RURAL TRAVELERS HEAR THE RUMBLE OF SAFER ROADS
Center line rumble strips improve rural road safety.

NEW ONLINE RESOURCE
Highway specifications are now available on the web.

MISSOURI PROFESSIONALS LEARN A NEW EXPANSION JOINT REPLACEMENT METHOD
MoDOT demonstrates the XJS Expansion Joint System.

FALL 2003
Excerpts from “Center Line Rumble Strips Reduce Crash Risk on Rural Two-Lane Roads,” a report by Richard Retting of the Insurance Institute for Highway Safety. For a free copy of the full report, email publications@iihs.org.

On a national basis, rural roads account for approximately 40 percent of all motor vehicle travel but 60 percent of all fatal crashes. Approximately 90 percent of all fatal crashes in rural areas occur on two-lane roads, which typically lack physical measures such as wide medians or barriers to separate opposing traffic flows. As a result, a major crash problem on these roads involves vehicles crossing the centerline and either sideswiping or striking opposing vehicles head-on. These types of opposing-direction crashes account for about 20 percent of all fatal crashes on rural two-lane roads and result in approximately 4,500 fatalities annually.

A comprehensive before-after study was undertaken to estimate the nature and magnitude of crash reductions associated with installation of center line rumble strips on rural undivided two-lane roads. Data were drawn from seven states: California, Colorado, Delaware, Maryland, Minnesota, Oregon, and Washington. In total, 98 treatment sites along approximately 210 miles of road were studied.

Overall, motor vehicle crashes at treated sites were reduced 14 percent; injury crashes were reduced by an estimated 15 percent. Head-on and opposing-direction sideswipe crashes—the primary target of center line rumble strips—were reduced by an estimated 21 percent, while head-on and opposing-direction sideswipe crashes involving injuries were reduced by an estimated 25 percent. This result, taken together with the fact that installation costs are relatively low, suggest that consideration should be given to wider application of center line rumble strips on rural two-lane roads to reduce injury crashes.

The Missouri Department of Transportation is now conducting a similar investigation of the benefits of center line rumble strips along Rte. 21 in Jefferson County. Study results will be used to evaluate possible implementation on other Missouri roadways.
COUNTY ROAD 116: Clark County, Missouri

This National Register-eligible bridge is available for adaptive reuse at a new location. The 112.2-foot-long, 12.1-foot-wide, 20-foot-tall, six-panel, pin-connected Pratt through truss has steel stringers and was constructed by George H. Turner in the early 1920s. It currently crosses the North Wyaconda River near Luray, Missouri. If the bridge is transferred to another party, the transfer deed may include preservation covenants that require the new owner to preserve and maintain the bridge in accordance with established standards for historic bridges. Funds may be available for reuse of the bridge.

Contact: James W. Kempker, S & V Consultants, Inc., 2015 Schotthill Woods Dr., Jefferson City, MO 65101 T: (573) 634-3551 • F: (573) 634-3424

PARISH BRIDGE: Knox County, Missouri

Parish Bridge over the Middle Fabius River is available for adaptive reuse at a new location. This National Register-eligible bridge was build by the Ottumwa Bridge Company in 1907. The 84-foot-long center span is a Pratt through truss with a 12’ roadway width. The Bridge also utilizes two steel stringer approach spans for a total length of 146’. If the bridge is transferred to another party, the transfer deed may include preservation covenants that require the new owner to preserve and maintain the bridge in accordance with established standards for historic bridges. Funding may be available for reuse of the bridge.

Contact: Michael Purol, Great River Engineering, Inc., P.O. Box 1258, Hannibal, MO 63401 T: (573) 221-8443 • F: (573) 221-2230 • E: grtriver@socket.net
MISSOURI PROFESSIONALS LEARN A NEW BRIDGE EXPANSION JOINT REPLACEMENT METHOD

by James “Skip” Wilson, Non-State Bridge Inspector, MoDOT District 3

On May 12, 2003, members of the MoDOT District 3 bridge maintenance crew gave hands-on instruction of a new concept in expansion joint construction and rehabilitation. The XJS Expansion Joint System was demonstrated to bridge crew members and engineers from Audrain County, Lincoln County, and the City of Hannibal. During the training program, an Elastomeric Bridge Joint on Missouri Route J in Ralls County over Mark Twain Lake was replaced in the northbound lane, allowing traffic to still be maintained on one lane of the bridge.

The XJS System combines a wear-resistant polymer for expansion joint nosing with rapid-curing, high-movement silicone for joint sealing. The cold-applied system is designed to provide a watertight, chemical-resistant seal to accommodate high traffic loads and remain pliable in cold and warm temperatures. The silicone sealant will bond to itself. Thus it is ideal for maintenance applications in which only one lane of traffic can be sealed at a time, as it can provide a continuous seal.

If you are interested in learning more about the XJS Joint Replacement System please contact MoDOT District 3 Bridge Maintenance Supervisor Birney Herrick at 573.248.2449.
When MoDOT repair crews were faced with emergency repair of a heavily damaged overpass on I-70 in December 2002, inspectors looked to the concrete maturity method to facilitate reconstruction operations of one of the structure’s northern bents, which was severely impacted in a tractor-trailer accident. The maturity method, a non-destructive means of estimating in-place concrete strength as a function of time and temperature, is recognized as a more reliable and timely method as opposed to testing conventional 6”x12” compressive strength cylinders. Following placement of the bent footings, columns and cap on the I-70 overpass, thermocouples were inserted in the fresh concrete and a maturity value was calculated at desired times. In-place strength was then estimated from a pre-established relationship between maturity values and compressive strength. Application of the maturity method allowed earlier form removal and completion of the I-70 bridge repairs than if concrete cylinders had been used for strength determination. As a result, the bridge was open to traffic several days earlier than anticipated had conventional methods been used.

**The Maturity Concept**

While the maturity method has been around since the 1950’s, it hasn’t been until recent years, due to the increasing need to speed up construction operations and improve inspection efficiency, that the method and its benefits have been fully recognized. Based on the combined effects time and temperature have on strength gain in concrete, the maturity method is identified as a simple and reliable approach to estimating in-situ concrete strength in lieu of conventional 6”x12” cylinders. Although representative of concrete delivered to the site, conventional cylinders aren’t necessarily representative of the in-situ concrete. Differences in fabrication, curing conditions, and handling of standard cylinders can have a direct impact on tested strength results. However, establishing a relationship prior to construction between mix strength and maturity (computed from its time-temperature history), followed with time and temperature monitoring of the mix during construction, reliable and real-time in-situ strength can be estimated. Application of maturity technology can provide an ideal, non-destructive means of facilitating construction operations including sawing pavement joints, coring pavement, opening pavement to traffic, removing formwork, cold and hot-weather concreting, and others.

ASTM C 1074, the standard practice established for estimating concrete strength by the maturity method, provides two mathematical functions acceptable for generating the strength-maturity relationship or curve for a concrete mix. Depending upon the function used, the maturity index can be determined in terms of time-temperature factor (TTF) using the Nurse-Saul equation or equivalent age (t_a) using the Arhenius equation. Because of its simplicity and accepted reliability, the Nurse-Saul function using a datum temperature of 14°F (-10°C) is the more widely used, and preferred by MoDOT, of the two equations. To establish the strength-maturity curve, compressive strength is determined from cylinders at various ages along with corresponding maturity values or TTFs for a mix prior to construction. Strength is then plotted against maturity, providing the relationship necessary to estimate in-situ strength. During construction, tie and temperature of the placed concrete are monitored and calculated maturity values are correlated to a determined strength using the curve. As a result, timely construction decisions can be made based on more credible information and the labor and guesswork associated with conventional cylinders can be minimized or avoided.

**Application on UTW Overlay Placement**

While MoDOT’s Research, Development and Technology (RDT) program has been familiar with the maturity concept for some time, serious consideration of its application came as a result of recognizing its potential benefits to speed up construction of a fast-track, ultra-thin whitetopping (UTW) overlay in the late summer of 2000. Using maturity technology on the fast-track overlay at the busy intersection of Rte. YY and Belt Highway in St. Joseph provided an excellent opportunity to demonstrate its benefits in the field. Prior to construction of the UTW overlay, RDT staff worked with the ready mix producer at the plant to generate a strength-maturity relationship for the mix to be used. During construction, thermocouple wires were inserted mid-depth in the 3 in. overlay at various locations to monitor time and temperature. Throughout construction, strength of the in-situ pavement was estimated according to the maturity curve, enabling efficient decisions to be made concerning the optimum time to saw joints and to open the pavement to traffic causing minimal disruption.

Application of the maturity method on another fast-track, UTW overlay at the intersection of Rte. 291 and 23rd Street in Independence was just recently completed. Like the St. Joseph project, a strength-maturity curve for the high early strength overlay mix was established prior to construction. Time and temperature of the newly placed concrete was monitored during construction, and the in-situ concrete strength was estimated according to the curve. As a result, sawing of the pavement joints and opening of the intersection to traffic was handled much more efficiently reducing total construction time.

**Maturity Equipment**

The maturity method can be conducted simply using minimal equipment such as thermocouple wire and a data logger, where mix time and temperature data are collected then used to manually calculate maturity values. Commercial maturity meters, more sophisticated devices capable of monitoring time and temperature and automatically computing maturity values in terms of time-temperature or equivalent age as desired, even more simplify the use of maturity technology. Commercial maturity equipment has advanced recently to the availability of sacrificial sensors placed in the concrete with wireless transmission of the data directly to inspectors.
Ultrathin Whitetopping
MoDOT
Ultrathin concrete overlays were constructed on US 60 near Neosho and at the intersection of Rt. 169 (Belt Highway) and Rt. YY in St. Joseph in 1999 and 2000, respectively. Ultrathin concrete overlays are typically 2” to 4” thick, sawed into 2’ to 4’ square panels, and often reinforced with fibers. They are bonded to existing asphalt pavements and designed to perform as stiff flexible surface layers. The purpose of the ultrathin overlay is to prevent the rutting and shoving that typically occurs on asphalt surfaces at locations where heavy traffic is slowed, turning, or brought to a complete stop, such as at an intersection.

Granular Base Permeability
UMC & MoDOT
MoDOT currently designs new pavements with two types of unbound granular bases: 4” dense-graded Type 5 and 2’ rock fill. The purpose of this study was to determine the permeability of these bases.

Longitudinal Joint Keyways
MoDOT & ARA/ERES Consultants Inc.
Keyways are a traditional means of providing load transfer at longitudinal construction joints. Missouri has used keyways on nearly all longitudinal construction joints for many years. The purpose of this study was to determine their load transfer capacity and whether load transfer is even necessary in certain situations.

Precast Post-Tensioned Concrete Pavement Panels
UMC & MoDOT
A precast post-tensioned concrete panel project will be constructed on a segment of I-57 in Mississippi County. The purpose of this design is to greatly reduce the structural thickness required for heavy-duty pavement and shorten the lane closure time necessary to replace old pavement.

The Transportation Engineers Association of Missouri (formerly the Highway Engineers Association) will hold its 94th Annual Conference next spring. The conference will include four breakout sessions with a variety of presentations from which to choose. Check the winter issue of RDT Quarterly for agenda details. For registration information, log on to the association website:

www.modot.org/TEAM

When: March 30—April 1
Where: Chateau on the Lake
Branson, Missouri
**New Resources in the RDT Library**

### BRIDGE ENGINEERING
- Measured behavior of a curved precast segmental concrete bridge erected by balanced cantilevering
  - ID: RD0003140
- Investigation of differences in deterioration of two North Carolina bridges due to alkali-silica reactivity (ASR)
  - ID: RD0003154
- Boundary conditions for bridge scour analysis
  - ID: RD0003150
- Moisture content variations of nail laminated timber bridges in a northern climate
  - ID: RD0003153

### ENVIRONMENTAL TECHNOLOGY
- Overview of the quality and quantity of roadway runoff and current status of phase II storm water rules
  - ID: RD0003155
- Textural and mineralogical characterization of Kansas limestone aggregates in relation to physical test results
  - ID: RD0003161
- Seventy-five years of aggregate research in Kansas
  - ID: RD0003159

### ENGINEERING & CIVIL ENGINEERING
- Highways operations: progress and products update
  - ID: RD0003172
- Evaluation and modification of sight distance criteria used by TxDOT
  - ID: RD0003174
- Polish resistance of selected Kansas aggregates
  - ID: RD0003152
- Phase II environmental site investigation procedures and technologies for property transfer and PS&E development
  - ID: RD0003145
- Guidelines for mixture design and thickness design for stabilized bases and subgrades
  - ID: RD0003142
- Evaluation of the use of shredded tires around buried pipes
  - ID: RD0003156
- Development of a procedure to rate the application of pavement maintenance treatments
  - ID: RD0003162

### TRANSPORTATION & COMMUNICATION
- Information systems for transportation agencies
  - ID: RD0003147
- The railroad system of Texas: a component of the state and national transportation infrastructure
  - ID: RD0003146
- A summary of the railroad system of Texas: a component of the state and national transportation infrastructure
  - ID: RD0003176
- Six county rural transit feasibility study: final report
  - ID: RD0003173
- Enhancements of the KRONOS simulation package and database for geometric design planning, operations and traffic management in freeway networks/corridors: phase III
  - ID: RD0003148
- Effective traffic calming applications and implementation: final report
  - ID: RD0003151
- Investigating speed management techniques
  - ID: RD0003175

### TRANSPORTATION RESEARCH RECORD
- Traffic flow theory and highway capacity, 2000
  - ID: RD0003166
- Geology and properties of earth materials, 2003
  - ID: RD0003164

The RDT Library includes a variety of materials related to transportation research. The library is located at the MoDOT Research, Development and Technology office at 1817 Missouri Blvd., in Jefferson City, Missouri. The facility is open Tuesday through Thursday, from 11:30 A.M. to 4:30 P.M. CST. Items can be requested by phone at 573.526.4326 or via email to liaoc1@mail.modot.state.mo.us

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**Did you know...???

Many of the RDT technical briefs and reports are now online!**

[www.modot.org/services/rdt/byTitle.htm](http://www.modot.org/services/rdt/byTitle.htm)
during construction, further increasing the efficiency and effectiveness of the maturity method.

RDT’s initial experience with maturity testing equipment included various data loggers and thermocouple wire. Depending upon the type of data logger used, problems were sometimes encountered due to the equipment’s sensitivity to extreme ambient conditions (high humidity, heat or cold) and some data loggers were felt to be awkward or difficult to manage in the field. In addition, values for maturity had to be manually calculated. RDT currently uses commercial maturity meters to conduct maturity testing and have found these devices to be dependable and operate much more efficiently than equipment used in the past.

Procedure Limitations
While the maturity method is no doubt a valuable tool, it does have some limitations. The following should be kept in mind when applying the method. The maturity method assumes that sufficient moisture is available during cement hydration and, therefore, does not account for inadequate curing. Hence, any variation in strength due to poor curing during construction would not be reflected in the maturity curve. Once the strength-maturity relationship for a particular mix has been established prior to construction, no changes in mix design constituents or proportions during construction should be allowed other than minimal changes within acceptable tolerances. Otherwise, the accuracy of the maturity curve to estimate strength of the mix during construction will be compromised, resulting in an unreliable curve. Early age temperatures of the mix used to establish the maturity curve similar to those anticipated of the mix during construction are also recommended for improved reliability. The maturity method does not take into account any errors in placing and consolidation; thus, good construction practices are essential, as with any project. Each of these issues can and should be easily addressed through good project quality control and should not serve as an obstacle to applying maturity technology.

Future of Maturity and MoDOT
The maturity method has demonstrated itself as a desirable and reliable means of indicating in-situ compressive strength and facilitating construction operations. When procedures are properly followed, maturity can be an exceptional tool allowing timely decisions impacting construction operations. With a specification recently developed and in-place, MoDOT intends for contractors to invest in maturity equipment and conduct their own testing to facilitate work on future projects, as opposed to MoDOT providing the equipment and conducting maturity testing on previous projects. Recently, the new specification was included in the contract for the construction of an unbonded concrete overlay on I-55 in St. Louis, which required accelerated construction and optional contractor application of the maturity method. Application of the maturity method is also currently allowed on MoDOT QC/QA (quality control/quality assurance) paving projects as an option to the contractor for determining the earliest time pavement cores can be retrieved for thickness and design strength verification. As more contractors become familiar with maturity technology and recognize its benefits, future application in Missouri is only expected to increase.

For more information...
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