LTAP
Center for Transportation Studies
University of Minnesota

13th Annual

Minnesota Pavement Conference:

Session Summaries

February 12, 2009

University of Minnesota

St. Paul Campus

Sponsor:
Transportation Engineering and Road Research Alliance (TERRA)

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Minnesota Local Road Research Board (LRRB)
Pavement Research Institute (PRI), University of Minnesota

Hosted by:
Center for Transportation Studies, 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.

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Additional Materials Online

Slides from all the presentations are available for download at **www.terraroadalliance.org.** This includes materials from the following presentations that are not summarized in this document:

Innovations in Construction Practices

Infrastructure Challenges for 2010 Winter Olympics: Sea to Sky Highway, British Columbia
Alternate Bids for Pavements

Sustainable Pavements

Ethanol Co-Products and Bio Oil
The Payback of Green
Warm-Mix Asphalt at MnROAD

Video of several presentations is also available on the TERRA site: www.terraroadalliance.org

Annual Pavement Conference Award

2009 Gerald Rohrbach Minnesota Pavement Conference Award

The 2009 recipient of the Gerald Rohrbach Annual Pavement Conference Award is Mark Maloney, the public works director/city engineer of Shoreview. The 2008 recipient, Doug Schwartz (concrete pavement engineer with Mn/DOT's Concrete Engineering Unit) presented the award.

Maloney chairs the Minnesota Local Road Research Board Research Implementation Committee (LRRB-RIC) and the TERRA Research and Implementation Committee. He is also a member of the Legislative Committee of the City Engineers Association of Minnesota and the Executive Committee of the Minnesota Chapter of the American Public Works Association.

Doug Schwartz, Mark Maloney

Plenary Sessions

Moderator: Maureen Jensen, Minnesota Department of Transportation

Welcome

Thomas K. Sorel, Commissioner, Minnesota Department of Transportation

Tom Sorel welcomed participants and briefly outlined his vision for transportation in Minnesota.

Building Success and Avoiding Surprises: The Use of Risk Analysis and Decision Making

Khalid Bekka, HDR Decision Economics

When asked for a project cost estimate, we typically provide a single dollar figure—but Khalid Bekka labeled that a mistake. In his presentation at the 2009 Minnesota Pavement Research Conference on February 12, Dr. Bekka, an economist with HDR, Inc., said, "If we do it that way, it means there's a 50% likelihood the eventual cost will be above that number and also a 50% likelihood the cost will be below that number. How many of us would bet our mortgage on a 50-50 chance? We wouldn't! So why are we willing to do that with an infrastructure project?"

Furthermore, Bekka predicted that, with the funds on the way from the American Recovery and Reinvestment Act of 2009 (the "stimulus package"), we can expect our "due diligence" processes to be carefully scrutinized. "We will be judged on the types of processes we use, the transparency of those processes, and what kinds of risk we assume." *(Ed. note: This prediction became reality a few days later when President Obama appointed a former Secret Service agent*

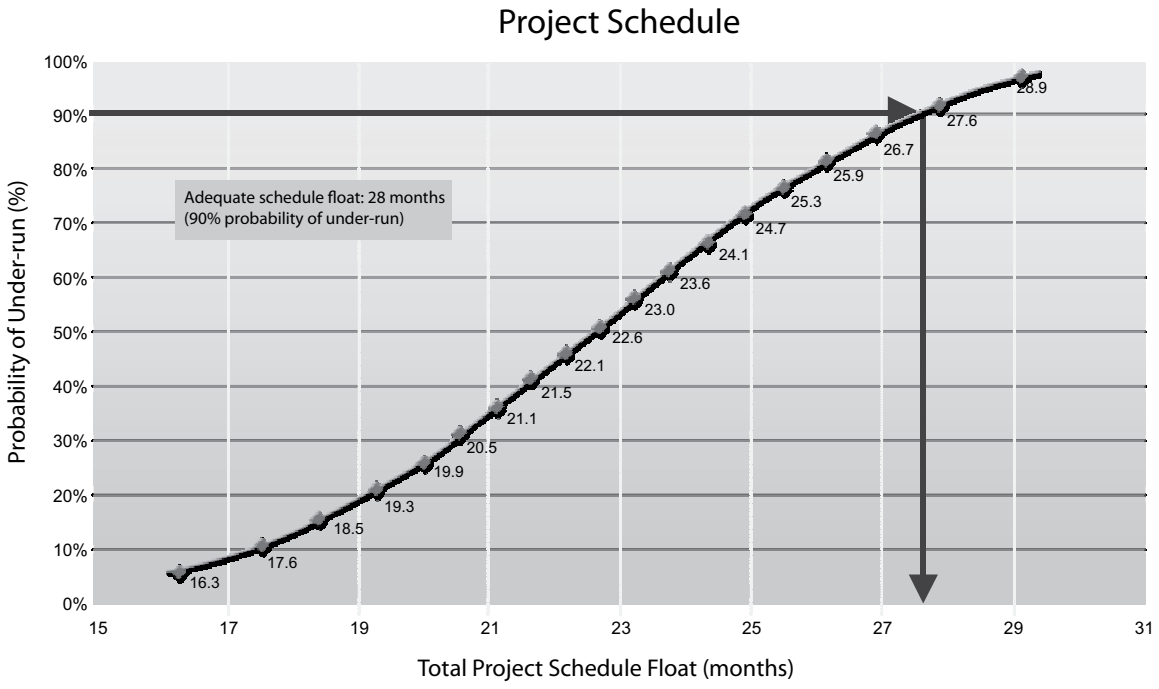

Figure 1: Probability of under-run plotted against schedule impact

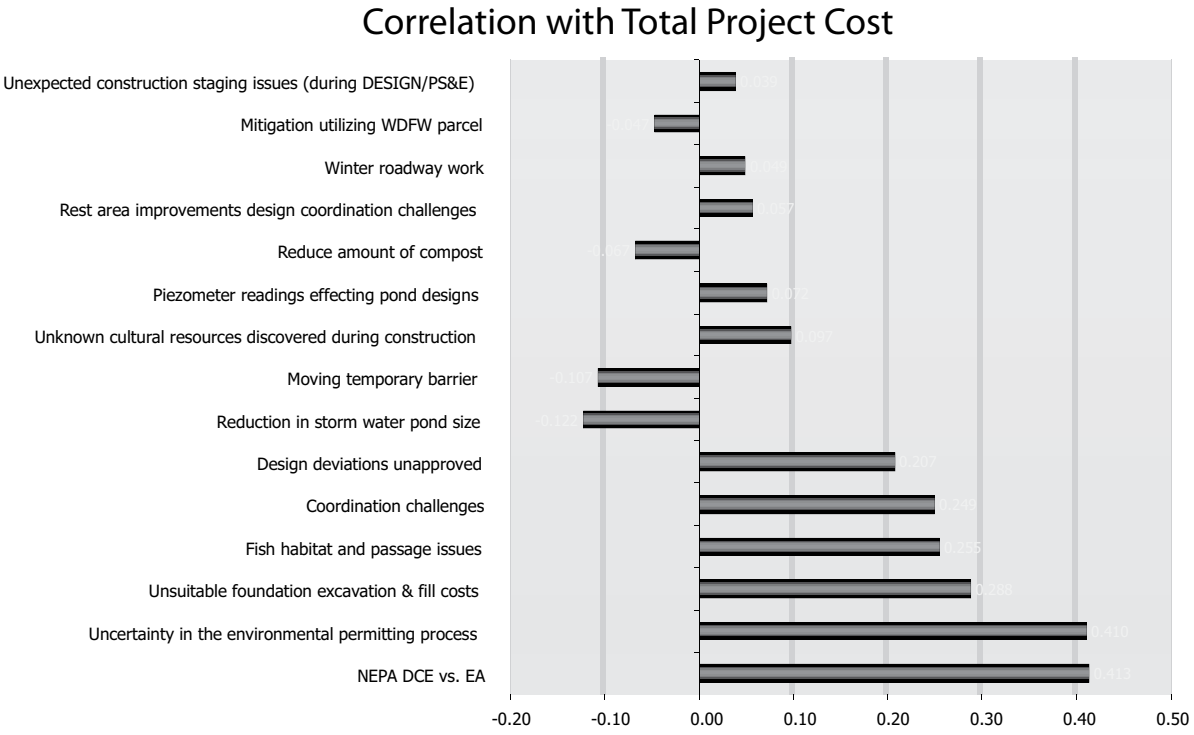

Figure 2: Comparing risks in terms of how they impact cost

with experience in rooting out corruption as chairman of the Recovery Act Transparency and Accountability Board.)

In response to these issues, Bekka explained a process that he has used to manage risk in more than 100 infrastructure projects. The first step, he said, is to state each key variable as a range rather than a single number: "I like what Warren Buffett said: 'I would rather be approximately right than precisely wrong.' "

Bekka emphasized that this should be done for the broadest possible range of factors that might affect a project. As an example, he discussed a 2003 project at Ground Zero in Lower Manhattan. "The MTA showed us their time estimate for digging a tunnel. But we concluded that they should move the completion date out at least two years. One risk that led us to that conclusion was the possibility of archaeological findings. It turned out that, on average, archaeological findings had delayed them an additional year in previous projects." Figure 1 shows how Bekka and his associates plotted this variable: To achieve a 90% probability of completing the project by its estimated completion date, the MTA needed to push its prediction out 28 months.

To be sure all important factors are being considered, Bekka recommended proactively inviting a broad range of opinions to the table as early as possible in planning each project. "Of course you will bring in experienced engineers," he said, "but you should also invite academics, planners, and the public—even skeptics—and let them all throw darts at your project."

Bekka's next step is to assess the risk attached to each factor involved in a project. Figure 2 is an example of how he compares factors in terms of their probable impact on project cost.

Finally, Bekka explained that, once you see where the uncertainty is in your project, you can take steps to mitigate those uncertainties. "Do I need more surveying? More public relations? How can I reduce the uncertainty? The more you mitigate, the more you have due diligence, confidence, credibility, and transparency."

As a final example, Bekka discussed the ROC-52 project, completed in 2006, in which U.S. Highway 52 in Rochester, Minnesota, was widened. "The major issue was whether to do it in the design-build mode or the traditional way," Bekka said. "We heard from lots of people that their businesses would be disrupted during the project. Initially, construction plans were projected for 11, 7, or 3 years. With input from local citizens, Mn/DOT, and some university professors who we hoped would not be tied to a political viewpoint, we did a side-by-side assessment of design-build and design-bid-build. What emerged is that, by doing the project with design-build in three years, there would be a cost

increase. But there would also be a tremendous amount of public benefit in terms of reducing the impacts on business, property values, and congestion. It was the difference between a short pain and a long pain. I'm not saying you should always use design-build, but in that specific project, the rate of return completely outweighed the premium in cost."

For an in-depth look at risk assessment in infrastructure projects, see *Highlights of an Expert Panel: The Benefits and Cost of Highway and Transit Investments* (GAO-05-423SP) available at http://www.hdrinc.com/15/42/1/default.aspx?listingID=801 (accessed 2/22/09). This U.S. Government Accountability Office document summarizes ideas on how to conceptualize, measure, improve, and use information about benefit-cost analysis of highway and transit investments.

Minnesota's Transportation Investment Strategies

Tim Henkel, Minnesota Department of Transportation

Tim Henkel, director of Mn/DOT's Planning, Modal & Data Management Division, summarized the "Minnesota Statewide Transportation Plan: 2009-2028" at the Minnesota Pavement Conference. The plan, which is required by state and federal law, has been in the works since 2007 and will be published this year. The purpose of the plan, said Henkel, is to "establish a transportation vision—not just for Mn/DOT but for the entire state."

Although the plan addresses all transportation needs, Henkel focused his presentation on highway construction and maintenance needs. As shown in Figure 3, the plan projects that Minnesota will require $65 billion over the next 20 years to achieve the highway system performance targets defined in the plan.

What's more, the gap between those targets and available funds is growing. Henkel reminded his audience that the last version of the plan (in 2003) stated the gap as $1 billion per year. The 2009 plan "gives us a new figure: $2.5 billion per year for the next 20 years," he said. (Costs are calculated for the year of construction to reflect cost increases over the next 20 years; the previous plan estimated costs and revenues in constant 2004 dollars.) He also predicted that during the 20-year timeframe of the plan there will be a tripling of "troubled roadways"—from 600 miles to 1,800 miles.

Henkel said this new funding gap figure is based on modest revenue growth in keeping with historical levels. However, the projection does take into account new revenue that will flow from the

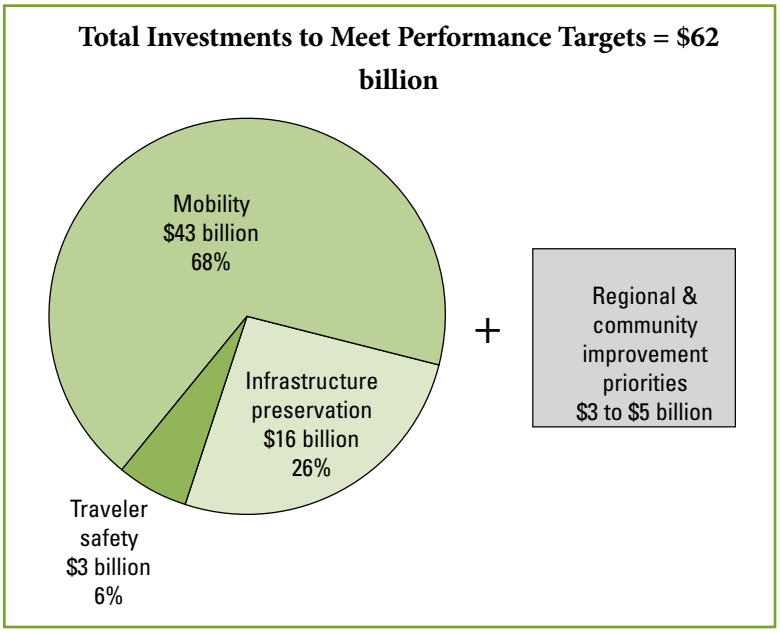

Figure 3: Statewide Highway System Needs, 2009 – 2028 (in billions of $, calculated for the year of construction)

Chapter 152 legislation passed in 2008 (see Table 1). He also warned that this projection is "our best guess at this point in time"—it gives a long-term, overall outlook—and, inevitably, it will evolve as conditions change.

Given the predicted revenue shortfall, Henkel said Mn/DOT is making a "significant change" in its overall highway infrastructure investment strategy. Instead of placing emphasis on preserving existing structures as has been done in the past, the new plan takes a "balanced approach" that will allow districts more flexibility in deciding which

projects to authorize. This shift was necessitated by "the fiscal climate we're in, the differences that exist in different areas of the state, and the varying needs of our constituents," he said.

At the same time, the plan contains alternative strategies that can be implemented when additional funds, such as the federal stimulus package, become available (see article below). Specifically, Henkel said, the plan lists a set of priorities for the top 5% of projects that are left out of the most conservative scenario. This 5% amounts to about $2.5 billion in additional projects.

Henkel also summarized the distribution of funds from Chapter 152 to highway infrastructure projects. "The department received trunk highway bonding authority; in addition, there was a change in the gas tax rate and a few other areas that provide additional revenue—overall about $1.8 billion." Table 1 shows how that money is to be allocated.

Mn/DOT conducted open houses around the state to explain the draft plan and solicit public comment. The department also encouraged comments by phone, fax, and Web. To learn more about the plan or submit your comments, go to www.dot.state.mn.us/planning/stateplan/index.html.

Table 1: $1.8 billion in trunk highway bonds authorized in Chapter 152

- Buildings, Great River Road, etc.:
  - $130M
- Bridge Program (Tier 1 and Tier 2)
  - $1.2B in bonds (on $2.5B of projects) to repair or replace Tier 1 and Tier 2 bridges by 2018.
  - 161 Tier 1 bridges identified, 120 will be replaced
  - Cost estimating and design in progress
- Pavement
  - $275M for accelerated pavement/safety projects (FY 2009–2010)
- Interchange Program
  - $40M (50% metro, 50% Greater Minnesota)
  - Devil's Triangle ($10M, FY09)
  - Solicit for remaining $30M by June (FY 2010–2012)
- Transit Advantages (under development)
  - $50M (FY 2012–2018)
- TH 60 Legislative Direction
  - $100M (FY 2011–2012)

Minnesota's allocation of stimulus funds

On February 17, President Obama signed into law the American Recovery and Reinvestment Act of 2009—also known as the "stimulus package." On March 3, Mn/DOT received authorization from the Federal Highway Administration (FHWA) to spend $502 million (M) of stimulus funds on Minnesota highway projects. These funds are federally classified as Surface Transportation Funds (STP). Mn/DOT spokespeople have stated that they will be guided by the historical division of 70% on trunk highways and 30% on local roads.

Within the $502M total, $150.7M is designated for urban areas and further broken down according to population: $73.2M is for urban areas larger than 200,000 people (which means it will be used in the Twin Cities metro area). In addition, $61.8M is designated for urban areas with populations of 5,000 to 200,000, and will be used in areas such as Rochester, Duluth, and St. Cloud; $15.7M is designated for urban areas with populations of less than 5,000. Because of the flexibility allowed within the STP program, Mn/DOT has discretion as to whether this $150.7M can be spent on local or trunk highways. All of this $150.7M must be allocated to projects by Mn/DOT and approved by FHWA by March 3, 2010.

Mn/DOT has generally broader discretion in allocating the remaining $351.6M in stimulus funds. Within that amount, $15.1M is designated as "Enhancement" funds, meaning they can be used for purposes such as landscaping and bike/pedestrian accommodations. Mn/DOT has full discretion in allocating the remaining $336.5M to highway projects. Rules established in the stimulus package state that 50% of the $351.6M (i.e., $175.8M) must be allocated to projects and approved by FHWA within 120 days of March 3—i.e., by July 1. The remaining 50% must be allocated to projects and approved by FHWA by March 3, 2010. In all cases, advertising and awarding of projects will begin after the projects are allocated by Mn/DOT and approved by FHWA.

Sustainability Through People, Process, and Product Innovation

Jean-Claude Roumain, Holcim (U.S.) Inc.

Going green and achieving sustainability seem to be terms thrown around in many industries today, but according to Jean-Claude Roumain, the cement industry can achieve the goal of sustainability—through people, process, and product innovation.

Roumain, corporate product manager for Holcim (U.S.) Inc., a cement company, gave his argument for how the cement industry can reach sustainability in his presentation at the 2009 Minnesota Pavement Conference.

Concrete is the most widely used man-made product in the world and is second only to water as the world's most utilized substance, Roumain said, which is why it's crucial to make sure it is environmentally friendly. More than a ton of concrete is produced each year for every human being.

The reason for concrete's high usage, he said, is its universal availability. Concrete is used all over the world in roads, schools, homes, and hospitals, as well as in many other buildings.

The cement industry was one of the first, in 1999, to make a sustainability commitment by pledging to reduce its carbon footprint. But sustainability considers more than just CO_2 issues and climate change. It includes land and water impacts, energy use, depletion of non-renewable materials and resources, and indoor environmental quality, Roumain said.

Concrete has many sustainable attributes: for example, it's locally derived, consumes CO_2 from the atmosphere once in place, is non-toxic, and is resource efficient. On the flip side, Roumain said, the industry faces several challenges to sustainability. The concrete industry is fragmented and diverse. It has limited acceptance of new performance standards, is slow to investigate and adopt new technology, and reluctant to change. And a gap in product knowledge often exists.

To achieve sustainability, Roumain presented what he calls the "Sustainability Triple Bottom Line" of people, process, and production innovation. People—architects, engineers, contractors, and suppliers—need to be educated about sustainability and the benefits of cement and concrete. The industry also needs to recruit the "best and the brightest" to the field.

Concrete is a product but it is also a process, he continued. The industry needs to identify how people (architects, engineers, specifiers, testing agencies, batchmen, ready mix truck drivers, contractors, and finishers) facilitate or hinder the process to achieve durable and cost-effective concrete.

And most important, Roumain said, the industry must be receptive to innovation. To remain competitive, the industry must continually improve the delivery, quality, ease of placement, and sustainability of concrete. Different strategies and tactics will be needed to accelerate the acceptance of new technologies.

His presentation concluded with a look at future trends in the industry, citing specific examples in cement manufacturing techniques.

Asphalt Supply in a Volatile World

Clint Rybak, ConocoPhillips

With many transportation and road projects likely to receive funding from the recently passed stimulus package, many members of the industry are wondering, "What does the supply situation for asphalt binder look like for this year?"

"Good," said Clint Rybak, of ConocoPhillips, as a part of his session at the 2009 Minnesota Pavement Conference. While Rybak said there might be localized shortage issues at times, the asphalt supply looks to be stable in the upcoming year.

Rybak discussed how the last few years have seen dramatic fluctuations in the price and supply of asphalt and additives such as polymers.

Although oil prices have dropped, Rybak said the future of asphalt supply remains uncertain. He discussed the primary drivers of supply and price volatility of asphaltic products.

Asphalt base is derived from crude oil. Although the U.S. demand for oil has seemingly been down, Rybak said, the United States has not been a driver of the oil markets since 2004. "Developing nations are becoming more and more of an influence in global markets," he explained.

The refining process also affects the supply of asphalt, as the refineries convert crude oil into the asphalt base. This base is one of the several possible products from crude oil, along with jet fuel, gasoline, and diesel fuel. Most often refiners focus on producing either fuels or asphalt, Rybak said.

While the number of refiners is down in the United States, the production level is up in the refineries that are in operation. Today's typical refinery is bigger and produces more than in past decades.

Because gasoline margins have held up and pricing has been good, Rybak said the outlook is positive for the asphalt market. The higher asphalt prices are relative to crude, the more asphalt will be produced.

While numbers look different year to year, Rybak said there is "no reason to believe (asphalt supply) will be anything but … normal" this year.

"As we go forward, the outlook will look different year to year," he said, "but certainly there are plenty of refiners that have plans to give themselves the option of putting the bottom of the barrel in the highest valued market."

Concurrent Sessions

Infrastructure Investments

Moderator: Mark Maloney, City of Shoreview

Minnesota County Pavement Data

Dave Janisch, Minnesota Department of Transportation

The Mn/DOT Pavement Management Unit crews have now collected data on all 27,000 miles of CSAH (County State Aid Highway) throughout Minnesota's 87 counties. In his presentation, Dave Janisch reported on the very large amount of data that has been collected since the County Highway Pavement Testing Program was begun in 2004. Between now and 2012, the crews will repeat the entire survey. Thus, eventually there will be at least two sets of data on every mile of CSAH in the state.

What is collected?

With funding from the Division of State Aid, the Mn/DOT Pavement Management Unit collects data on at least one quarter of the state's CSAH miles each year. In addition, some counties pay to have other roads surveyed, and some counties pay to have all of their CSAHs surveyed every year. Crews use trucks equipped with lasers that precisely measure the pavement surface. In addition, as shown in Figure 4, four video cameras provide a "movie" that shows the left and right wheel paths, the driver's view, and the right-of-way—all synchronized on one screen. Janisch reported that this video log has been the most popular component of the data delivered to the counties. "The fact that anyone can sit down at a Mn/DOT computer, pull up any road in the county, and virtually drive it back and forth has been a very useful tool."

Figure 4: Typical composite video

Table 2 summarizes the types of data collected.

Table 2: Types of information collected by Mn/DOT Pavement Management Unit

Type of data	Notes
Roughness and rutting	Data collected in both directions Ride Quality Index recorded for every mile (0= very poor; 5= very good) Roughness measured in left and right wheel paths
Cracking	First 500 feet of outer lane of each mile is surveyed One direction only on two-lane roads Surface rating (a number that aggregates data on cracking, rutting, faulting, etc.) is calculated: 0 = many defects; 4 = no defects
Digital video	Synchronized cameras record: Left wheel path pavement surface Right wheel path pavement surface Driver's-eye view Right-of-way

What do the data tell us?
Janisch reported the following on the condition of Minnesota's CSAHs:

- Average Ride Quality Index (RQI) in 75 of the 87 counties is in the "Good" range—3.0 or above.
- About half the counties meet Mn/DOT's target of having an RQI greater than 3.0 on at least 65% of CSAH miles.
- About half the counties meet Mn/DOT's target of having 3% or fewer of their CSAH miles with an RQI below 2.0; however, only five counties have more than 15% of CSAH miles below 2.0.
- All counties have average CSAH crack indexes above 3.0, which is considered quite good.
- The statewide average crack index is better for CSAHs than for state roads, all of which are evaluated the same ways with the same tools.
- Generally, the worst CSAH conditions are in the Twin Cities metro counties where there is the most traffic.

Kicking the Asphalt Around: Foamed Asphalt

John Grindeland, Fillmore County, and Andy Eller, Minnesota Department of Transportation

Fillmore County highway engineer John Grindeland and Andy Eller of the Mn/DOT Materials Office discussed their experience with foamed asphalt in cold-in-place recycling projects. In the foamed asphalt process, a small amount of water—typically 2% to 4%—is injected with asphalt binder—typically 320° to 360°F—and mixed with RAP in the reclaimer. The water instantly vaporizes, thus foaming the asphalt material. The major benefit of using foamed asphalt in CIR is the short cure time. Traffic can be allowed on the pavement in two to four days.

Eller listed some basic facts about the process:

- To date in Minnesota, all foamed asphalt projects have employed cold-in-place recycling (CIR) and have been done with Superpave 52-34 PG binder.
- Foamed asphalt coats the fines, forming a mastic that increases the surface area of the mixture; as a result, foamed asphalt works well with a wide range of minus 200 material: 5% to 20%, though 8% to 15% is typically optimum.
- Lime, fly ash, and portland cement are often added to increase moisture resistance and reduce the amount of asphalt required.
- Asphalt temperatures of 320° to 360°F are a safety hazard.

Eller discussed three major factors in determining the mix design for a foamed asphalt project:

- Optimum foaming characteristic is approached by balancing the water content (typically 2% to 4%) with the asphalt temperature (typically 320° to 360°F).
- Optimum bituminous content is achieved by maximizing saturated indirect tensile strength.
- Optimum moisture content is achieved by adding the residual moisture content in the RAP + water injected to foam the asphalt + additional water added during compaction.

However, John Grindeland, who has been using foamed asphalt in CIR projects for seven years, said he has good success without doing a laboratory-based mix design. "We rely on experience," he said. "We assumed our minus 200 was probably 10, 12, 13 percent—and we found that to be fairly consistent. Then we might adjust in the field with a little more oil. We worked with the operator of the machinery, who had done hundreds of miles. He told us we should maybe add a third of a percent or half a percent [of water] to get the density we wanted."

Thin Unbonded Overlays

Mark Watson, Minnesota Department of Transportation

Though unbonded overlays (UOs) have been placed on concrete pavements in Minnesota for decades, little research has been done on their functionality or effectiveness. Accordingly, Mark Watson of Mn/DOT is managing a project to provide longitudinal evaluation and best practices for UOs. At the 2009 Minnesota Pavement Conference, Watson presented preliminary information on several recent UO installations.

Watson first defined UOs: "The key defining feature of an unbonded overlay is the bituminous interlayer." Figure 5 shows a typical cross-section:

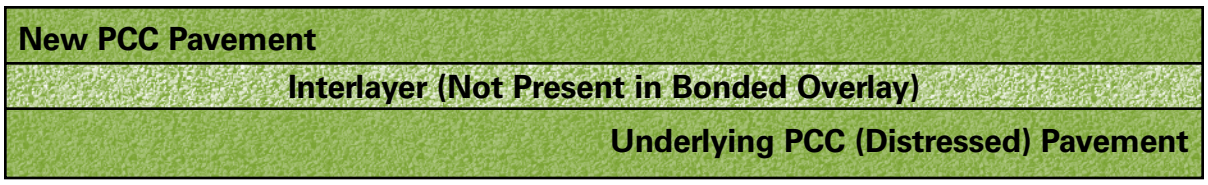

Figure 5: Typical unbonded concrete overlay with bituminous interlayer

Watson listed the major advantages of UOs, which are mostly due to the interlayer:

- Greater retardation of reflective cracking.
- Cushions the PCC overlay.
- Distributes vehicle-derived stress widely because the interlayer is continuous under the overlay joints.
- Significantly better ride quality index and surface rating over 20 years, compared to concrete pavement.
- Cost-effective due to minimal requirement for surface preparation of existing pavement.

He also listed disadvantages of UOs:

- Clearance issues—added thickness may be up to 9.5 inches.
- May be more expensive than HMA overlay.
- Little available data on long-term cost-benefit.

Two types of bituminous interlayers have been used in UOs: dense material intended to keep water out and permeable material intended to drain water to the shoulders. Both are being tested in the four test sections that Watson discussed. These are profiled Table 3:

Table 3: Unbonded overlay test sections in Minnesota

Location	Original Pavement	Overlay Thickness (inches)	Interlayer	ADT	UO Notes
I-94 at Mn/ROAD	7.1-inch Doweled Constr. 1992	5 (2 sections) 4 (2 sections)	1-inch permeable	62,000	Placed 2008 No dowels No longitudinal ties or joint sealant Highly instrumented
I-90 near Dexter	No information provided	8	1.5 inch permeable	5,650	Dowels Tied longitudinal joints Edge drain system
TH 53 near	8-inch Doweled Constr. 1972 Poor condition before overlay	5	1-inch dense-graded interlayer	12,300 (heavy trucks)	No dowels Supplemental panel reinforcement Instrumented
TH 10 near Hawley	No information provided	7	1-inch permeable	11,900	Dowels Tied longitudinal joints Edge drain system Instrumented

Intelligent Compaction

Moderator: Glenn Engstrom, Minnesota Department of Transportation

TPF Intelligent Compaction Project—Overview and Recent Findings

George Chang, Transtec Group

It has been three years since information on intelligent compaction (IC) was presented in a Minnesota Pavement Research Conference. In 2006, representatives from Mn/DOT and Caterpillar discussed a variety of IC equipment and compaction measurement methodologies. At that time, few people had practical experience with IC.

This year's Pavement Research Conference also included a session on IC, and this time there was solid, local, field-based evidence of IC's value. Four presenters talked about their experiences in a variety of demonstration projects. Some of these have been part of a three-year Transportation Pooled Fund (TPF) study (#954) on IC begun in 2007. Mn/DOT and local agencies in Minnesota are taking a leading role in the project.

How do you spell IC?

Dr. George Chang of the Transtec Group defined IC as a system with four key characteristics:

- Continuous measurement of compaction
- Feedback of compaction measurement to control the roller
- GPS-based mapping
- Real-time automated reporting

Chang explained that 12 states are participating in the TPF study, which is investigating IC use in cohesive and non-cohesive subgrade soils, aggregate base, stabilized base materials, and asphalt pavement. As part of the study, three IC demonstration projects were constructed in 2008, one of which was in Olmsted County, Minnesota. Five projects will be constructed in 2009, and four more will be constructed in 2010. The goals of the study are to accelerate development of IC specifications, increase and disseminate IC knowledge in the participating states, and identify ways that manufacturers can improve IC equipment.

Intelligent Compaction Round-up

David White, Iowa State University; Rebecca Embacher, Mn/DOT; Mike Sheehan, Olmsted County

Following Dr. Chang, additional data and conclusions were presented by Dr. David White of Iowa State University, Olmsted County Engineer Mike Sheehan, and Rebecca Embacher of the Mn/DOT Materials Office.

White said the major conclusions so far in his studies are that "IC measurement of subgrade and base material values are linked to pavement design values, and IC values provide useful information to characterize spatial variability [of compaction] across a project." In fact, he claimed that "you can explain 50 to 80 percent of the measurement values on the HMA surface just by looking at the sub-base." This led him to state that, contrary to common belief, placing high-quality base material is unlikely to solve the problem of poor-quality subgrade; in fact, the problems of the subgrade are likely to be reflected through the base into the pavement.

Following is a digest of the presenters' other major conclusions:

- IC data show compaction variation over short distances within a project, and that the data on the variations are repeatable from pass to pass.
- IC data provide information about material

as much as 2 meters below the surface, whereas a dynamic cone penetrometer (DCP) measures material within about 1 meter of the surface, and lightweight deflectometers (LWD), falling weight deflectometers (FWD), and nuclear density gauges measure material from 1/5 to 1/3 meter below the surface.
- Comparative QA data gathered via DCP, LWD, and FWD all demonstrate repeatability and reliability.
- IC + QA via LWD or DCP could effectively replace test rolling.
- LWD shows great promise as a QA device.
- Instead of multiple random QA sampling, IC data can be used to target problem areas for QA measurement.
- It may be appropriate to develop a specification with two levels of rigor and reliability: one with relatively lower reliability for general fill placement and another with higher reliability for the top one or two meters of base material.
- Though contractors have felt overwhelmed by the high volume of data generated by IC, that data will become useful pavement management data in the future.
- IC data analysis software is currently under development.
- The traditional top-down arrangement within which a construction supervisor gives direction to a roller operator must be reversed to a great extent in IC-driven projects.
- Material stiffness, roller speed, and roller amplitude affect the validity of IC data, which means roller operators must be well-trained on how to control the equipment.
- Roller operators need to be computer-literate; but paradoxically, better-educated operators tend to be bored by the work.

INNOVATIONS IN CONSTRUCTION PRACTICE:

Sweden's innovative contracting practices

Mats Wendel, national coordinator of pavements for the Swedish Road Administration (SRA), was in Minnesota as part of a work-exchange program with Mn/DOT's Office of Materials and Road Research. He shared how the SRA's innovative contracting practices use performance specifications to reach quality and cost goals for road repairs and new construction.

Sweden has used performance-based contracts for more than 20 years, at first on a limited basis. Specifications typically describe performance objectives that address road functionality or surface characteristics, such as ride quality, friction, and rut depth. It is important, Wendel said, to have requirements that can be measured.

Most contracts in the United States typically address lower-level requirements such as elementary material properties. In Sweden, the lowest levels are used only in standard contracts.

According to Wendel, the SRA has outsourced all its daily road maintenance, including winter maintenance, for more than 10 years. In 2008, it spent almost $200 million on innovative contracts for construction out of a total of $850 million and another $500 million on daily maintenance.

By using innovative contracts, traditional tasks are transferred to the contractor, Wendel said, allowing know-how, price, and quality to decide the solution. Contractors pay greater attention to details and, as a result, pavement life is increased through higher-quality workmanship. Such contracts also allow for the most up-to-date technology to be used in projects. In addition, transferring responsibility to the contractor opens up possibilities to more creatively meet users expectations for accessibility, safety, comfort, and travel time.

When using innovative contracting with performance-based specifications, Wendel cautioned, the road owners are still accountable for delivery. Financial incentives (i.e., lane rental, bonuses, penalties) and warranty agreements are ways to ensure contractors deliver quality. Road warranties, while rare in the United States, are common in Europe. In Sweden, the typical length of a warranty is five years.

For road owners, Wendel concluded, innovative contracting increases efficiency and makes innovations available more quickly to the driving public.