$7,000. And since an overlay costs roughly 10 times what a chip seal costs, he focused his attention on the possibility of increasing the use of chip seal. But he cautioned that, overall, the best way to reduce the cost of pavement preservation is to increase the quality of the work. “That requires a lot of monitoring,” he said, but concluded it pays off by extending the life of the treatment, thereby saving money in the long run.

Quality

Mahoney challenged the widely held belief that chip seal produces a rougher surface than hot mix. In a study of the roughness of pavements of varying ages in Washington State, he found that chip seal pavements were “a little rougher but not much.” This is one reason he recommended chip seal for those who need to stretch their budgets. He added that the smoothness of the ride can often be increased by using a “level-up” solution: laying down a thin layer of finely graded hot mix before applying the chip seal.

Quantity

Mahoney acknowledged the two major problems with chip seal: First, it has a limited lifespan—typically 5 to 9 years compared with up to 15 years for an overlay—but he added that this is balanced by lower cost. The second problem is chip seal’s traffic limit. He reported the results of a recent study using a software program called HDM-4, which combines economic, material, structural, and condition factors. “As we guessed, routes with an AADT of less than 2,000 were completely viable for chip seal.” But he went on to say that 2,000 should not be considered the upper limit. He recommended the use of chip seal with traffic up to 4,000 AADT—and said a new Washington State standard allows its use up 5,000 AADT.

Mahoney concluded by advocating alternation between the use of chip seal and overlay as a way of extending pavement lifespan while contributing to a greater standard of ride quality. But he also cautioned that whenever we save money on pavement preservation, we “shift the cost to users through roughness.”

Russian Visit

Roger Olson, Minnesota Department of Transportation

As part of Minnesota’s ongoing relationship with one of Russia’s upper regions, state transportation officials visited the nation in summer 2007.

Minnesota’s “twinning” program is one of four that the Federal Highway Administration (FHWA) developed to establish relationships between the DOTs of four U.S. states and four Russian regional highway administrations to facilitate technology transfer.

In July 2007, two delegates from Mn/DOT, Gennadiy Begelman from Innovative Contracting and Roger Olson from the Office of Materials, along with Goodhue County Engineer Greg Isakson, traveled to the City of Yoshkar-Ola in the Mariy El Region of Russia for a week. The city is about 450 miles east of Moscow.

The Minnesota representatives exchanged research on highway administration and road issues, with an emphasis on recycling and reclaiming bituminous highways. Russian representatives gave tours of active bridge, road reconstruction, and bituminous milling projects.

According to the Mn/DOT trip report, the Mariy El Highway Administration is facing many of the same issues as Mn/DOT and Goodhue County, but to a greater extent because of the condition of its roads. Despite the difficulties facing the Russians, they found a few different ways to fix their roads.

The Mariy El Highway Administration has a different relationship with its contractors because contractors have some responsibility, and more long-term interest, in the roads after construction is completed.

“The Russians also use different bidding procedures and we may be able to use some of their procedures to get a ‘best value’ contract versus the lowest bid (and occasionally the lowest quality) contracts,” according to the Mn/DOT report.

The Russians are also utilizing other design mixes that could be useful on Minnesota roads. They are currently using a stone matrix asphalt (SMA) design mix. SMA is used in Europe but hasn’t been widely adopted in the United States.

Minnesota delegates also introduced the city to many state resources and products, including 3M, ADDCO, and RailMate.



A cold in-place recycling machine in Russia. From left: Jim Walton (RoadTec representative), Greg Isakson, Igor Starigin (host, MariyskAvtodor), Roger Olson, and Gennadiy Begelman

Concurrent Sessions

Pavement Reclamation

Moderator: Art Bolland, Minnesota Department of Transportation

Pavement Rehabilitation 101

Dave Miller, ROADTEC, Inc.

“Reclaimed asphalt pavement is a gold mine,” Dave Miller declared. The aggregate is originally mined in a rock quarry and eventually mixed with several different products. Then AC binder from crude oil is added. “These two products keep getting more expensive,” he said. “When you mill, you can recapture 100 percent of aggregate and oil at today’s prices.”

In that RAP pile, Miller continued, the aggregate is already sized. “All you need to do to get it back is crush it again, use a high frequency screen, and you can produce the same clean aggregate coated with AC binder.” One way to look at it: 30,000 tons of RAP equals 28,000 tons of clean aggregate.

Miller described systems used for reclaiming pavements and gave examples of their use and benefits. “For whatever you budget today to do asphalt paving, you could take the same dollars and do 50 percent more by using cold in-place recycling,” he said, as one example.

Miller also stressed the benefits of smoother roads. A 50 percent reduction in initial roughness increases asphalt service life 27 percent. Improving smoothness by 10 percent improves gas mileage by about 4 percent for all vehicles, whereas higher roughness increases vehicle repair costs. Smoother roads are also safer, with no sudden braking or lane changes to avoid bumps. In addition, smoother roads improve mobility and traffic flow. “There is an incredible incentive to build a smoother road,” he concluded.

FDR/CIR: A County’s Experience

Darrell Pettis, LeSeur County

Darrell Pettis reported the county’s plans for several summer projects that will use full-depth recycling (FDR) or cold in-place recycling (CIR). He also reviewed a number of completed CIR projects in the county. Some CIR positives: it allows projects to be constructed under traffic, reduces/delays reflective cracking, and can be used to make spot grade repairs. On the negative side, an adequate aggregate base of at least 6 inches is needed, it’s more expensive than basic overlay or mill and overlay, and soft subgrades are a problem.

The average cost of CIR and overlay is about \$250,000 per mile. With the county’s budget, that means pavements would be treated every 29 years. “I don’t think they will last that long,” Pettis said.

Selecting the Right Fix: Overlays, FDR, CIR

Gene Skok, Department of Civil Engineering, University of Minnesota

Gene Skok described a project he and Shongtao Dai of Mn/DOT led with funding from the Minnesota Local Road Research Board (LRRB). The objective was to lay out best practices for the selection of asphalt concrete recycling techniques: full-depth reclamation (FDR), cold in-place recycling (CIR), and mill and overlay (M&O).

For the project, the research team conducted interviews, surveys, and site visits at Mn/DOT districts and counties to obtain relevant rehabilitation information on more than 120 projects. A database was constructed to organize the details of these projects including the following

parameters: cracking, ride, rutting, age, and traffic volume. From studying the existing rehabilitation projects in the state, Ride Quality Index (RQI) and Surface Rating (SR) were selected as the descriptors of pavement surface condition.

The researchers then developed a decision procedure based on the analysis of all available projects. The decision procedure included (1) consideration of road geometrics; (2) pavement condition survey; and (3) structural adequacy evaluation. Furthermore, they developed a step-by-step checklist to provide local engineers with a simple and useful tool to follow the decision procedures. The checklist includes selection of rehabilitation method, pavement thickness design, materials mixture design, and construction.

The report, *Mn Pavement Rehabilitation Best Practices* (2008-06), is available on the LRRB Web site: www.lrrb.org.

Sustainable Innovations in Concrete Pavements

Moderator: Doug Schwartz, Minnesota Department of Transportation

Performance of Concrete Pavements Constructed Using Recycled Concrete Aggregate—FHWA Study Update

Mark B. Snyder, Geotech Innovations

The long-term performance of projects involving recycled concrete aggregate (RCA) has been mixed, said Mark Snyder, an independent pavement-engineering consultant from Bridgeville, Pennsylvania. He reported on his work in a 2006 FHWA-sponsored project titled “RCA Concrete Pavement Survey Outreach” through the University of New Hampshire’s Recycled Materials Resource Center. The project produced a more long-term assessment of test sections first surveyed in the 1990s. The sections studied included jointed plain, jointed reinforced, and continuously reinforced concrete pavements.

Table 1: Comparison of two sections of I-94 near Brandon, Minn.

Performance Measure	Value	Section MN 1-1 RCA	Section MN 1-2 No RCA
Transverse joint spalling	% of joints	76	54
Transverse cracking	% of slabs	31	0
Deteriorated transverse cracks	Cracks/km	35	0
Total transverse cracks	Cracks/km	38	0

Most common failure modes

Snyder said the most common failure modes in pavements with RCA are deteriorated mid-panel cracks and loss of load transfer. His group conducted a literature search and performed an array of field evaluations and laboratory testing with the following goals:

- Determine the causes of these problems.
- Develop guidelines for concrete mix designs that include RCA.
- Identify pavement designs that work with RCA.

Appropriate to a presentation in Minnesota, Snyder focused mostly on pavement sections in the Upper Midwest. For example, he showed the results for a pair of 18-year-old sections of I-94 in northwestern Minnesota near Brandon—one with RCA and a control with no RCA. The RCA section has 77% mortar content, while the section without RCA has 66% mortar content; other

RCA and non-RCA pavements in the study had similar percentages. Snyder reported that, predictably, higher mortar content often yielded a somewhat higher coefficient of thermal expansion and contraction. Though in 1994 both of these sections had been assessed as performing well, the RCA section had significantly greater distress when it was re-evaluated in 2006, as shown in Table 1.

Also, though testing on the two sections in 1994 produced relatively similar results, 2006 tests showed that the RCA section had consistently lower—though adequate—strength. Other Minnesota RCA sections evaluated in the 2006 study showed similar results: more distress and decreased (but adequate) strength compared with the non-RCA sections. However, sections that had been rehabilitated (mostly via retrofitted dowel bars, crack repair, and joint repair) were doing about as well as non-RCA sections.

Mix-design and structural-design guidelines

So what are the critical factors in the deterioration of RCA pavements? Snyder pointed to issues related to both mix design and structural design.

On the mix-design side, he said RCA sections performed equal to or better than control sections when the water-cement ratio was reduced in the recycled mix. He also mentioned that, in one case, concrete that had experienced significant alkali-silica reactivity (ASR) was used as recycled concrete. In that project (in Wyoming), the contractor used Class F fly-ash as an ASR mitigator and there has been almost no recurrence of ASR distress.

On the structural design side, Snyder said panel length appears to be a major factor. Since high mortar content yields greater shrinkage (due to increased coefficient of linear expansion and less natural aggregate for restraint), shorter panels produce fewer cracks. He recommended panel lengths of approximately 15 feet (perhaps shorter on stabilized bases), showing that panels more than 18 feet long were more prone to cracking.

He also noted that controlling the process of crushing the recycled product can help to improve the resulting RCA pavement. He noted that impact crushing removes more mortar from the aggregate, making it perform more like natural aggregate; the removed mortar can then be used as fines or as backfill in other applications.

In summation, Snyder said any problems related directly to the physical properties of the mortar can be controlled by treating RCA as an engineered material.

Diamond Grinding for Quiet Pavements

Bernard Izevbekhai, Mn/DOT, and Terry Kramer, Diamond Surfaces, Inc.

A project studying ways to rehabilitate portland cement concrete (PCC) pavements without the need to restore structural capacity moved to the MnROAD mainline in October 2007 with the help of project partner Diamond Surfaces, Inc. Diamond Surfaces, based in Maple Grove, Minnesota, donated grinding services to cut test patterns into two 500-foot cells, each consisting of two 12-foot-wide lanes of the 3.5-mile mainline segment carrying “live” interstate traffic.

Project manager Bernard Izevbekhai, the concrete research operations engineer with Mn/DOT’s Office of Materials, said the research project is funded at \$275,000 over five years. It is led by the Minnesota Department of Transportation (Mn/DOT) in partnership with the Texas Department of Transportation (TxDOT), the Federal Highway Administration (FHWA), and the American Concrete Paving Association (ACPA).

Diamond grinding is one way researchers have found to rehabilitate existing PCC pavements to make them quieter without sacrificing friction. The grinding process removes much of the pavement roughness and restores texture and friction. This portion of the project studying the rehabilitation of PCC surface characteristics aims to validate an innovative one-pass diamond-ground configuration developed over two years at a Purdue University laboratory. The innovative grind pattern is being used in MnROAD mainline Cell 7, while a conventional grind pattern is being used in mainline Cell 8 for comparison. MnROAD’s low-volume road (Cell 37) was used as

an initial test bed for three 18-inch grinding patterns (traditional, innovative one-pass, innovative two-pass), which were monitored before the two mainline test cells were ground.

In particular, researchers are studying details in the grinding operation, such as blade spacing, depth of cut, and kerf (width between cut) configuration. Research findings will enable transportation agencies to set standard specifications for diamond grinding that optimizes ride quality, quietness, safety against hydroplaning and splash/spray, and concrete durability. The development of the one-pass innovative grind is important, too, because it saves time for grinding contractors, often required to make the more expensive multiple passes.

“The parameters here are so sensitive,” Izevbekhai explained, describing specifications measured in fractions of a millimeter. The state standard for the surface texture on new roads is 1.0 mm. Texture, when combined with suction, helps create the friction with tires necessary to keep a vehicle on the road, especially in wet conditions. Typically, road surface texture, which ranges from 0.7 mm to 1.5 mm, lasts 20 to 35 years, but roads generally deteriorate before then. The October mainline diamond grinding produced a surface texture of 1.52 mm in one fresh spot measurement, which Izevbekhai assessed as “very good.”

Izevbekhai also explained that the innovative diamond grind lowered tire-pavement noise by 4 decibels (or 67 percent), adding that a 3-decibel decrease equals the sound of about 50 percent less traffic. At highway speeds, tire pavement noise is the dominant noise source, exceeding aerodynamic and power train noise. Current research at MnROAD indicates that concrete road surfaces get quieter as the texture wears, while asphalt roads, which are quieter than concrete roads when fresh, get noisier as the pavement stiffens and deteriorates.

(Revised and reprinted from the TERRA E-News, January 2008.)

Local Pervious Pavement Experiences: Design, Build, Operate, Maintain

Kevin MacDonald, Cemstone

Storm water runoff from impervious surfaces can affect streams, lakes, and wetlands. To reduce this problem, some communities in Minnesota are looking at the use of pervious pavements, which allow some infiltration.

Porous concrete has the same components—portland cement, water, aggregate—as dense concrete, said Kevin MacDonald. But the aggregate is single-sized (no. 89 is common) with no sand or fines to fill voids.

In addition to its environmental benefits, pervious pavement can reduce cost, MacDonald said. Unlike dense pavement, which needs a downstream appendage for drainage, porous pavement provides a built-in solution.

The hydrologic and structural success of porous concrete depends on correct selection, design, installation, and maintenance. Failures—clogging and structural degradation—result from neglecting one or more of these steps, he said.

The understanding of the performance of pervious concrete in northern climates is still limited. A project under way at the MnROAD facility (with the Aggregate & Ready Mix Association of Minnesota) is investigating a number of questions, such as whether freeze-thaw cycles will result in pavement deterioration or frost heaving. The pavement was placed in September 2005.

MacDonald also reviewed some current pervious concrete projects in the state, including one located in Minneapolis at 10th Avenue South and Lake Street that was placed in October of 2006.

Geotech Innovations

Moderator: Glenn Engstrom, Minnesota Department of Transportation

Analysis of LWD In-situ Stress and Strain

Patrick K. Miller, Olson Engineering Instruments

Patrick K. Miller described findings from a research project that analyzed light-weight deflectometry (LWD). The project's main objective was to use in-situ sensors to measure LWD-induced stress and strain levels. This included characterizing stress and strain state under LWD loading, comparing the secant modulus from in-situ stress and strain data to the modulus value given by the current analysis method, and characterizing the "influence depth" of the LWD.

Miller reported three main conclusions:

- Contact stress between the soil and LWD is dependent on the soil type and the level of loading.
- Strain decreased much more rapidly than stress with depth.
- The secant modulus values calculated from the in-situ stress and strain data did not compare well with values obtained from the LWD

LWD Fundamentals

Rebecca Embacher, Minnesota Department of Transportation

Rebecca Embacher discussed the fundamentals of light-weight deflectometry (LWD). LWD is a plate-bearing test that measures vertical motion (deflection). The peak deflection and estimated elastic modulus are recorded.

Uniformity is the priority in testing for compaction, she said. Traditional testing used empirical design based on trial and error. Mechanistic design is based on stiffness measured by tools such as LWD.

Mechanistic field tests help achieve agreement between construction quality assurance and pavement design, Embacher said. They also help quantify alternative materials and innovative construction practices, and show the economic benefit of improved materials in terms of longer pavement life.

LWD is quick and easy, Embacher said, and makes contractors more aware of what is needed for acceptance. It gives a better understanding of water content and processes, and improves uniformity. It is not really "light" weight, however, and can be a two-person job. Other concerns are that the water table can be drawn up and affect results, and the LWD will move if sand is too wet and sloped.

For more information, see the Web site of Mn/DOT's Grading and Base Unit: www.mrr.dot.state.mn.us/pavement/GradingandBase/gradingandbase.asp.

Green Transportation

Moderator: Curt Turgeon, Minnesota Department of Transportation

Green Roads

Joe Mahoney, Department of Civil Engineering, University of Washington

Joe Mahoney provided an overview of "Green Roads," a proposed rating system being developed by the University of Washington and CH2M Hill to improve the sustainability of our roadway design and construction practices.

Road-building: the hungry consumer

Mahoney began by laying out the problem, which is that our current road-building and road-use practices are primary sources of environmental degradation. For example, he used the statistics in Table 2 to dramatize just how much material we consume every year in road construction.

Mahoney then went on to show that our transportation activity, much of which obviously involves road use, accounts for about 29% of the energy consumed in the United States. He also cited statistics from the California Integrated Waste Management Board showing that waste from all forms of construction, including road building and maintenance, accounts for between 20% and 40% of the municipal waste stream.

Mahoney’s conclusion was that by focusing on our road-building practices, we can contribute significantly to solving the world’s environmental problems. Our goal, he said, should be sustainability, which he defined as “maintaining economic prosperity and a high quality of life for all while protecting the natural systems of the planet.”

Table 2: Annual Material Use in U.S. Road Construction

Material Type	Annual U.S. Use (millions of tons)	Annual Cost (billions of dollars)
Individual Materials		
Virgin Aggregate	1,300	10
Asphalt	40	13
Portland Cement	10	1
Hot-Mix Asphalt	600	36
Portland Cement Concrete	60	6

(Numbers come from USGS, NAPA, and PCA)

Aren’t we already recycling?

Like Newcomb, Mahoney acknowledged and praised pavement recycling as an environmentally responsible practice. He showed that the combined amount of recycled HMA and PCC from pavements in Washington State has quintupled since 2000. While that sounds impressive, he also pointed out that the United States still derives only 6% of its aggregate from recycled sources; 94% is virgin material. He challenged the road-building community to do better. For example, he urged us to get more value from recycled material by putting it into a road’s surface rather than into its base.

Green Roads: A roadway sustainability rating system

Another part of the solution, Mahoney predicted, will be the Green Roads initiative, which has been developed and promoted in Washington State by Steve Muench, also a professor at the University of Washington. The Green Roads initiative is a systematic way to rate the sustainability of roadway design and construction—in other words, said Mahoney, a way to quantify sustainability.

The Green Roads system is patterned after the highly successful LEED (Leadership in Energy and Environmental Design) rating system, which is administered by the U.S. Green Building Council

Table 3: Green Roads Credit System

Category	Goal	Maximum Possible Credits
Sustainable Design	Reduce impacts due to design choices including the road alignment.	10
Material & Resources	Reduce impacts from material extraction, processing, and transport.	11
Storm Water Management	Reduce impacts of polluted storm water and treatment devices.	8
Energy & Environmental Control	Improve human and wildlife health.	12
Construction Activities	Reduce impacts from construction activities.	9
Innovation	Encourage innovation in design.	4
Total:		54

(USGBC). Since 1998, USGBC inspectors have certified more than 800 new and rehabilitated buildings throughout the U.S. In the LEED program, buildings are certified at four levels: certified, silver, gold, and platinum. To achieve these levels, building designers and builders can apply for certification by designing for energy efficiency, designing building components that can be re-used rather than discarded, choosing recycled materials, employing energy-efficient construction methods, and reducing construction waste.

Mahoney presented the information in Table 3, which outlines a similar credit system for the proposed Green Roads program.

Mahoney also provided a more detailed view of the categories. For example, Table 4 shows a breakdown of the Materials & Resources category.

The promoters of the Green Roads system hope to gain support throughout the pavement industry. For more information, go to www.greenroads.us.

Table 4: Materials & Resources Category

Description	Maximum Possible Credits
Construction waste management	1
Re-use of pavement	2
Recycled content	4
Pavement lifecycle analysis	3
Regionally provided material	1
Total credits available:	11

Making Greenways Greener: Developing a Sustainable Trail in Ramsey County

Victoria Reinhardt and Bridget Beck, Ramsey County

When neighbors said they wanted a hiking and biking trail on the south edge of Ramsey County's Battle Creek Regional Park, state, county, and local officials went to bat for them. The Lower Afton Trail was completed in November 2007. Ramsey County Commissioner Victoria Reinhardt and Ramsey County staffer Bridget Beck, two of the project leaders, described the project at the conference.

Reinhardt said that nationally 20% of all landfill is material from building demolition and 91% of that is roofing shingles. With these statistics in view, Ramsey County's project managers decided early on that the Lower Afton Trail would be as "green" as possible. The project includes recycled materials in retaining walls, pavers, benches, and the trail base. In addition, several rain gardens that naturally filter run-off contain recycled sand.

The project's centerpiece—the asphalt surface of the trail itself—contains recycled asphalt shingles. Roger Olson of Mn/DOT's Office of Materials, who produced the mix design, specified Superpave PG 58-28 as the binder for the wearing course with 5% of the asphalt to be derived from recycled asphalt shingles.

The specification for the shingles stated that all contaminants, including metal, plastic, wood, and glass, must constitute less than 0.5% of the finished material. The shingles came from a residential reroofing project in Elk River, Minnesota. The roofing contractor and the hauler sorted the material twice—once on the job site and again at the hauler's depot—before delivering them to Omann Brothers Contracting, of St. Michael, Minnesota. By sorting, screening, and grinding, Omann Brothers removed 100% of the metallic material (mostly roofing nails) and produced a clean product. Though the specification stated that the shingles were to be ground to ½-inch-minus size, Omann Brothers actually produced them at 7/16-inch-minus size. That material was then provided to Midwest Asphalt Corporation of Hopkins, Minnesota, which produced the hot-mix and constructed the pavement.

Ramsey County's Bridget Beck said the amount of monetary savings to be realized by using shingles in pavement is yet to be determined. However, Midwest Asphalt stated that, in this project, it saved on the cost of the binder material.

Warm-Mix Asphalt

Dave Newcomb, National Asphalt Pavement Association

As an industry, we already have moved toward environmental responsibility by recycling asphalt, said Dave Newcomb of the National Asphalt Pavement Association. But we can do more, he said, by paying attention to the temperature of asphalt mixes. By reducing temperature, we will decrease both our fuel usage and emissions. Furthermore, he pointed out that lower temperatures will benefit the industry by providing:

- Earlier start dates
- Earlier start times
- Longer haul distances when needed
- Cooler working conditions
- Reduced plant wear
- Decreased binder aging
- Improved compaction with stiff mixes

Although Europeans had a head start on the technology, the United States has rapidly gained ground with 10 warm-mix technologies currently available and more in development. As a signatory to the Kyoto Accord, a treaty whereby countries have agreed to reduce their greenhouse gas emissions, the European Union was compelled to look for ways to reduce emissions in many ways—including in its paving methods. By the year 2000, the EU had introduced new paving strategies, including warm-mix asphalt (WMA), which Newcomb defined as mixes produced and placed between 200° and 275° F. He said at least 72 WMA field trials have now been conducted in the United States.

“High temperatures are brought on by polymer-modified binders,” Newcomb said. He went on to discuss several strategies for reducing temperature while maintaining acceptable physical properties. One of these is to reduce viscosity by use of an additive.

Figures 1 and 2 illustrate a project that evaluated one such additive: Advera®, a zeolite product manufactured by PQ Corporation. The zeolite releases a small amount of steam into the mix during production. Figure 1 shows a control project in which conventional HMA was placed at 320° F. Figure 2 shows WMA with Advera being placed at 245° F. The difference in emissions is obvious in the photographs.

Another successful technique is to achieve lower viscosity by mechanically foaming the asphalt.



Figure 1: Conventional asphalt mix placed at 320° F.



Figure 2: Asphalt with Advera additive placed at 245° F.

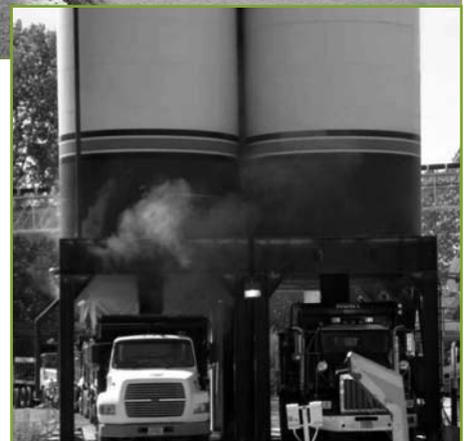


Figure 3: Truck at right is being loaded via ASTEC's Double Barrel Green process, in which water is introduced into the asphalt mix to decrease viscosity.

One example is ASTEC's Double Barrel Green process that introduces water into the mix at the plant. Figure 3 illustrates the difference in visible emissions between a conventional mix on the left and the Double Barrel Green process on the right. This particular mix contained 50 percent RAP.

The Double Barrel Green process reduces smoke and odor because the lighter oils in the liquid asphalt are not volatilized.

But an obvious question is: How do WMA's perform? To answer that question, Newcomb provided preliminary data from a research project on I-70 in Colorado in which WMA was compared side-by-side with conventional HMA. Results showed that the WMA had about the same optimum asphalt content, reduced air voids in field-produced mixes, comparable tensile strength, and generally favorable rutting characteristics.

Newcomb recommended the following practices with WMA:

- Work to minimize aggregate moisture through proper handling and stockpiling practices.
- Make sure the burner is tuned for the temperature.
- Keep baghouse temperature above the condensation point.
- Consider superheating aggregate ahead of RAP addition.
- Follow normal placement practices.

For more information on warm-mix asphalt techniques, go to the Web site of the WMA Technical Working Group: warmmixasphalt.com. The group is cosponsored by multiple agencies, organizations, and companies. Newcomb also announced a NAPA publication titled *Warm Mix Asphalt: Best Practices* and an international WMA conference to be held November 11–13, 2008, in Nashville, Tennessee.

Trunk Highway 36

Moderator: Gene Skok, Department Civil Engineering, University of Minnesota

Three Minnesota Department of Transportation (Mn/DOT) officials discussed several innovations used during the reconstruction of Minnesota Trunk Highway 36 through North St. Paul in 2007. Chris Roy, Mn/DOT metro district north area manager, spoke about the T.H. 36 project development and full road closure. Steve Adamsky, Mn/DOT project engineer in charge of the reconstruction, gave an overview of the construction and project innovations. Tom Ravn, Mn/DOT acting state construction engineer, talked about innovative contracting and FHWA Highways for LIFE (HFL), which helped fund the project with a grant.

The reconstruction project is especially noted for its use of complete closure and intelligent compaction. It was also the first HFL demonstration project in the country. HFL is a \$75 million federal funding program created by Congress in 2005 to develop new and innovative techniques to build better pavements and bridges faster, safer, and more efficiently while reducing congestion caused by construction.

In addition to complete closure and intelligent compaction, Adamsky and Ravn also provided details about several other innovations used on the job: A+B bidding, locked-date incentive, lane rental, stakeless surveying, improved job safety, smoother pavement requirements, no top lift of pavement in the first year, and materials recycling. For instance, a lot of the old road was crushed on-site and reclaimed for use as granular material, and trees in the construction area were either replanted or shredded on-site to line truck entrances and filter water.

The \$27 million project, which grew out of a project to build a pedestrian bridge over the busy Highway 36 bisecting the North St. Paul community, drew funding from 12 different sources at various levels of government.

The complete closure of Highway 36 was expected to cause a major traffic problem in the east metro and cut off local businesses, but instead produced results to the contrary. "It was one of the biggest non-events of the year," according to Mn/DOT's Roy, discussing the full-road closure used to accelerate the construction process. "In the right circumstances, full-road closure can be a very useful tool."

The highway, which closed to all traffic May 1, partially reopened to traffic in August with

the majority of the construction completed by late October and at an estimated 15 percent under budget. The project, which could have taken more than two years using traditional methods, eliminated six heavily used at-grade crossings needed to access the northern side of the small city. In addition, tons of earth and material were moved, a 25-foot-deep cut made, five detention ponds were created, and 3,900 feet of retaining walls were constructed.

Mn/DOT has funded a study of the full closure by University of Minnesota researchers John Hourdos, director of the Minnesota Traffic Observatory (MTO), and Professor Gary Davis of the Department of Civil Engineering. Full closure is a relatively new strategy for addressing present-day transportation network needs in Minnesota. Their analysis includes an evaluation of all traffic operation alternatives in the greater project area, a cost/benefit comparison with other construction alternatives, market research to identify the public's acceptance of the project during and after completion, and identification of lessons learned. The final product will be a guide for other projects considering full-road closure as a construction alternative.

Related resources: Mn/DOT's Highway 36 in North St. Paul project page (www.dot.state.mn.us/metro/projects/th36); FHWA Highways for LIFE (www.fhwa.dot.gov/hfl)

Under the Road

Moderator: Maureen Jensen, Minnesota Department of Transportation

Subsurface Drainage Manual for Pavements

John Nieber, Department of Biosystems, University of Minnesota

Well-drained base courses and subgrades improve pavement quality—they increase subgrade strength, decrease deflection drastically, and lower the opportunity for fines pumping, said John Nieber. All this means pavements last longer, saving money. More detailed information is needed, however, to help with the design process.

To help fill this need, the Minnesota Local Road Research Board (LRRB) sponsored a project to develop a subsurface drainage manual for pavements.

The manual will include the following:

- Guidelines for when subsurface drainage is needed
- Components of subsurface drainage systems
- Design tools
- Installation practices (excavating, laying drains, backfill, drain outlets, turf establishment, marking outlet locations, inspection and cleanout)
- Maintenance
- Sample applications

The manual will include guidelines for site evaluation and a method for estimating hydraulic load. It will explain how to evaluate the time required to desaturate the base, determine the grade for the drain, size the drain, and design the granular filter materials. It will also describe systems such as longitudinal edge drains, longitudinal centerline drains, transverse drains (for very steep roadways), and ditch drains. Other topics will include pipe drains, geocomposite drains, French drains, optional permeable base materials, geofabrics, trench filler material, and drain outlet structures.

The project began with a summary-of-practice survey sent to practitioners around the state, including city, county, Mn/DOT, and consultant representatives. Sixty-five percent indicated that drainage system maintenance was not a high priority. "I argue it is a very important activity," Nieber said.

Common maintenance problems are growth around pipe outlets, rodents' nests, mowing clippings, sediment on rodent droppings, and collapse of tile drains. Nieber recommended marking drain outlets with paint or recording their locations with Geographic Positioning Systems (GPS). He also urged routine inspection and preventive maintenance, good record keeping, spot detection and repair, and continued monitoring and feedback.

Electrical Resistivity Imaging in Minnesota

Jason Richter, Minnesota Department of Transportation

Jason Richter described a new approach for site scoping. With electrical resistivity imaging, an electric current is injected into the ground, and the electrical response is measured. “This gives an idea of the resistivity property in the earth, to get a sense of what’s going on at depth,” he said. Ultimately, the tool can provide two- or three-dimensional resistivity profiles to help interpret the subsurface of a job site.

The tool is especially useful for sensitive sites or places where drilling rigs are unable to operate safely. A recent project in Duluth had both issues: It was near a DNR-designated trout stream, so impacts to the stream had to be avoided. The site also had overhead power lines, making it hard to get drill rigs underneath while avoiding electrocution, and the terrain was rugged and laden with boulders. Drilling was not possible at this site, so no information was going to be collected. “Thankfully,” Richter said, “we had just acquired this tool and used the new method to acquire profiles of the area. We obtained a very good data set, which affected the decision on what type of bridge structure to build.”

Subgrade Soil Stabilization

Jim Holland, Terex Roadbuilding

Jim Holland described stabilization methods: mechanical (adding granular material such as crushed aggregate and pulverized asphalt pavement); chemical (treatment with lime, cement, fly ash, or other additives); bituminous (adding asphalt emulsion or foamed asphalt); and bituminous plus chemical (foamed asphalt plus cement and other combinations).

Factors in selecting a stabilizer include the types of soil; lab testing results; availability and cost of stabilizers; availability of required equipment; dust problems (urban or rural site); pavement structural requirements; and expected performance.

Weather limits the use of chemical stabilization, Miller said. The air temperature in the shade cannot be less than 30° F, and rain cannot appear imminent. The soil cannot be frozen, and stabilization must be completed at least one month before a hard freeze.

Chemical stabilization does offer benefits, however. It allows use of and eliminates the need to remove unsuitable soils. No transport and placing of new materials is needed, and construction time can be reduced. Cost savings result when mixing in place.

The benefits of bituminous stabilization are very similar to those of chemical, Miller added, just using different kinds of additives.

