University of Minnesota
Center for Transportation Studies

LTAP
Minnesota Local Technical Assistance Program

Minnesota Department of Transportation

10th Annual Minnesota Pavement Conference: Session Summaries

February 16, 2006

Continuing Education and Conference Center
University of Minnesota St. Paul Campus

Conference Sponsors:

Minnesota Department of Transportation (Mn/DOT)
Minnesota Local Technical Assistance Program (LTAP)
Department of Civil Engineering, University of Minnesota
City Engineers Association of Minnesota
Minnesota County Engineers Association
Minnesota Street Superintendents Association
Minnesota Public Works Association
State Aid for Local Transportation
Minnesota Local Road Research Board (LRRB)
American Council of Engineering Companies of Minnesota
Transportation Engineering and Road Research Alliance (TERRA)

Hosted by:

Center for Transportation Studies, University of Minnesota

Facilitated by:

College of Continuing Education, University of Minnesota

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.

Conference Planning Committee

Art Bolland, Minnesota Department of Transportation
Glenn Engstrom, Minnesota Department of Transportation
Wayne Fingalson, Wright County, Engineering Department
Philip Forst, Federal Highway Administration
Mark Gieseke, Minnesota Department of Transportation
Lori Graven, College of Continuing Education, University of Minnesota
Jim Grothaus, Center for Transportation Studies/Minnesota LTAP, University of Minnesota
Mark Hanson, City of St. Louis Park, Department of Public Works
Dave Johnson, Minnesota Department of Transportation
Lev Khazanovich, Department of Civil Engineering, University of Minnesota
Dick Larson, Mille Lacs County, Engineering Department
Erland Lukanen, Pavement Research Institute, University of Minnesota
Mark Maloney, City of Shoreview, Engineering Department
Mihai Marasteanu, Department of Civil Engineering, University of Minnesota
Roger Olson, Minnesota Department of Transportation
Thomas Ravn, Minnesota Department of Transportation
Douglas Schwartz, Minnesota Department of Transportation
Mike Sheehan, Olmsted County, Engineering Department
Gene Skok, Department of Civil Engineering, University of Minnesota
Linda Taylor, Minnesota Department of Transportation
Curt Turgeon, Minnesota Department of Transportation
Dave VanDeusen, Minnesota Department of Transportation
Teresa Washington, College of Continuing Education, University of Minnesota

Production

Writing: Pamela Snopl, Richard Kronick, Michael McCarthy, Lisa Hartley
Editing: Pamela Snopl
Design: Cadie Wright

The Minnesota Local Technical Assistance Program is part of the Federal Highway Administration's Local Technical Assistance Program (LTAP). LTAP is a nationwide effort designed to foster and improve information exchange among local practitioners and state and national transportation agencies. Minnesota LTAP is administered by the Center for Transportation Studies at the University of Minnesota, and cosponsored by the Minnesota Local Road Research Board and the Minnesota Department of Transportation.

Minnesota LTAP
Center for Transportation Studies
University of Minnesota
200 Transportation and Safety Building
511 Washington Avenue S.E.
Minneapolis, MN 55455
Phone: 612-626-1077
Fax: 612-625-6381
E-mail: mnltap@umn.edu
Web: www.mnltap.umn.edu

Contents

Plenary Session

Concurrent Sessions

Annual Pavement Conference Award

Pat Hughes (right) accepts the 2006 Minnesota Pavement Conference Award from Wayne Fingalson, last year's winner. Hughes's long career at Mn/DOT included positions as assistant commissioner and director of the Office of Minnesota Road Research.

Plenary Session

Moderator: Dave Johnson, Minnesota Department of Transportation

Welcome

Doug Differt, Minnesota Department of Transportation

In his welcome to the conference, Mn/DOT deputy commissioner Doug Differt reviewed the past year's accomplishments and touched on upcoming initiatives, including plans for MnROAD. The governance structure that oversees MnROAD—the Transportation Engineering Road Research Alliance, or TERRA—is working to expand utilization of the facility and attract additional partners. New partners of late include Iowa, Michigan, and Norway. "MnROAD is a national treasure right here in Minnesota," he said. "We're making national headlines with it."

Differt also reviewed the budget outlook and advised audience members to pay attention to a state constitutional amendment on the ballot this fall. Voters will have an opportunity to dedicate all of Minnesota's motor-vehicle sales-tax revenue to highways and transit by voting YES on November 7 to the proposed amendment.

MnROAD Impacts

Derek Tompkins, Department of Civil Engineering, University of Minnesota

The Minnesota Road Research Project—the world's most advanced cold-climate pavement research center—is nearly a teenager. Known as MnROAD, the center was opened to traffic in 1994. Since then, it has contributed significantly to pavement design and construction in Minnesota and many other parts of our nation and the world.

Located near Albertville, Minnesota, MnROAD has two components. The "mainline" section is a 3.5-mile segment of Interstate Highway 94 composed of heavily instrumented asphalt- and portland concrete-surfaced pavement "cells." As part of an interstate highway, the mainline section receives live high-volume loading. The second component, which is adjacent to the mainline, is just as heavily instrumented. But its character is completely different. It is a 2.5-mile closed loop composed of asphalt-, PCC-, and aggregate-surfaced segments. The loop simulates low-volume roads and receives loading from just one calibrated truck that traverses it continuously.

In a presentation at the pavement conference, Derek Tompkins, a civil engineering graduate student at the University of Minnesota, reviewed some of MnROAD's most significant contributions to pavement engineering and discussed the research program's near-term future. Following are highlights of his presentation.

Mechanical-empirical pavement design

Since MnROAD arrived on the scene in the early nineties when the idea of mechanistic-empirical (M-E) pavement design was relatively new, it is not surprising that validation and development of M-E design models was one of the research center's first stated objectives. As a direct result of many M-E studies using MnROAD data, Mn/DOT created its free down-loadable software, MnPAVE, which allows computer-based M-E pavement design (software available at www.mrr.dot.state.mn.us/research/mnpave/mnpave.asp). M-E models such as MnPAVE are more sophisticated than so-called empirical models. The latter take into account only historically observed performance from a limited number of locations, whereas M-E models include factors for theoretical behavior, local conditions, and increases in loading over time.

Savings from soil moisture data

Taking advantage of MnROAD's tremendous data gathering and analysis capabilities, important research has been conducted on how the moisture content of base and subgrade soils affects soil strength. This research has been done in collaboration with the U.S. Army Cold Regions

Research and Engineering Laboratory and the University of Minnesota's Department of Soil, Water, and Climate, among others. One important result is that Minnesota city and county agencies can include localized climate and soil characteristics to refine their MnPAVE calculations. A related group of studies showed that sealing of pavement edge joints can decrease moisture absorption and retention in soils under pavements by up to 85 percent. The moisture retention information also has been incorporated into the MnPAVE software and is likely to be reflected in a future Mn/DOT specification.

Furthermore, soil moisture data also is currently being used by local officials all over Minnesota to refine their spring load restriction postings. MnROAD officials estimate that this data helps to increase the life spans of some local roads by up to ten percent and is therefore saving Minnesota's local agencies about $14 million annually.

Whitetopping: an effective pavement rehabilitation

Another important result of MnROAD research has been refinement of the practice called ultra-thin whitetopping (UTW)—that is, overlaying asphalt pavement with a thin layer of fiber-reinforced concrete that is bonded to the asphalt. Beginning in 1997, several MnROAD sections on I-94 were whitetopped with excellent results. As a direct result of this research, several states have done their own research with whitetopping. A current Mn/DOT objective is to validate the UTW design methods used at MnROAD, compare them with the experience of other researchers, and ultimately to write a national UTW design specification.

Dynamic cone penetrometer validation

A byproduct of the original construction of MnROAD's pavement sections has been the validation of the dynamic cone penetrometer (DCP) as an effective tool for measuring subsurface soil conditions and strength. An analysis of the more than 700 DCP tests conducted during MnROAD's construction showed that when soil has been properly compacted, DCP testing is a reliable indicator of soil strength. As a result, MnROAD engineers refined the design of the DCP apparatus and developed training materials for workers. Use of the DCP method was then incorporated into Mn/DOT's specification for pavement edge drain backfill and granular base compaction. The relatively inexpensive DCP apparatus is now used throughout the state.

Tangible and intangible results: international cooperation

If you build it ("it" being the world's premiere cold-climate pavement testing facility), they will come—and "they" have come from all over the U.S. and the world to take advantage of MnROAD's capabilities. In its first 13 years, the facility has hosted researchers representing the National Cooperative Highway Research Project, the U.S. Army Cold Regions Research and Engineering Laboratory, many state DOTs, private industry, and researchers from Manitoba and Finland. Tompkins reported that one important focus for visitors is the design of road test tracks themselves. MnROAD's extensive publications on instrumentation, design and construction, and data collection methods have proved invaluable to other test tracks. Furthermore, many people have brought their unique MnROAD experience with them when they have moved on to other agencies. On this intangible benefit, Tompkins quoted Roger Green, a research engineer at Ohio DOT: "The major impact [of MnROAD] is the number of young engineers from Mn/DOT and the University who have learned about pavement while working on projects at MnROAD and are now making an impact on the pavement community by training others."

Research on the drawing board

Tompkins closed by listing additional research studies that are likely to be conducted using existing MnROAD data:

- Base type study and distress/performance comparison
- Introduction of thinner PCC pavements as a result of M-E design verification, especially for low-volume roads
- Rational base thickness selection

- Overall comparison/analysis of test section performance and design
- Account for test cell responses during spring using spring load findings
- Seasonal effects on International Roughness Index
- Distribution of strains under loading
- Use knowledge of concrete thickness to further inform design

Using MnROAD data

To harvest some of MnROAD's bounty, go to: http://mnroad.dot.state.mn.us/research / mnroad_project/mnroadreports/mnroadreports.asp and http://search.state.mn.us/dot /query.html.

Concrete Pavements: Past Accomplishments and Future Directions

Tom Cackler, Iowa State University

In his presentation, Tom Cackler, director of the National Concrete Pavement Technology Center at Iowa State University, announced the recently published comprehensive, coordinated national research plan.

The *Road Map*, endorsed among others by Mn/DOT, FHWA, AASHTO, and the TRB, is in part a response to America's growing highway gridlock. Cackler said that while the number of lane miles in America is likely to remain approximately static through 2020, the number of vehicle-miles traveled in that year is expected to be about one-third higher than in 2006. He said traffic slow-down currently wastes 2.3 billion gallons of fuel a year.

Road Map research will focus on reducing the cost of building and maintaining our concrete pavements and on reducing environmental impact. Cackler said we can achieve both of these goals in part by increasing our use of recycled aggregate and supplementary cementatious materials such as fly ash, slag, and fumed silica.

The *Road Map* includes 250 problem statements within 12 research tracks. These establish objectives for mix design, materials improvement, roadway design, construction methods, pavement management, and business systems. The goal is to produce a comprehensive, nationally integrated, fully functional system of concrete pavement technology by 2015.

For details: www.cptechcenter.org.

Asphalt Pavements: Past Accomplishments and Future Directions

Dave Newcomb, National Asphalt Pavement Association

Dave Newcomb is familiar to many civil engineers in Minnesota because he was their professor at the University of Minnesota. Now the vice president of research and technology at the National Asphalt Pavement Association, he spoke about the past and future of asphalt paving.

Recycling to avoid oil importation

Newcomb began by summarizing past milestones in asphalt paving technology. He recalled that asphalt recycling was developed as a response to the oil embargo of 1974. He said recycling provided a consistent product—as good or better than that produced with virgin materials—and eliminated the cost of hauling material from an asphalt plant and then stockpiling it. Newcomb also said the "unsung hero" in recycling was the development of the milling machine.

Emphasis on quality

The Quality Control/Quality Assurance (QC/QA) movement of the mid-1980s was Newcomb's second asphalt paving milestone. By defining and tracking the consistency of critical mix properties, he said, QC/QA has shifted responsibility from agencies to contractors. In turn, this has allowed agencies to "do less about telling a contractor how to put a mix together and more about what you want at the end." This, Newcomb said, has shifted the emphasis away from price to where it ought to be: on quality.

Superpave: son of SHRP

Newcomb identified the "Superpave" specification, which appeared in 1993, as a third major milestone in asphalt paving. A product of the Strategic Highway Research Program (SHRP), Superpave introduced the idea of performance-graded (PG) binders, which include ratings for maximum and minimum service temperatures. Newcomb said this "gave us a more rational means of choosing an asphalt binder and was probably the most successful result of SHRP," though he added that Superpave had to be considerably refined in Minnesota and other states to make it work "in the real world." He reported that, in a national survey conducted in 2005 by NAPA and FHWA among agency and contractor pavement professionals, about twice as many agreed that Superpave has improved asphalt performance as disagreed. Newcomb said most people who like Superpave do so because its ability to target high-temperature performance has significantly reduced rutting.

Stone-matrix surface

The fourth and last major milestone identified by Newcomb was stone-matrix asphalt for surface mixes, which was developed in Europe and brought to the U.S. in the 1990s. This provided "a binder-rich stone skeleton mix that was resistant to rutting and had all the durability people would hope for in a surface mix…Today it's the premiere surface mix in the U.S. for asphalt pavements. For high-volume roads, it's…definitely a big benefit for us."

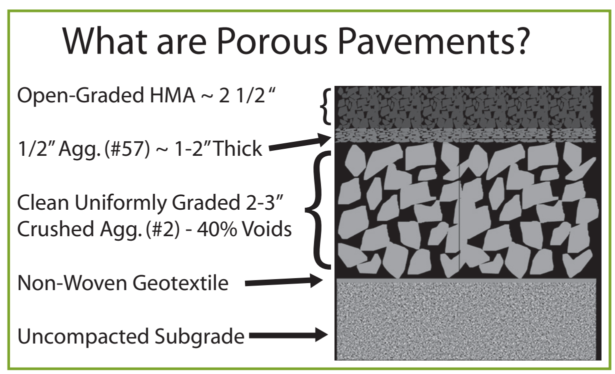
Next, Newcomb turned his attention to the future of asphalt pavements.

Pavement everlasting

He first addressed the idea of perpetual pavement: "How do we get around the issue of having to go in and completely reconstruct a pavement structure?" Answering his own question, Newcomb said, "You want to eliminate bottom-up fatigue cracking and structural rutting." Then he asserted that paving designs are often thicker than they need to be. "If you design for the weight of the trucks as opposed to the volume…you wind up with a more realistic pavement section than if you just keep increasing the thickness."

Porous pavement

Porous pavements for parking lots were Newcomb's next topic. As shown in the figure, a porous pavement is composed, from top to bottom, of open-grade HMA, small aggregate (a "choker course" that provides a stable paving platform), 2-to-3-inch aggregate with about 40 percent voids, and a non-woven geotextile—all placed over an uncompacted subgrade.



Though porous pavements have been around for about 20 years, Newcomb said they need to be considered more because of their environmental and cost implications. They eliminate the need for other forms of drainage, such as retention ponds and storm sewers. He cautioned, however, that porous pavement cannot be used where winter sanding and salting are employed, nor at the bottom of a slope where erosion would be washed onto the pavement.

Nip noise at the surface

Newcomb's next topic was noise pollution. He summarized a United Kingdom study showing that a highway noise reduction of 2 decibels produced a reduction of 25 percent in the number of people nearby who said they were annoyed by the noise. Instead of constructing expensive noise walls, Newcomb recommended two strategies for reducing noise at the source. First, incorporate voids in the pavement surface because voids absorb noise. Second, apply a fine-textured surface. "Surface texture is related to essentially the amount of coarse aggregate [used] and the maximum size of the aggregate." He discussed results of a New Jersey study showing that the quietest surface was a crumb rubber asphalt with fine aggregate. But he also pointed out that diamond-grinding a PCC pavement reduces noise considerably. "It's not a concrete-versus-asphalt type of issue." And a Purdue study showed that "for every one decibel you drop the noise, you can decrease the height of the sound walls by two feet. If you take into account how much it costs to build sound walls, two feet makes a lot of difference."

WMA: warm-mix asphalt

Newcomb then turned his attention to asphalt temperature. "For those of you who are paying gas bills, you can appreciate the need for reducing the energy consumption." He pointed out that reducing asphalt temperature reduces emissions and allows paving in cooler weather because material that starts out cooler loses less temperature during transporting and application. Furthermore, "warm-mix asphalt quality is the same as what we get with hot-mix asphalt."

Plant feedback loops

Building from his earlier remarks on QC/QA, Newcomb said another important strategy for the future is to improve feedback systems in asphalt plants. "The ability to constantly monitor gradation and moisture content will give contractors a better understanding of the variability in their operations." This, in turn, will allow producers to control in real time what they're putting into their mixes.

E-learning

Newcomb also stressed the need to improve asphalt paving by taking greater advantage of the Internet. He said NAPA has already developed two computerized training tools with the University of Washington: a Virtual Superpave Laboratory, "which is an interactive lab manual," and an online "hot-mix asphalt encyclopedia." But he said these are just the beginning. "We firmly believe…people are going to need [computerized] access to information about construction, mix design, and material selection."

Product acceptance—not ingredient control

Newcomb's last strategy for future improvement of asphalt pavement was product acceptance criteria. "If we're going to encourage innovation…we've got to have a system [that tracks] not so much the ingredients [but] performance." Several states already do this for rutting, he said, and the UK highway department's product acceptance system allows contractors to submit proprietary materials for evaluation. When these products have passed an approval process, they can then be specified in contracts.

Newcomb ended with the following advice: "Without innovation, the whole thing just sort of collapses…and in order to do that, the industry has to be proactive in encouraging research and education."

FHWA Pavement Initiatives

Mark Swanlund, Federal Highway Administration

Mark Swanlund of the Federal Highway Administration's Office of Pavement Technology provided an overview of FHWA's current pavement technology activities. He began by reviewing highlights of the 2005 highway bill (known as SAFETEA-LU). Congress has allocated about $22.625 million per year through 2009 for research and deployment of innovative pavement concepts. Key initiatives include:

Mn/DOT proposals for truck sizes and weights

• *80,000-pound gross-vehicle-weight (GVW) straight trucks* would be able to use all roads, including the Interstate and 10-ton network. In order to allow the full 80,000-pound limit, these trucks would be allowed up to 45 feet long, up from the current restriction of 40 feet.

• *90,000-pound GVW, six-axle trucks, 53-foot trailer*. By putting an extra axle under a standard truck, an extra 10,000 pounds could be loaded without doing extra damage to the road. This weight is not allowed on the Interstate system but it could be used on the 10,000 miles of state highways that are rated for 10-ton axle weights. The additional axle spreads weight out and reduces the stress on the pavement. With the extra axle and the addition of brakes on that axle, this configuration actually adds a better braking capacity per pound of weight.

• *97,000-pound GVW, seven-axle trucks, 53-foot trailer*. By adding another axle, the weight limit on a standard size truck could rise to 97,0000 pounds. This could also be used on the 10-ton Minnesota network.

• *108,000-pound GVW, eight-axle, twin trailers (28.5 feet each)*, is the same size as twin trailers used by express carriers on a preapproved system of about 5,000 miles of Interstate and other Minnesota roads. This proposed configuration would add three extra axles to handle the higher weights within the same size limits. It would also require an improved connection between the two trailers. It could be used on the Twin Trailer Network, except for the Interstate system. This configuration was approved by the 2005 legislature for the transport of lumber products from Grand Rapids to Duluth.

• Construction of a cold-in-place recycling project in South Dakota in 2006 ($1.5M)
• Research to prevent and mitigate alkali-silica reactivity ($2.45M / year through '06)
• Continued work at the Western Research Institute (WRI) to characterize the fundamenztalproperties of asphalt ($3.5M / year through 2009)
• Establishment of an asphalt research consortium with leadership from WRI ($7.5M / year through 2009)
• Support for the National Concrete Technology Center at Iowa State University ($10M over five years)

Swanlund then highlighted some of the FHWA's pavement technology activities, including:

• Implementation of Technical Advisory T 6120.3 on using contractor quality-assurance test results.
• Refinement and implementation of NCHRP's *Mechanistic-Empirical Pavement Design Guide,* published in 2004.
• Using recycled materials (see the Recycled Materials Resource Center at the University of New Hampshire: www.rmrc.unh.edu)
• Pavement smoothness criteria; several products are available including AASHTO's provisional standards at www.fhwa.dot.gov/rnt4u/ti/pave_smooth .htm
• Quiet pavement initiatives — for example, see Arizona DOT's pilot program at www.azdot.gov/Highways/EEG/QuietRoads.
• Surface texture technical advisory at www.fhwa.dot.gov/legsregs/directives/techadvs/t504036.htm.
• Mobile laboratories for both asphalt and concrete pavements, which are traveling around the country to disseminate new technologies.

Truck Weight Survey

Betsy Parker, Office of Government Affairs, Minnesota Department of Transportation

Betsy Parker, director of the Minnesota Department of Transportation (Mn/DOT) Office of Government Affairs, outlined a pending state legislative proposal to allow heavier trucks on Minnesota roads, changing current truck-size-and-weight (TSW) allowances (see sidebar at left). Overall, the TSW plan is aimed at helping Minnesota shippers to stay competitive.

Opponents, including the American Automobile Association (AAA), the Minnesota State Patrol trooper's union, and the rail industry, have raised issues about both truck and vehicle driver safety. In response, Parker cited a significant drop in crash rates, better equipment and enforcement, and research studies showing no significant damage or harm resulting from heavier trucks.

"We recognize that this is a series of tradeoffs," Parker said. "Minnesota haulers are feeling severely disadvantaged when it comes to dealing with the states around them." (Other states permit heavier trucks.)

Parker said the proposal is a response to a steady stream of requests for truck weight increases and exceptions as well as to an increase in truck traffic. Forecasts point to a 60 percent increase in the amount of freight moving within Minnesota between 2001 and 2020—the vast majority riding on trucks.

The proposal is based on a comprehensive review of Minnesota's truck weight laws. More than 40 meetings were held with public and private stakeholders throughout the state, and committees were convened to provide policy and technical reviews of research conducted by a Mn/DOT consultant.

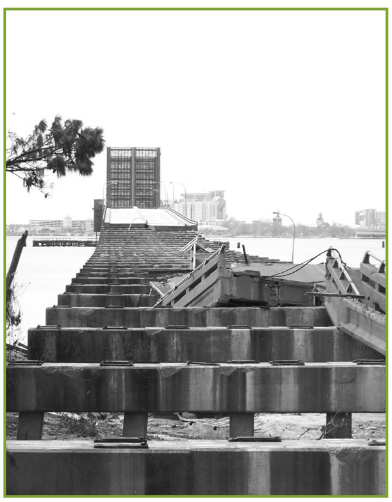
Though Minnesota doesn't set weight limits on the Interstate Highway System—the federal government does that—it can bring the rest of the Minnesota-controlled roads up to a consistent 10-ton weight limit. State law regulates trunk highways as well as county, municipal, and township roads.

Parker outlined several truck configurations that Mn/DOT has proposed for consideration during the 2006 legislative session to allow increased vehicle weights and truck sizes. The proposal will include appropriate additional driver requirements, permits, and other requirements on the vehicles to assure their safety. In addition, Mn/DOT has proposed uniformity across spring load restrictions, including an increase to 7 tons, up from the current default of 5 tons, on all county roads during the busy construction and hauling season.

Challenges Faced by the Mississippi DOT Before, During, and in the Aftermath of Hurricane Katrina

Randy Battey, Mississippi Department of Transportation

Roads, bridges, guardrails, signals—no element of the transportation infrastructure was left untouched by Hurricane Katrina. Randy Battey of the Mississippi DOT described the damage and told of his department's actions before and after the storm.



U.S. 90 bridge at Biloxi Bay, Mississippi

Pavement repair was only one of the challenges faced by the Mississippi DOT, Battey said. The department had begun emergency planning earlier in 2005 with the creation of a hurricane evacuation guide (www.mdot.state.ms.us/cetrp/default.htm) and contraflow instructions. Before Katrina made landfall, 52 miles of interstate—the north/south routes for more than 1.4 million residents of southeast Louisiana—were set up for contraflow. This required 250-plus construction and maintenance personnel, 100-plus barricades, 80 barriers, 40 variable message boards, and "too many drums and barrels to count," Battey said. It was all done in just eight-and-a-half hours.

The afternoon of the hurricane (Monday, August 29), MDOT began clearing roads to open paths for emergency vehicles. "Debris was on every highway in the southern half of the state, and most routes were not passable immediately after the storm," Battey said. One lane was open on U.S. 49 south by 11 p.m. Monday. Crews made every highway passable by Wednesday evening and opened all lanes by Friday. Personnel were brought in from northern districts to help.

In the second phase of debris removal, debris was cleared off shoulders; in the third phase, still under way, debris is being hauled to approved landfills. To date, an estimated 6 million cubic yards of debris has been moved, at a cost of more than $172 million.

Other issues immediately after landfall included a problematic supply chain, fuel shortages (three tankers are being purchased for future storms), and downed communications.

Damage assessment teams made up of MDOT, FHWA, and city crews inspected bridges, roads, and signals. The teams found that emergency repair costs were very inflated—on average, by 50 percent—because materials were scarce, prices inflated, and housing limited (which meant trailers had to be brought in for staff).

Katrina moved this entire casino onto U.S. 90.

MDOT gave incentives to contractors to complete repairs quickly. For example, MDOT reconstructed more than 29 miles of four-lane pavement (over 116 lane miles) of U.S. 90 in Harrison County in three months, using three paving contractors, at a total cost of approximately $25 million.

The scope of destruction was immense. More than 18,000 miles of guardrail and 12,000 signs were damaged. On U.S. 90 in Harris County, Battey said, traffic signals were “obliterated” and 40 intersections were damaged. (All signals were up and running by September 19.)

As of February 9, projected storm costs were $765 million, Battey said, with the amount growing weekly.

Many issues remain for the longer term. Planners in northern areas, where traffic counts are 50 to 70 percent higher post-Katrina, are struggling to gauge if the population shift is temporary or permanent. “Never-ending debris” keeps appearing in areas that were cleaned, Battey said, apparently dumped by nearby residents. And reaching consensus on the balance of aesthetics and functionality has slowed rebuilding.

Concurrent Sessions

Pavement Management Can Save Your Asphalt

Moderator: Wayne Fingalson, Wright County

Developing a Statewide Database for Local Pavements

Rick Kjonaas, Minnesota Department of Transportation

Demands are increasing on all local roads these days, said Rick Kjonaas, Mn/DOT's Deputy State Aid engineer. Demand is also growing for more and better statewide data to help in making policy decisions.

Fortunately for Minnesota, Mn/DOT collects such data. The State Aid database—known as the Needs Study—was first developed in 1958 and serves as an inventory of information for statewide analysis. Every year, county engineers update the database to document the percentage of adequate and deficient county roads and estimate what's needed to handle future traffic. The report, which drives State Aid funding apportionments, "is the envy of many other states," Kjonaas said.

Adding impact to the database is its recent linkage to Mn/DOT's statewide base map, Kjonaas said. Other improvements make the data easier to query. The vision for future enhancements includes adding data from vehicle class counting, pavement condition surveys, and falling-weight deflectometers.

The database has been very useful for discussing roadway conditions at the state legislature, Kjonaas said. An example of its value is the current discussion of spring load restrictions. A recent LRRB-funded study found that restrictions burden haulers and have adverse economic impacts for the state. Removing restrictions, however, means shorter pavement life. "Policymakers need to study how to gather funds from the haulers that result from the economic gain," Kjonaas said.

Counties feel the impact of many truck-weight issues. To limit truck-related damage, Kjonaas said, the LRRB and Mn/DOT have been sponsoring truck-weight training workshops across the state. The free classes, managed by Minnesota LTAP, are part of a broader Truck-Weight Education and Outreach effort that will include a Web site as well as updates to the training. Another related LRRB initiative is the new *Roads and Loads* DVD (see page 15).

For more information: Rick Kjonaas, Rick.Kjonaas@dot.state.mn.us

Pavement Condition Measurement on County Roads

Dave Janisch, Minnesota Department of Transportation

Mn/DOT's Office of Materials and the Division of State Aid have entered into an agreement to test one-fourth of the County State Aid Highway (CSAH) system each year for eight years, said Dave Janisch, Mn/DOT pavement management engineer. There are also provisions whereby the county may request testing on any of its other paved roads.

The data collection includes the following:

Roughness and rutting

- Data collected annually on one-fourth of the CSAH system.
- Roads are driven and data collected in both directions.
- Data stored on a mile-by-mile basis.
- Roughness measured in left and right wheel path.

Cracking

- Data collected annually on one-fourth of the CSAH system.
- First 500 feet of each mile is surveyed (10 percent sample).
- Outer lane is surveyed.
- Only one direction is surveyed on two-lane roads.

Video log

- Digital images of the right-of-way and pavement surface are collected on all roads driven. Special software allows county employees to view the roadway conditions (right-of-way and pavement) from the comfort and safety of their office.

Twenty-four counties were tested in 2005: 6,375 centerline miles of CSAH and 912 miles of paved county road. The process went very well, Janisch said. Three additional counties were also tested in 2005 for another 1,943 miles. The additional county testing was paid for under partnership agreements between the county and Mn/DOT.

In past years, Mn/DOT had surveyed county roads, via partnership agreements, when it finished covering state highways, but was only able to do four to five each year. With State Aid funding, Janisch said, Mn/DOT now plans to test about 6,500 miles of county highways per year.

The bulk of the State Aid money was directed for the purchase of a new tool: a Pathway Services Inc., Digital Inspection Vehicle (DIV) and two digital workstations. The DIV is equipped with three height sensing lasers, two rut measuring lasers, four digital cameras, and a GPS unit. It can measure pavement roughness, rutting, faulting, and collect images of the pavement surface and right-of-way at highway speeds.

Mn/DOT calculates three indices from the data collected by the DIV. The first is the ride quality index (RQI), which indicates the roughness of the pavement. It is a numerical rating, on a zero to five scale, (very poor to very good) that represents how an average citizen would rate the roughness measured. The height sensing lasers measure the longitudinal profile in both the left and right wheel path. An algorithm is then used to simulate how much body and axle movement (roughness) would occur if a reference vehicle drove over the roadway. The RQI is then calculated from this roughness.

The second index is surface rating (SR), which is calculated from the visible distress (cracks, patches, etc.) on the pavement surface. Evaluators at Mn/DOT's Pavement Management Unit in Maplewood look at the images using custom software and rate the road section based on the type, amount, and severity of defects in the first 500 feet of each mile and section.

The pavement quality index (PQI) is the last of the three, calculated from the RQI and SR to give an idea of the overall condition of the road. These simple road indices makes it easier for engineers to explain why/when repairs are needed, for counties to see how their roads compare to their neighbors' roads, and to determine which roads need attention most urgently, allowing Minnesota counties and State Aid to direct resources more effectively. In addition, because the rating procedure is identical to what Mn/DOT uses on the trunk highway system, all parties have a common frame of reference when discussing pavement conditions as part of the Area Transportation Partnership (ATP) planning process.

For more information: Dave Janisch, 651-779-5567, dave.janisch@dot.state.mn.us.

Pavement Management of Local Roads

Don Theisen, Washington County

Why use a pavement management system? Don Theisen of Washington County said there are many reasons: to select projects, track pavement histories, monitor repair costs, and compare the performance of mixes, designs, and methods. "Pavement management can be a powerful tool," he said.

In his county's experience, Theisen said, the primary purpose of pavement management is to inform the county board of the overall condition of the road network. Board members use the data as a starting point to discuss and prioritize all preservation projects, rather than debate specific roadway repairs.

The county uses a 1-100 pavement rating system, Theisen explained, and illustrates the different pavement conditions with photos from county roads. The use of the visuals is key to helping policymakers understand the measurement system and the implications of their budget decisions, he said.

Theisen also gave some advice for choosing a pavement management system. Decide how you will use the data (for project selection or cost tracking, for example), since this drives your choice, and avoid the tendency to try to do too much. "It's easy to make this much more complicated than it needs to be," he said. Also, consider the technical support available and whether other locals have experience with the software.

Data collection used to make up 80 to 85 percent of pavement management work, Theisen said, but thanks to Mn/DOT's pavement condition measurement program (see related article on the Minnesota LTAP Web site), it's a resource problem that "has gone away." Some staff expertise is still needed to understand the data, however.

Pavement management doesn't replace field investigations or common sense, Theisen added. "It's much easier to get good data now, but [it] doesn't replace the need for good engineering."

Contracting Innovations

Moderator: Tom Ravn, Minnesota Department of Transportation

Precast Concrete Pavement

Ben Timerson, Minnesota Department of Transportation

Mn/DOT Metro District engineer Benjamin Timerson discussed the use of precast concrete pavement as part of test during a recent project along Crosstown Highway 62 in Minneapolis. It is hoped that the concrete panels will offer improved access to utilities while speeding up such work and lowering costs.

During his presentation, Timerson reviewed the project specifications, site preparation procedures, panel installation, and lessons learned. Timerson noted specific criteria used to determine the site, which involved only concrete rehabilitation rather than bituminous over concrete, a mainline section of roadway rather than a ramp, no superelevation, and a single lane.

Crews removed sections of pavement by sawing the concrete and lifting panels using a flatbed-mounted hydraulic crane claw. The procedure resulted in less damage to the grade and, as a result, less regrading was required. Next, steel rails were mounted on the remaining pavement along the sides of the opening to assist with grading after dowel holes were drilled at each end.

After using a powered screed to grade a fresh aggregate base, 12'x12'x9" precast concrete panels were lowered into place one at a time. Each panel had a dowel end and a dovetail end to securely lock them into place. In addition, each panel incorporated channels accessible via a small hole from the surface to inject flowable grout.

Finally, once grouting and patching of the gap along the shoulder side of the newly installed sections were complete, the pavement was rated using an inspection and testing van rigged with sensing equipment.

In conclusion, Timerson listed half a dozen lessons learned from the project, which included a need for better coordination with subcontractors, better grading procedures, better grouting, and ways to avoid cracking the precast panels. He also discussed several ideas aimed at reducing the cost of using precast panels.

Mobile Concrete Crusher

Dave Mavec, Minnesota Department of Transportation

A new piece of equipment in highway construction made its debut in Minnesota during the reconstruction of Trunk Highway 53, approximately 25 miles north of Duluth. Ulland Brothers of Cloquet, Minnesota, the project's prime contractor, used a mobile concrete crusher to crush all of the in-place concrete, reuse it in the road structure, and provide a potentially stronger aggregate base for a new bituminous pavement bituminous pavement.

Over many years, the four-lane concrete pavement, which connects Duluth with the Iron

Range, had deteriorated to the point that a new pavement surface was required. Pieces of concrete were popping out. "The project was put on a fast-track when a piece of concrete—the size of a football—went through a motorist's windshield and out of the back window," according to presenter Dave Mavec, Mn/DOT project engineer.

Ulland Brothers used a mobile crusher manufactured by Kolberg-Pioneer (RT 4250 Track Mount Impact Plant) of Yankton, South Dakota. The machine, which has remote control for convenient operation from the loading unit, can crush while moving, making a windrow of finished product. The entire process, from concrete pavement to Class 7C aggregate base ready for paving, has six basic operations.

The operating crew consisted of a crusher operator, a backhoe operator, and a laborer to deal with the reinforcement steel as it was discharged from the crusher. A reinforced spike tooth welded onto the back of the backhoe bucket was used to break concrete into desired 2' x 2' pieces for loading into the crusher. One lane at a time was removed and crushed for equipment location, and convenience of loading. Steel was separated using a large permanent magnet.

Crushing occurred in 12-hour shifts, and, at times, 24 hours a day. But because of a low production rate—the result of reinforcing mesh clogging the impact crusher, hoppers, and chutes, which one operator called "hairballs"—conventional crushers were also used to get the project back on schedule. Ulland Brothers recycled all of the reinforcement steel obtained in the operation.

Mavec pointed out that a much improved production rate could be achieved with pavements of non-reinforced concrete and bituminous.

In conclusion, Mavec said the project resulted in a pavement with a very smooth ride. The project also received a Mn/DOT-Minnesota Asphalt Paving Association paving award. In addition, 42,000 cubic yards of concrete were reused.

"Proving a good working relationship between the State of Minnesota and an innovative contractor can result in a final product of which they can both look upon proudly," Mavec said.

Intelligent Compaction Demos—Mn/DOT and Industry Perspectives

John Siekmeier, Minnesota Department of Transportation, and Dean Potts, Caterpillar

Intelligent compaction may be the next big thing in pavement construction. By combining several advanced technologies, manufacturers are producing compactors that show operators real-time information about the degree of compaction achieved throughout an entire construction project.

This leading-edge concept was described in two presentations at the Minnesota Pavement Conference. John Siekmeier, a senior research engineer at Mn/DOT's Office of Materials, and Dean Potts, Advanced Design Group Engineering manager at Caterpillar, discussed the promise and the challenges ahead for intelligent compaction.

How do you spell strength?

Siekmeier began by reviewing the history of soil strength measurement. He described the currently accepted approach as a "three-legged stool": By controlling moisture content and density, we are able to estimate and control material strength.

Intelligent compaction defined

Potts defined an intelligent compactor as a piece of equipment that measures soil/asphalt compaction, displays the measurements to the operator, records and maps the compaction results using global positioning system (GPS) coordinates, and controls (or guides) the machine compaction effort in response to the measurement system.

The equipment creates a map showing the quality of compaction across the entire area of each lift of material in a project. It also allows the operator to target problem areas, increase compaction where needed, and prevent over-compaction. And last, the speakers said, it archives all collected data for use if problems arise and to define requirements for later projects.

Mn/DOT and many other agencies across the U.S. are working on pilot projects with the goal of redefining compaction acceptance criteria and quality control / quality assurance procedures for subgrades and bases. Since moisture control is one of the "legs" of the stool, these projects are evaluating not only intelligent compactors but also various moisture measurement devices.

How they do it

Dean Potts described three different approaches to compactor-based compaction measurement:

Compaction meter value method. A drum-mounted accelerometer measures G-force at the vibratory drum's fundamental frequency (typically vertical accelerations only) and at harmonic frequencies. This information is used to control the drum's amplitude.

Force vs. displacement method. This is more of a direct measurement technique in which drum-mounted accelerometers and position sensors measure stiffness and send signals that control drum amplitude and frequency.

Energy or power method. The system measures the driveline power needed to roll over soil or asphalt and corrects for grade and machine acceleration; this is the only approach of the three that works for both vibratory and non-vibratory compactors.

Asphalt compaction

From research on the use of intelligent compactors in asphalt projects, Potts drew the following conclusions:

- The condition of underlying material is critical to the successful compaction of asphalt surface layers.
- Measuring asphalt compaction also measures the compaction of the base and subgrade materials. To what degree or depth depends upon the asphalt thickness and which of the three measurement-feedback systems is employed.
- Changes in asphalt temperature make significant changes in asphalt stiffness. Measurements need to be corrected for temperature.
- Changing amplitude and vibration frequency from first to last passes can significantly reduce the number of passes required to reach full density; this is more significant in asphalt than in soil compaction.

The researchers reached the following conclusions:

- Intelligent compaction produces better and more consistent compaction, which results in fewer road failures, which reduces cost and disruption of service — and increases safety.
- Intelligent compaction records will be useful in analyzing road performance so that future roads can be designed to be even more durable and provide greater value.
- Intelligent compaction is now possible at reasonable costs due to innovations in GPS, machine controllers, and sensors.
- Intelligent compactors guide crews during construction and allow precise and efficient inspection via proof rolling.
- Equal numbers of passes do not create equal compaction when base and sub-base are not uniform in soil type, gradation, moisture, or when there are problems in the deep structure below fill.
- Increasing the compaction effort on a soft spot does not always bring it up to the same level as the surrounding material, in which remediation of some sort is needed. Moisture content is an important variable.
- The operator can determine when an area has reached the desired compaction level or that an area will not reach the desired compaction without remediation.
- Over-compaction can be controlled by automatic amplitude adjustment (machine input) *and* by reducing the number of passes (operator input).
- The operator of an intelligent compactor gets immediate quantitative information that results in a better job with less wasted effort. Therefore, the importance of the operator is enhanced. Thus, the word *intelligent* in intelligent compaction refers to both the mechanical system and the operator.

For more information: http://mnroad.dot.state.mn.us

Local Roads: Issues and Answers

Moderator: Mike Marti, SRF Consulting Group

To Pave or Not to Pave Your Gravel Roads

Ann Johnson, Department of Civil Engineering, University of Minnesota

The question of whether to pave a gravel road was again raised at this year's conference. This time around, the answer is becoming clearer. Ann Johnson of the University's Department of Civil Engineering introduced a PowerPoint presentation designed to aid local engineers in making the decision of how and why to upgrade a gravel road. Minnesota LTAP is set to release the presentation later this spring.

The one-hour presentation, titled "To Pave or Not to Pave? Making Informed Decisions on When to Upgrade a Gravel Road," equips the engineer with necessary economic, political, and social information when considering an upgrade on local roads. The format of the presentation allows the engineer to easily share the information with employees, local boards, citizens, and others who weigh in on the decision. While the data trends represent those of Minnesota, the presentation includes slides in which the presenter can turn off the voiceover and insert data relevant to his or her area. The presentation is designed to supplement current Minnesota LTAP gravel road training materials.

The presentation is based on the findings of two reports, SD 2002-10: *Local Road Surfacing Criteria* and MN 2005-09: *Cost Comparison of Treatments Used to Maintain and Upgrade Aggregate Roads*. Together these reports create the foundation of the presentation by answering two key questions: "When is it best to maintain a gravel road?" and "When should it be upgraded to a paved surface?"

The reports detail the multitude of reasons to pave as well as reasons to hold off, and provide a tool to simplify the decision-making process. These reports also provide information including cost analysis based on historical spending for low-volume roads, a method for estimating cost of maintenance and construction specific to an engineer's area, and an economic analysis using data such as present worth evaluation.

The two reports and subsequent PowerPoint presentation will aid local engineers in the face of current trends in road use and maintenance. Rural areas are experiencing dramatic shifts in their populations including an increase in large commercial farms. These factors change the needs of agribusiness and road maintenance. Minnesota has also seen increased development in the urban fringe.

In addition, the maintenance costs of gravel roads are increasing while funding and resources are decreasing. These factors have created the need to optimize maintenance costs and plan for the future and long-term duration of gravel roads.

The results of the two research reports and PowerPoint presentation introduced by Johnson pave the way toward making informed decisions on the maintenance and upgrade of gravel roads. Look for more information about the presentation's release in future LTAP publications.

Duration of Spring-Thaw Recovery for Aggregate-Surfaced Roads

Rebecca Embacher, American Engineering Testing, Inc.

Current legal requirements for spring load restrictions are often not effective in preventing damage to roads, said Rebecca Embacher of American Engineering Testing. "Experience suggests many aggregate-surfaced roads require additional time relative to flexible pavements to recover strength sufficient to carry unrestricted loads." Her presentation covered the results of a three-year study and data collection throughout Minnesota on the spring-thaw periods for aggregate roads.

Specifically, this study sought to determine the effectiveness of current Minnesota Statute 169.87 "Seasonal Load Restriction; Route Designation, subdivision 2 "Seasonal Load Restriction" and to develop an efficient method of testing road strength during the spring-thaw.

The current law specifies eight weeks of spring load restrictions regardless of road material. However, results of Embacher's study indicate that these standards often remove restrictions during a critical period of weakening strength due to the thaw. This allows unrestricted traffic before the road surface has recovered to its full bearing capacity strength. Further, the current statute does not adequately differentiate between road surfaces which require varying time to recover from spring-thaw.

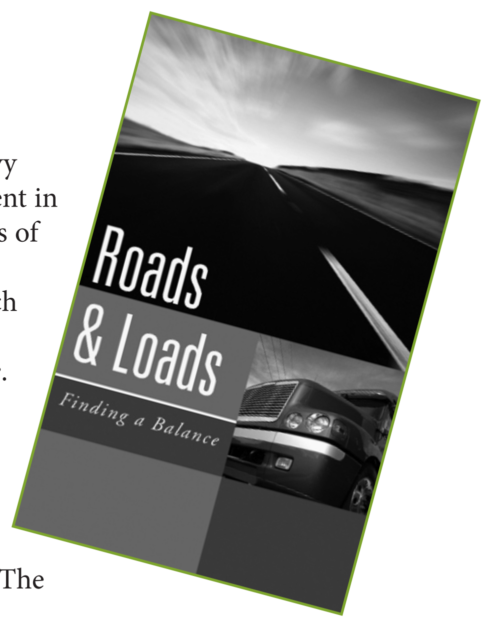
Embacher recommended the statute be modified to reflect these findings. An additional one and a half weeks is needed for aggregate-surfaced roads to fully recover, depending on surface type, traffic levels, among other factors. According to Embacher, this issue will be discussed at the legislature this year.

Another important outcome of the study is the determination of efficient methods for evaluating road strength and the optimal duration of spring load restriction. Embacher used dynamic cone penetronmeter (DCP) to "determine the underlying soil strength by measuring the penetration of the lower shaft into the soil after each hammer blow." With these measurements, Embacher developed an Area Under the DCP Penetration Index Profile (AUDP).

DVD Presentations: *Gravel Road Maintenance* and *Loads and Roads*

Mike Marti, SRF Consulting Group

Marti introduced presentations of the following new DVDs:



Finding a balance between loads and roads

Striking a balance between the needs of commerce to carry heavy loads on roads and the need to preserve the significant investment in our transportation infrastructure is a delicate process. Both sides of the picture can present compelling arguments.

The Minnesota Local Road Research Board (LRRB) Research Implementation Committee recently completed a 20-minute educational/training DVD, *Loads and Roads: Finding a Balance*. This DVD can be shown in its entirety for a comprehensive look at the subject, or it can be divided into about five-minute segments for viewing by different audiences.

The DVD is being distributed to Minnesota city and county engineers, along with a brochure and other materials that can be used when making presentations about this subject. The DVD is also on the LRRB Web site—www.lrrb.org.

The art of gravel road maintenance

The workers who maintain gravel roads are making an important contribution to the safety, comfort, and convenience of their communities. Maintaining these roads, however, isn't easy—in fact, it is a tricky combination of art and science that workers must aim to develop. Minnesota LTAP has created a toolkit to teach maintenance workers, supervisors, and engineers the right way to perform gravel road maintenance.

The key component of the toolkit is a new DVD, *Gravel Road Maintenance: Meeting the Challenge.* The DVD can serve either as a stand-alone tutorial or as an instructor's tool to introduce the topics of gravel road maintenance. Each chapter of the DVD discusses a specific maintenance topic:

- Correct Roadway Shape
- Shaping the Roadway
- Good Surface Gravel
- Dust Control

The DVD can also be used for presentations to the public to explain what can be done to their local roads, what is being done, and why it needs to be done. Because of the critical role these roads play—such as bringing goods to market and transporting children to school—citizens aren't shy about complaining to public officials when they see a problem.

The DVD was created in partnership with SRF Consulting Group with funding from Mn/DOT's State Aid for Local Transportation Division. In addition to the DVD, the toolkit includes the FHWA's *Gravel Roads Maintenance and Design Manual* and an instructor's guide.

Pavement Rehabilitation

Moderator: Erland Lukanen, Pavement Research Institute, University of Minnesota

Benefit Cost—Cold In-place Recycling vs. Full-Depth Reclamation

Sohila Bemanian, Nevada Department of Transportation

Cold In-place Recycling (CIR) and Full-Depth Reclamation (FDR) allow agencies to extend their resources and help protect the environment, said Sohila Bemanian, assistant chief materials engineer of the Nevada DOT.

This is increasingly important for four major reasons: limited funding for pavement preservation, rising costs of plant-mix, lack of quality aggregates, and stringent environmental regulations.

After defining CIR and FDR, Bemanian shared NDOT's approach for selecting projects:

- CIR
    - >>3" of plant-mix on 80% of the cores
    - < 15% of the pavement is experiencing load-related distress
- FDR
    - < 3" of plant-mix exists on 20% of the cores
    - >>15% of the pavement is experiencing load-related distress

With CIR, Nevada has had excellent short-term performance (less than 10 years) using lime slurry, she said. Between 10-20 years, data is not available for the use of lime slurry, but the department did find minor stripping in harsh climates when lime slurry is not used.

FDR shows excellent short-term performance, she said. In the long term, NDOT found transverse and isolated non-wheel path longitudinal cracking.

Overall, Bemanian concluded, CIR is a very cost-effective strategy in cases of functional deficiency, while FDR is a very cost-effective strategy in cases of structural deficiency. NDOT has saved more than $600 million in the past 20 years compared with the cost of complete reconstruction, she said. CIR and FDR also reduce interruptions and user-delay costs.

Bemanian recommends that all agencies consider using CIR and FDR in their pavement preservation program. "Start slowly and keep pushing the envelope," she said.

For more information: 775-888-7520, sBemanian@dot.state.nv.us

Pavement Rehabilitation Selection

Gene Skok, Department of Civil Engineering, University of Minnesota (ret.), and Marc Loken, Minnesota Department of Transportation

When a pavement needs rescuing, engineers have a range of options—from total reconstruction to doing nothing. Gene Skok of the Department of Civil Engineering presented material from a best practices report that he and Marc Loken of Mn/DOT are developing. The project, funded by the LRRB, will lay out best practices for the selection of asphalt concrete recycling techniques and summarize their cost and performance.

The project specifically looks at stabilized and unstabilized full-depth reclamation (FDR), cold in-place recycling (CIR), and mill and overlay (M&O). Skok described the techniques and when it is appropriate to use them (see table below).

The project will continue for another year. Plans are being made to develop and give workshops on pavement rehabilitation using these techniques later in 2006 and into 2007. The report will be published on the LRRB Web site (www.lrrb.org).

Type of Reclamation	What It Is	Why Use It
Total Reconstruction	• Redesign and rebuild road in its entirely, from pre-existing soil and/or road conditions. • Costly and time-consuming, long-term fix.	• Money is available. • Current or projected traffic warrants it. • Improve ride. • Fix foundation problems. • Increase road longevity. • Reduce frequent temporary fixes.
Full-Depth Reclamation	• Pulverize the entire pavement structure and blend it with a portion of the base/sub-base material. • Blended material is homogeneous and well graded. • Typical maximum particle size is 2 inches.	• Eliminate all distress areas. • Eliminate potential for reflective cracking. • Stabilize new base with emulsion, fly ash, or portland cement.
Cold In-place Recycling	• Reclaims 2-4 inches of the existing HMA pavement. • Leaves 1 inch of existing reused HMA in place. • Mixes recycled material with new AC. • Additional material can be obtained from RAP or virgin aggregate.	• Provides a uniform base that can be overlaid with HMA. • Mitigate reflective cracking problems associated with straight overlay. • Good rehabilitation technique for low-volume roads.
Mill and Overlay	• Mill off (remove) existing asphalt surface 1-2 inches. • Overlay with new HMA.	• Low initial cost. • Costs less than FDR and CIR. • Minimize clearance/grade issues. • Minimize construction time. • "Cover" up reflective cracks. • Short-term fix.
Do Nothing (DN)		• Money is not available. • Other roads have higher priority. • Low or reduced traffic. • Short-term fixes only as needed.

Concrete Pavement Rehabilitation Best Practices for Local Roads

Matt Zeller, Concrete Paving Association of Minnesota

Matt Zeller, executive director of the Concrete Paving Association of Minnesota, shared highlights of a manual published by Mn/DOT State Aid in September. *State Aid Concrete Pavement Rehabilitation (CPR) Best Practices Manual* (2005-33) provides specifications for concrete repair of local city streets and county pavements. It was developed from existing concrete repair standards used by Mn/DOT since 1981, and incorporates successful modifications by the cities of Owatonna and Austin, Minnesota. For the first time, the manual also incorporates standards for sidewalk, curb, and gutter repairs into a specification format.

Content from the manual is used in Minnesota LTAP's Concrete Pavement Repair workshop. Minnesota LTAP is also under contract with Mn/DOT to redesign the manual into an easy-to-use format later this year.

To download the current version (1.1 MB PDF), visit www.lrrb.org.