

CTS Catalyst

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Accelerating the pace of transportation innovation

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Where can you walk to work? Study ranks cities for accessibility to jobs by walking

When we think of the cities that are “most walkable,” it’s often in terms of pedestrian networks such as sidewalks and trails. However, there’s another factor at play in determining which cities are truly most pedestrian-friendly: accessibility.

In a new report in the *Access Across America* series from the U of M’s Accessibility Observatory, researchers ranked accessibility to jobs by walking in the 50 largest (by population) metropolitan areas in the United States. Currently, walking is the third most widely used commute mode after

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Low-cost system collects data needed for reducing roadway-departure crashes

Roadway-departure crashes are a major safety issue on both the national and state levels. Rapid advancements in vehicle technology—including systems that warn drivers when they’re leaving their lane or even take control of the vehicle—are opening up possibilities to tackle this challenge. Vehicle manufacturers, however, are unlikely to deploy these technologies widely until high-accuracy maps of lane and road boundaries are available nationwide.

To help acquire this road geometry information, U of M researchers have developed and evaluated a low-cost mobile data-collection platform. Mounted on a vehicle, the system consists of a

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Culverts will be more fish-friendly thanks to U of M research

Photo: SAFL



Installing culverts is a necessary part of most transportation projects, allowing water to pass under roads and other transportation infrastructure. However, when culverts create obstacles for fish and other aquatic life, the consequences can be serious.

“Culverts can create barriers in a stream network that fragment aquatic organism populations,” says Jessica Kozarek, a research associate at the University of Minnesota’s St. Anthony Falls Laboratory (SAFL). “This leaves fish vulnerable to dying off by chance events and can lead to a longer-term loss of genetic diversity.”

To allow fish to pass through culverts, many are installed slightly below streambed level. The expectation is that sediment from the stream will be carried into the culvert, creating a consistent streambed. But does this strategy actually work? A new study from SAFL researchers reveals that it may not always achieve the desired results—and outlines new strategies for making culverts more fish-friendly.

To determine whether setting a culvert below the streambed was enough to enable aquatic organisms to pass through a culvert, researchers created several model streams in their laboratory that represented Minnesota

streams with three different gradients, or slopes. Using these models, they tested the effectiveness of two installation methods: one in which the culvert was placed below the streambed but not filled with sediment and another in which the culvert was pre-filled with sediment.

“We found that pre-filling the culvert with sediment that replicates the streambed as part of the installation process helped prevent upstream erosion and the development of vertical drops that can become barriers to aquatic movement,” Kozarek says. “In addition, pre-filling the culvert helped ensure that the sediment remained inside the culvert when flows were high and when water moved quickly during rainstorms.”

For streams with steep slopes, researchers also found that adding structures such as steps, boulders, and riffles was critical to the stability of the sediment within the culvert. An experiment that used these structures inside the culvert showed that they helped stabilize the streambed upstream of the culvert.

Based on these experiments, the researchers developed design recommendations for embedded culverts where maintaining a natural

streambed to preserve fish and other aquatic organism passage is a design goal. These recommendations include making the culvert as wide as the width of the stream when water levels are highest, analyzing each installation site to predict sediment movement into the culvert, pre-filling the culvert with sediment that matches the sediment in the existing streambed, and installing structures within the culvert for streams with steeper slopes to maintain sediment stability and provide resting places for fish traveling upstream.

“A lot of what was done in the past was not based on research; it was mostly just opinion. This study provides us with real data from testing in a lab setting to help us better design culverts,” says Petronella DeWall, MnDOT bridge waterway engineer. “Moving forward, MnDOT will be using these recommendations when designing culverts in environmentally sensitive areas.”



Photo: SAFL

A model stream in the St. Anthony Falls Lab

Biking and walking are on the rise in the Twin Cities

Throughout the past decade, the popularity and importance of biking and walking have increased significantly across the nation. Pinpointing exactly how people incorporate biking and walking into their travel behavior, however, is a persistent challenge.

In an extensive five-part research study sponsored by the Minnesota Department of Transportation (MnDOT) and the Metropolitan Council, U of M researchers are exploring a rich set of data generated through detailed travel behavior inventories in the Twin Cities region. The data allowed them to analyze changes in walking and biking behavior during the past decade.

“Overall, our team found that auto travel decreased between 2000 and 2010, while biking and walking increased during that time,” says Professor David Levinson, RP Braun/CTS Chair in the Department of Civil, Environmental, and Geo- Engineering (CEGE) and the study’s principal investigator.

Bicycling grew from 1.4 percent of all trips in 2000 to 2.2 percent in 2010—an increase of 58 percent. Walking started with a larger share in 2000 (4.5 percent) and grew by a larger amount to 6.6 percent of trips in 2010—a 44 percent increase. One of the most important findings is that the actual bicycle mode share in the Twin Cities region is two to three times larger than reported by national data.

“Though the private auto still consistently dominates travel in the region, these relatively small mode shares translate to a substantial number of walk and bike trips on an average day in the region,” says Jessica Schoner, CEGE research assistant and lead author of the study. “We estimate about 12 million daily trips across the metro area, which means that on an average day people are making 190,000 bike trips and 735,000 walking trips.”

The researchers noted key differences between bicyclists and pedestrians and their walk and bike trips, including demographics, geography, trip purpose, and trip distance. For example, they found that while men and women



choose to walk at an equal rate, a “gender gap” persists among bicyclists.

“Most of the growth in cycling came from increases in men commuting by bicycle, but closer examination of the gender gap in bicycling revealed some encouraging information,” Schoner says. “The gap appears to be in bicycling participation rates of men and women—there was no observed gap in the frequency of making bicycle trips among cyclists. This shows that programs encouraging women to try bicycling may help to further boost bicycling mode share.”

New bike infrastructure appears to have played a key role in the increase of bicycle mode share in the past decade. “While infrastructure was a significant factor in predicting bicycling in 2001, by 2010 the quantity of bicycle lanes around the home no longer differentiated bicyclists from non-bicyclists,” Schoner says. “This suggests that the Twin Cities’ expanded bicycle infrastructure has created pervasive and easy access throughout the city.”

Greg Lindsey, professor in the Humphrey School of Public Affairs and MnDOT’s first Scholar-in-Residence, is a co-author of the report. He was also the principal investigator of research conducted under MnDOT’s Bicycle and Pedestrian Counting Initiative.

“MnDOT is developing a program to monitor bicycle and pedestrian traffic that is modeled after the motor

vehicle count program,” says Lisa Austin, MnDOT bicycle and pedestrian planning coordinator. “When used together, the traffic volumes and the travel diaries provide a clearer picture of how, when, and why people are traveling. This helps MnDOT and other agencies plan for better systems and analyze safety.”

The first project completed under the five-part study examined how changes in the accessibility of destinations have altered travel behavior in the past 20 years (see article in the February 2015 *Catalyst*). Additional parts of the study will look at the effect of transit quality of service on people’s activity choices and time allocation, changes in travel behavior by age group, and transportation system changes. The *Catalyst* will feature coverage of these projects as they are completed.

On an average day,
Twin Citians make
190,000
BIKE TRIPS
and
735,000
WALKING TRIPS.

Minnesota concrete bridge design detail holds strong under testing

Photo: CFGE



Prestressed concrete is one of the most common materials used today for bridge girders. Since the 1990s, one detail of Minnesota's prestressed concrete bridge design has differed from industry standards. To determine whether this detail was performing well, the Minnesota Department of Transportation (MnDOT) enlisted the help of researchers from the University of Minnesota.

Prestressed concrete girders are made by casting the concrete around tensioned cables. When the concrete hardens, the cables are cut from the forms, transferring their forces to the concrete. The aim is to reduce the likelihood of cracking in the girders, which helps to create a durable system.

"When prestressed girders are cast,

steel stirrups are inserted vertically along the length of the girder," says Catherine French, the principal investigator and CSE Distinguished Professor in the Department of Civil, Environmental, and Geo- Engineering. "MnDOT has specified the use of U-shaped stirrups in its prestressed concrete girders, but national guidelines specify stirrups with bent legs to anchor the stirrups. We wanted to ensure that the U-shaped stirrups are working just as well as the nationally specified stirrups in this application."

Researchers conducted a two-phase experiment to test the performance of the MnDOT stirrups. First, researchers conducted a test to measure the strength required to pull the stirrups out of concrete blocks, simulating the

anchorage conditions in the girders. Next, two full-scale girders (four girder ends) were fabricated and tested to study how well the U-shaped stirrups reinforced the beams for shear, a force that can cause cracking along the sides of the beams at approximately 45-degree angles.

The results of all of the tests showed that the MnDOT-specified U-shaped stirrups performed just as well as would be expected from the nationally specified stirrups with bent legs in prestressed concrete girders. "As a result of this research, we know that the existing Minnesota bridges built with U-shaped stirrups will perform as we expect bridges built with bent-leg stirrups to perform, and that the state can feel confident about building similar bridges using this design detail in the future," says Professor Carol Shield, the co-investigator of the research.

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Research Partnership Award: Better designs for Minnesota concrete pavements

Concrete is the material of choice for many roads. A team of experts recently created a new tool for designing concrete pavements that last longer and cost less—work that earned them the 2015 CTS Research Partnership Award.

The award, presented at the CTS Annual Meeting and Awards Luncheon (see related article on page 5), recognizes research teams that have drawn on the strengths of their diverse partnerships to achieve significant impacts on transportation.

Professor Lev Khazanovich and research associate Derek Tompkins from the Department of Civil, Environmental, and Geo- Engineering worked in partnership with the Minnesota Department of Transportation and the Concrete Pavement Association of Minnesota to develop the new design tool—named MnPAVE-Rigid.

Before this project, MnDOT designed concrete pavements using a program

Partnership award continued on page 6



Photo: MnDOT

Leaders honored at CTS Awards Luncheon

CTS presented the following awards at its Annual Meeting and Awards Ceremony on April 6 in Minneapolis.

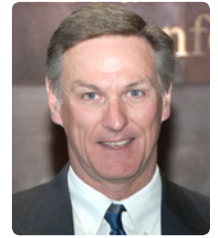
Richard P. Braun Distinguished Service Award

(outstanding leadership in research and innovation)

Timothy Henkel, assistant commissioner and director of the Modal Planning and Program Management Division at the Minnesota Department of Transportation



Timothy Henkel



Brian Lamb

Ray L. Lappegaard Distinguished Service Award

(outstanding leadership, mentorship, and support for the profession)

Brian Lamb, general manager, Metro Transit

William K. Smith Distinguished Service Award

(leadership, mentorship, and education of future leaders in private-sector freight transportation)

Ronald Dvorak, marketing director for Lake Superior Warehousing, the terminal operator for the Duluth Seaway Port Authority's Clure Public Marine Terminal



Ronald Dvorak



D. Scott Dibble

Distinguished Public Leadership Award

(public leaders who have influenced innovative transportation policy directions)

Senator D. Scott Dibble, chair of the Minnesota Senate Transportation and Public Safety Committee



Indrajit Chatterjee



Andrew Guthrie

Education Awards

Matthew J. Huber Award *(students in engineering, science, and technology fields)*

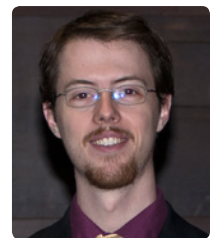
Indrajit Chatterjee, doctoral candidate, civil engineering; Gary Davis, advisor

John S. Adams Award *(students in policy and planning fields)*

Andrew Guthrie, doctoral candidate, public affairs; Yingling Fan, advisor
Spencer Peck, master's candidate, urban & regional planning; Frank Douma, advisor



Spencer Peck



Stephen Zitzow

Roadway Safety Institute Outstanding Student of the Year

Stephen Zitzow, master's candidate, civil engineering; John Hourdos, advisor

Video shows how transportation research makes a difference

CTS aired a new video at the awards luncheon: *How Does University of Minnesota Transportation Research Make a Difference?* Research highlights in the 4:35-minute video include hardier roadside grasses, tribal transportation safety, and clear roads in winter. The video is available for viewing at cts.umn.edu/Publications/Videos.



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GPS receiver capable of receiving real-time corrections, a LIDAR (light detection and ranging) scanner, and a computer—all costing roughly \$40,000.

“Using this hardware, the system was able to detect and position curbs and guardrails with an accuracy of better than 4 inches,” says Brian Davis, a research fellow in the Department of Mechanical Engineering. “It could also determine road centerlines to within 2 inches relying only on the GPS-provided data.”

Also as part of their work, the researchers created an algorithm to process the data after collection to reduce the need for costly manual extraction of road features. Davis co-authored the final report with principal investigator Max Donath, director of the U’s Roadway Safety Institute.

The new system can serve multiple purposes and could especially benefit rural counties, which typically do not have access to high-end data-collection systems. “For example, more accurate measures of road curvature acquired inexpensively and automatically could be used to better match speed limits with curves and provide curve-speed warnings using smartphones, especially where low average daily traffic volumes do not justify signage on a system-wide basis,” Davis says.

Rick West, the project technical liaison and a rural Minnesota county engineer in Otter Tail County, had two goals for the project. “The first one was to determine if low-cost data-collection equipment could be developed,” he says. “The second was whether this equipment would provide data with the necessary level of accuracy without complex post-collection data analysis. Both goals were achieved.”

Up-to-date, detailed information is also needed for other organizational functions, such as maintaining maps for network-level analysis, tracking roadway assets, and assessing pavement quality to inform maintenance decisions. Generally, however, units collect only the information they need to perform their particular function, which leads to multiple, separate data-collection efforts.



Photo: Mechanical Engineering

The sensor platform can be installed on various types of vehicles.

The new system offers a way to make these efforts more efficient. “In addition to collecting data for multiple functions at once, the system can be installed on vehicles already traveling the roads for other purposes, such as MnDOT’s pavement monitoring van,” Davis says. “Data can be acquired without the added operational costs to fund additional drivers and operators.”

In the second phase of the project, researchers augmented the system with a video camera to allow automated fog line detection and location. “Testing demonstrated an accuracy generally better than 3 inches,” Davis says. LIDAR wasn’t needed, which reduced the cost of the sensor suite to \$30,000 for the application.

The study was funded by the Minnesota Department of Transportation, the Minnesota Local Road Research Board, CTS, and the Intelligent Transportation Systems Institute (a former University Transportation Center).

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based on a modified version of a national design procedure from 1981. It was based on outdated data, didn’t take several important factors into account, and produced very conservative designs, Khazanovich says.

The new design tool makes use of the latest design procedure from the American Association of State Highway and Transportation Officials (AASHTO) and incorporates local climate and traffic data, along with calibration specific to

Minnesota pavements. This produces a program that better models concrete pavements and ensures that road designs are suited to local conditions, Khazanovich says.

MnPAVE-Rigid, a standalone Windows executable program, was officially made the MnDOT concrete pavement design program in 2014. It’s now being used by MnDOT district personnel and MnDOT-contracted consultants. New designs are typically one to two inches thinner

than the previous designs, which will significantly reduce construction costs.

More about the Research Partnership Award—including project team members and an enhanced PowerPoint, as well as information about two other projects that received special recognition—is at cts.umn.edu/about/awards/rpa.

Walk to work from page 1

driving and transit, accounting for around 2.8 percent of commute trips nationally and 5 percent within large cities.

The rankings were determined using a weighted average of accessibility, giving a higher weight to closer jobs. Jobs reachable within 10 minutes were weighted most heavily, and then were given decreasing weights as walking travel time increased up to 60 minutes.

The report—*Access Across America: Walking 2014*—presents detailed accessibility values for each metropolitan area, as well as block-level maps illustrating the spatial patterns of accessibility within each area.

“Our report provides a snapshot look at how much economic opportunity exists within a reasonable walking distance in metropolitan areas,” says Andrew Owen, director of the Accessibility Observatory. “In addition, it offers a framework to further our understanding of accessibility by walking. For example, not all jobs are the same—some are higher paying, some are lower skilled, and jobs exist in a variety of industries.”

The cities that make up the top 10 all have a combination of employment density and fast, frequent transit service. “Employment density is a primary factor in whether an area is economically walkable or not, and employment densities are typically high in cities that employ heavy rail systems leading into a central core,” Owens says. “In this way, transit systems promote walkability and walking accessibility, without requiring a user to board a transit vehicle to experience the positive effects.”

The research team included Professor David Levinson, RP Braun/CTS Chair in the Department of Civil, Environmental, and Geo- Engineering (CEGE), and graduate research assistant Brendan Murphy. The research will be useful for other studies, such as a Roadway Safety Institute project now under way, Murphy says. “It gives us a basis for estimating pedestrian traffic in places where we don’t have good data.”

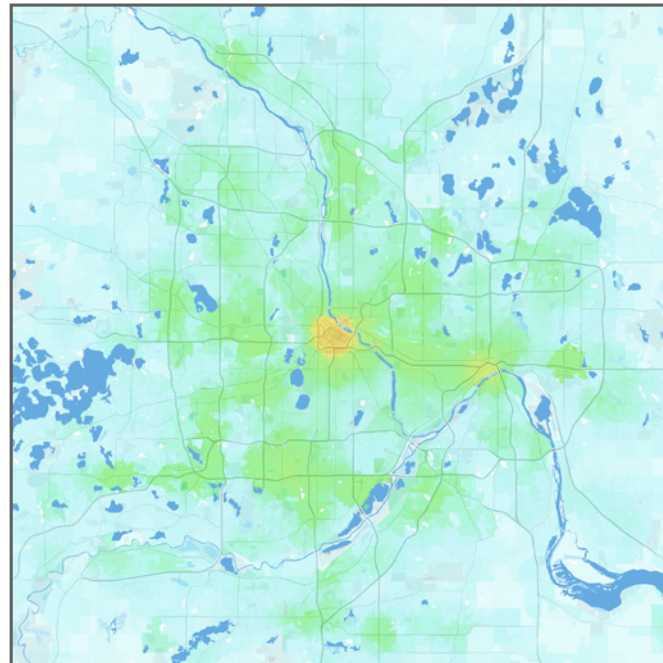
The research was sponsored by CTS and CEGE. The new report is a companion study to previous *Access Across America* reports on transit and auto accessibility. To view reports and accessibility maps from the studies, please visit access.umn.edu/research/america.

Top 10 metro areas: job accessibility by walking (2014)

1. New York
2. San Francisco
3. Los Angeles
4. Chicago
5. Washington
6. Seattle
7. Boston
8. Philadelphia
9. San Jose
10. Denver

Minneapolis

Minneapolis-St. Paul-Bloomington, MN-WI



Jobs within 30 minutes by walking

- 0 - 1,000
- 1,000 - 2,500
- 2,500 - 5,000
- 5,000 - 7,500
- 7,500 - 10,000
- 10,000 - 25,000
- 25,000 - 50,000
- 50,000 - 75,000
- 75,000 - 100,000
- 100,000 - 250,000
- 250,000 - 500,000
- 500,000 - 750,000
- 750,000 - 1,000,000
- 1,000,000 +

— Metropolitan Area Boundary

The Minneapolis–St. Paul area ranked 14th in the study.

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