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CTS Research E-News brings you the latest research project milestones, published reports, and seminar coverage.

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Policy & Planning

STREET project featured in Webcast seminar

For undergraduate students in introduction to civil engineering courses, using software programs to assist with assignments is not often feasible due to the complexity and prohibitively high costs of off-the-shelf commercial software. Consequently, students must complete their work by hand and rely on textbooks to learn highway design and urban planning concepts.

Henry Liu and **David Levinson,** faculty in the the civil engineering department, and **Chen-Fu Liao**, educational systems manager at the Intelligent Transportation Systems (ITS) Institute's Minnesota Traffic Observatory, are working to change that through the Simulating Transportation for Realistic Education and Training (STREET) program.

At a September 16 CTS Research Seminar, Liu discussed how the STREET program is providing students with a more interactive, hands-on learning experience. Sponsored by the National Science Foundation with matching funds from the ITS Institute, STREET has developed a suite of Web-based simulation modules to communicate the basic concepts of highway design, traffic flow theory, and transportation/urban planning to college students. An additional objective of the program is to use the simulation-based teaching material to create an online "active textbook" accessible to a wide variety of users.

The simulation modules are largely the result of previous work completed by those involved in the STREET program, Liu noted, and primarily cover the topics included in the University of Minnesota's introduction to civil engineering course. Roadway Online Application for Design (ROAD), Simulation of Freeway Traffic (SOFT), Online Application of Signalized Intersection Simulation (OASIS), Agent-based Demand and Assignment Model (ADAM), and Simulator of Network Growth (SONG) are the modules contained within the STREET program. Each of them allows students to experience a topic in an interactive setting.

Liu explained that the focus of these modules is on providing students with a clearer understanding of the critical concepts rather than on the software itself. Although the modules do not always replicate real-world scenarios with complete fidelity, they have proven successful in providing students with stylized examples and in emphasizing the challenges involved in transportation engineering tasks. The modules are not meant to compete with professional software, Liu stressed, but rather to provide students with a simple, easy-to-use tool that enhances their learning experience. To ensure ease of operation and access, the modules are all available online and require no special software.

STREET's second objective, the development of active textbooks, has been realized with the creation of three online, open-content books on the Wikibook site: Fundamentals of Transportation, Transportation Economics, and Urban Traffic Operations. The first, Fundamentals of Transportation, contains all of the STREET simulation modules as well as critical concepts, exercises, examples, questions, and quizzes designed for use in an introductory class. The books also contain links to related games, including the ITS Institute and Web Courseworks-developed Gridlock Buster and ROUTE, a road optimization game related to geometric highway design.

The creation of the books on the Wikibooks site was a collaborative effort, Liu explained, because anyone with Internet access can edit or contribute to them, although the books are monitored to ensure the accuracy of posted information. They have also proven to be a useful way to disseminate STREET materials, recruiting faculty from other schools to use the modules, and gather feedback.

STREET modules have thus far received favorable reviews from U of M students, who have reported that they have a better understanding of core concepts and appreciate the hands-on experience gained through the use of the Web-based tools. Looking forward, Liu said that he and his colleagues hope STREET will improve the transportation curriculum in educational institutions beyond Minnesota and also help educate the public on transportation issues.

- Watch seminar or download podcast

Study examines link between school choice and transportation

School choice, the policy of allowing parents to choose which district school their child will attend, has a substantial impact on school-related transportation behavior, according to a recent University of Minnesota study sponsored by the Intelligent Transportation Systems (ITS) Institute.

Elizabeth Wilson, assistant professor at the Humphrey Institute; **Julian Marshall**, assistant professor in the Department of Civil Engineering; **Kevin Krizek**, a former Humphrey Institute researcher; and former graduate student **Ryan Wilson** surveyed parents of elementary school children in two metro-area cities, St. Paul and Roseville, to determine how the type of school a child attends affects factors such as commute distance and transportation modes.

The study found that elementary school children who attend "magnet" schools—those that often draw students from throughout a district—have to travel 2.7 times further than students who attend their neighborhood school. Fewer magnet-school students walk or bike to school than neighborhood school attendees, often because they live too far away. Magnet-school students are also less likely to be driven to school in private automobiles; instead, the study discovered, these students bus as their principal mode of transportation.

District transportation costs can increase from this reliance on busing by magnet-school attendees, according to the study, as schools in Minnesota are required to provide bus service to students living more than 1.6 kilometers from the school they attend. In St. Paul, where 95% of elementary school students live within that distance of their neighborhood school, the need for busing could be nearly eliminated. The policy of school choice, however, allows for more than half of those students to attend a different, and often more distant, school than the one located nearest to them.

Parental attitudes also differed between those with students attending magnet versus neighborhood schools, as well as between parents of different races, according to the study's survey results. Magnet-school parents were more likely to rank curriculum as highly important, while parents of neighborhood school attendees valued the proximity of their children's school. A much higher percentage of non-white parents ranked bus service and bus-stop safety as highly important than did white parents, regardless of school type. Distance was the most frequently cited reason by all parents why children did not walk to school.

Changes to district transportation policies should be considered in light of school choice, study findings suggest. The popularity of magnet schools and the transportation-related effects of magnet-school attendance could potentially inhibit a district's attempts to reduce transportation costs. Efforts to reduce busing services and increase the use of walking or biking as a mode of transportation could potentially be hampered by the increased distance between children and the schools they attend.

A final report on the project, *School Choice and Children's School Commuting* (CTS 09-01), is available from the CTS Web site.

Intelligent Transportation Systems

Intelligent decision support inside the vehicle: Can it help drivers make safer driving decisions?

A disproportionate number of crashes and fatalities occur at rural thru-stop intersections where a secondary road crosses a divided highway. Drivers trying to cross the highway or enter traffic are very vulnerable, especially when traffic is heavy. Intelligent decision-support systems may help drivers make better choices about when to enter the intersection.

At the September 9 ITS Institute Advanced Transportation Technologies seminar, **Caroline Hayes**, professor of mechanical engineering, presented the results of an ITS Institute-sponsored study that compared three decision-support systems.

Two of the decision-support systems are based on visual interfaces. The first consists of an active LED icon-based sign in the intersection. A yellow rectangle indicates an approaching vehicle, and a red circle and red rectangle warn that the approaching vehicle poses a threat to drivers preparing to cross or merge. This system is currently being field-tested at the intersection of Highway 52 and County Road 9 in Goodhue County, Minnesota.

The second system consists of a modified LED icon display placed on the right- and left-side mirrors. The display features an approaching car with speed lines and a fill bar. The amount of color in the fill bar indicates the time to arrival of oncoming traffic.

These interfaces are easy to understand and provide drivers with a lot of information, but they rely on the visual channel, which is already overloaded because driving is a very visual task, Hayes said.

The third interface consists of a seat with two vibrating pads that provide vibrotactile feedback. A vibration in the right pad signals that traffic is approaching from the right; a vibration on the left indicates traffic approaching from that side.

Testing of the three systems was conducted in the HumanFIRST driving simulator with 24 subjects between the ages of 19 and 69. Subjects were evenly divided between male and female. Once trained, the subjects were asked to drive through a simulated thru-stop intersection under four conditions: 1) without using decision support (this was the control), 2) using the LED icon traffic sign, 3) using the LED side-mirror displays, and 4) using the vibrotactile seat.

The seat was more effective than either of the visual displays, Hayes said. Drivers were able to keep their eyes on the road and enter traffic with more space between their car and the oncoming traffic. But drivers didn't prefer the vibrotactile interface because they found it "weird" or "annoying." They also reported that they expected the interface to tell them when to "go" instead of when "not to go."

Drivers preferred the icon sign in the intersection, probably because the location and the interface were familiar, Hayes said. The sign gave drivers nuanced information, but they also continued to look at it after a gap in traffic became available. This effectively reduced the safety margin.

Hayes pointed out, however, that although the vibrotactile seat provided a better safety margin than the icon sign, that margin was not significantly better than the safety margin when no decision-support system was used.

Going forward, researchers may wish to experiment with modifications of the vibrotactile seat, such as changing the vibration to make it less annoying or to provide more information. Increased training would probably make the seat more familiar and acceptable to drivers, Hayes said. But, she added, there are larger questions to address. For example, can intelligent decision-support systems really help drivers make better decisions? Right now, the answer to that question is "maybe." Another question to consider is whether drivers really want their cars to tell them what to do. According to Hayes, "Some do, and some don't."

- Watch seminar or download podcast

A causal model of traffic conflicts and crashes: Minnesota's SHRP2 SO1 project

At the September 23 Advanced Transportation Technologies seminar, **Gary Davis**, professor of civil engineering at the University of Minnesota, described the development of analysis methods for data that are currently being collected by the Strategic Highway Research Program 2 (SHRP2).

SHRP2, funded by Congress in 2006 to investigate the underlying causes of crashes and congestion, focuses on four areas: improved safety through the understanding of driver behavior, infrastructure renewal, reduction of congestion and travel time, and planning for new capacity. Davis noted that SHRP2 is unique because it treats safety as a separate focus rather than a component of another activity.

To better understand driver behavior, SHRP2 researchers will conduct a naturalistic study of driver behavior by outfitting nearly 2,000 vehicles in six locations across the United States with an instrumentation package to monitor drivers' actions. The instrumentation package includes four cameras and front radar. Once the study is concluded, the collected data will be made available to researchers, with the hope that the study will provide more real-world information about driver behavior than researchers have ever had, Davis said.

Davis and his colleagues were involved in one component of SHRP2: the development of analysis methods for the data that will be collected in the naturalistic study. This is important because the number of actual crashes among the 2,000 drivers participating in the field study will probably be fairly small. But researchers are interested in events that explain something about crashes even when no crash occurs. To create a model for analyzing the SHRP2 data, Davis and his team needed to obtain available data like those that will be collected in the naturalistic study.

Davis and his team used vehicle-based data from a completed 100-car pilot study, along with site-based data from the Minnesota Traffic Observatory (MTO) and the Cooperative Intersection Collision Avoidance Systems (CICAS) project. Their analysis focused on the statistical relationship between near-crashes, or conflicts, and actual crashes.

Near-crashes have two features: a counterfactual component and an extremity component. In other words, a crash did not occur ("counterfactual"), but there would have been a crash without "extreme" evasive action. The research team's goal was to develop a method for quantifying these features in actual near-crash events—that is, to express mathematically the degree to which a near-crash could have been a crash.

Davis and his team first created a simple rear-end collision model, using video data collected by the MTO's advanced detection and surveillance stations, which are located on high-rise buildings overlooking I-94 in downtown Minneapolis. A crash occurs when the distance required for the following car to come to a stop is greater than the available stopping distance. When numerical values are assigned to variables in this model, a mathematical computation can determine whether these values will result in a crash.

Using data from all three sources, the researchers also considered near-crash situations with more complicated trajectories than simple rear-end collisions. For each situation, they described driver behavior as a sequence of accelerations. Using that sequence, along with the initial speed and position of the vehicle, they were able to create and solve an equation to determine the degree to which a near-crash could have been a crash.

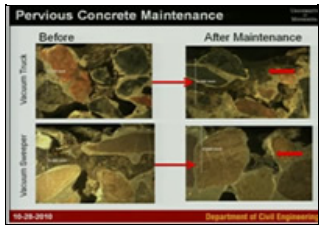
Davis and his team came to the following conclusions:

- Trajectory-based reconstruction is feasible using both vehicle-based and site-based data.
- It is possible to extend methods of counterfactual analysis to differential equation models.
- There is limited evidence that the distributions of evasive actions for crashes and near-crashes overlap.
- The CICAS system, with modifications, could support site-based field research at lower-volume intersections.
- The usefulness of vehicle-based field data will strongly depend on the ability to calibrate and maintain the data-collection systems.

Watch seminar or download podcast

Transportation Infrastructure

"Upside-down" concrete intrigues pavement researchers



From a pavement engineer's point of view, "everything is upside-down" in the world of pervious concrete. Unlike standard concrete, pervious concrete is specially formulated to contain myriad tiny pores that allow water to drain through to the subgrade instead of running off into storm drains. It offers potential benefits in stormwater management, especially in large paved areas such as parking lots. University of Minnesota civil engineering professor **Lev Khazanovich**, a leading expert in pavement analysis and modeling, has been studying the drainage properties and durability of pervious concrete, and presented some of his team's findings at a CTS seminar on October 28, 2010.

Among the most important issues related to pervious concrete, Khazanovich explained, are drainage capacity and durability. Because pervious concrete is not completely solid like conventional concrete, it has different

physical properties including higher flexibility. Khazanovich's research, sponsored by the National Ready Mixed Concrete Association, looked at how pervious concrete stands up to wear over time and how its drainage properties are affected by environmental conditions.

The effect of freeze-thaw cycles on pervious pavement is a particularly important question for paving projects in Minnesota. The researchers asked whether water freezing within the concrete matrix could damage the pavement, leading to cracking or a reduction of its drainage performance. But even without freeze-thaw damage, the porous nature of pervious concrete could, the researchers hypothesized, render it less resistant to repeated mechanical stress from heavy vehicles.

Although testing the mechanical properties of paving materials using small samples in the laboratory is a useful technique, Khazanovich noted that long-term monitoring and testing of real-world pavements is the best way to ensure accurate results. "What we see in the laboratory is not always how things are in the field," he noted, due to the many environmental variables that affect pavement performance.

To study pervious concrete under real-world conditions, Khazanovich turned to the Minnesota Road Research project (MnROAD), which operates a dedicated experimental low-volume roadway for pavement testing. The researchers constructed several pavement sections using pervious concrete and monitored the pavement over time as it was exposed to precisely controlled vehicle traffic on the closed course.

Analyzing the wear and deformation of the pervious concrete proved problematic, however, because conventional pavement-coring techniques damage the porous matrix of the pervious material. The problem was solved by **Kevin MacDonald** of Cemstone, who realized that the concrete's structure could be preserved by saturating it with a clear, non-viscous epoxy while taking the core sample. The epoxy fully penetrates the concrete's porous structure and supports the pervious material as the coring bit cuts out a sample.

The researchers analyzed the pavement samples to determine how much permeability was affected by the accumulation of fine particles in the porous concrete matrix. They found that most fine particles accumulate within the top quarter-inch of pavement, and that even a small volume of particles can significantly degrade the concrete's ability to drain water. Cleaning pervious concrete using vacuum devices is an important maintenance task that can restore much of the material's ability to drain water; however, such cleaning methods are most effective in the uppermost one-eighth inch of pavement, making the removal of deeper particles a significant maintenance concern.

The majority of pervious concrete sections studied proved resistant to freeze-thaw damage, while a few fared significantly worse. However, the researchers were unable to identify consistent factors that made certain pavements more durable in the Minnesota climate. Khazanovich noted that the implications of freeze-thaw damage are not limited to pervious concrete—non-pervious pavements may experience similar effects but manifest damage in different ways due to the higher strength of standard concrete.

One unusual finding from the study was that pavements constructed later in the summer performed better than those constructed early in the season. Previous research has established that conventional concrete pavements tend to perform better when they are constructed earlier in the summer.

The researchers also asked whether the same engineering models used to design conventional concrete pavements could be relied on to predict the performance of pervious concrete given the material's porous and relatively flexible nature. Khazanovich and Vancura compared the results of a traditional and widely used concrete model to the performance of their real-world samples using finite element modeling. They found that the model generally produced good predictions of pervious concrete performance.

The researchers also analyzed subgrade reaction using data from the MnROAD long-term pavement performance database. Model results for both rigid and pervious concrete pavements showed that the performance of both materials differed from the classical model's predictions. Given that the performance of pervious concrete differs from the model in roughly the same way as rigid, non-pervious concrete, the researchers concluded that conventional models could be used in the design of pervious pavements.

However, Khazanovich noted the need to alter the model's parameters to accommodate the new material's modulus of elasticity to avoid overestimating stresses on the pavement. Currently, he said, there exists no fatigue model properly calibrated for pervious pavement, although the StreetPave model appears most relevant to the task. The base layers appear to contribute significantly to the flexural strength of pervious concrete, more so than in the case of rigid concrete. Further calibration of models for pervious concrete applications appears to be necessary to achieve the best results.

- Watch seminar or download podcast

Transit, Bicyling, and Walking

TCRP research publications available online

The federal Transit Cooperative Research Program (TCRP), administered by the Transportation Research Board, provides practical transit research to address technical and operational issues. TCRP emphasizes putting research results into the hands of organizations and individuals that can use them to solve problems.

Recent TCRP publications include:

- *Application of Physical Ability Testing to Current Workforce of Transit Employees* (TCRP Legal Research Digest 34)

Upcoming Events

December 2

Advanced Transportation Technologies Seminar, 3:30 p.m. - 4:30 p.m. CDT, 1130 Mechanical Engineering

December 3

Freight and Logistics Symposium, 7:30 a.m. - 12 p.m. CDT, Ramada Plaza, Minneapolis

December 7

CTS Fall Luncheon: Climate Change and the Transportation Community, 11:30 a.m. – 2:00 p.m. CDT, McNamara Alumni Center, U of M East Bank Campus

February 10

15th Annual TERRA Pavement Conference, St. Paul, MN

May 24-25

22nd Annual CTS Transportation Research Conference, Crowne Plaza, St. Paul, MN