TRANSPORTATION RESEARCH DIGEST

NOVEMBER 2009

ARIZONA TRANSPORTATION INSTITUTE

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TO: TRANSPORTATION PROFESSIONALS, MANAGERS, & POLICY MAKERS

FROM: ARIZONA TRANSPORTATION INSTITUTE

The volume of information on transportation issues, policies, technologies, and related topics is huge. Not even the most well-read professional can keep up with everything that might be useful to know. The *Transportation Research Digest* series is designed to expedite the transmission of information by condensing and summarizing significant documents. Busy professionals or managers may quickly obtain the gist of new developments and determine whether they need to see the full document.

The *Transportation Research Digest* is not meant to present definitive resolutions of scientific or policy controversies, but contributions to the pursuit of knowledge and the debate of issues. The intent is to be comprehensive rather than conclusive on the multitude of issues and topics of concern to those working in the field of transportation. Readers are encouraged to obtain the original document summarized in the *Transportation Research Digest* and subject the content to their own judgment.

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Transportation Research Digests from December 1995 to November 2003 are available on request.

A "Topic" code in the Table of Contents will help readers more quickly identify items of interest. The topic codes are explained in the table below.

Code	Topic	Code	Topic
ADM	Administration	PLAN	Planning
AIRP	Airports	PRIV	Privatization
AVIA	Aviation	RAIL	Railroads
BIKE	Bicycles	RDSD	Roadside
CON	Construction	ROW	Right-of-Way
ECON	Economics	SAFE	Safety
ENV	Environment	STR	Structures
FIN	Finance	TECH	Technology
INOV	Innovations	TOLL	Toll Roads
MAIN	Maintenance	TRAN	Transit
MISC	Miscellaneous	TRF	Traffic
MVD	Motor Vehicle Dept	TRK	Trucking
PAVE	Pavement	VEH	Vehicles

Requests or inquiries may be made via e-mail (jsemmens@cox.net).

Thank you.

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Should State DOTs Prefer Bicycle Lanes or Wide Curb Lanes? by A. L. Dennison (Arizona Department of Transportation, 206 S. 17th Avenue, Phoenix, Arizona 85007; Ph. 602-712-3138; http://www.azdot.gov/TPD/ATRC/publications/project_reports/PDF/AZ598.pdf) (Jun 2008).

Highlights
- There is no apparent relationship between fatal bicycle/motor vehicle collisions and type of bike facility.
- A significant handicap to any analysis of bicycle travel or safety is the paucity of reliable data.

Bicycle facility advocates have long debated the respective merits of bicycle lanes (BLs) and wide curb lanes (WCLs); this report investigates their claims. A BL, defined by a 6-inch stripe located 5 feet from the curb face, is reserved primarily for bicycle traffic. A WCL (also known as a wide outside lane), alternatively, is at least 14 feet wide; bikes and automobiles share this lane, and can overtake each other without changing lanes. The report provides input from various departments of transportation (DOT) officials on how WCLs or BLs are chosen in their states. The report examines police files of bicycle/motor vehicle collisions in the State of Arizona.

The report has three sections. First, a literature review summarizes the evolution of bicycle facilities legislation, official definitions of BLs and WCLs, their use in various jurisdictions, agency liability, and the ongoing debate between bicycle facility experts. Second, the report gives survey results from bicycle facility professionals at other state DOTs. The third section reviews fatal bicyclist/motorist collision reports from police agencies in Arizona and submits conclusions.

Literature Review
- The United States Congress responded to the call for bicycle facilities with: the Intermodal Surface Transportation Efficiency Act (ISTEA), passed in 1991; the Transportation Equity Act for the 21st Century (TEA-21) in 1998; the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) in 2005. The legislation supported bicycle advocacy in metropolitan and state government, and promulgated bicycling as an efficient travel mode in the nation's transportation system.
- The American Association of State Highway and Transportation Officials (AASHTO) has pioneered bicycle facilities design. Its most significant contribution, Guide for the Development of Bicycle Facilities (1999), reaffirmed the bicyclist's legitimate status on America's roads. This review outlines AASHTO's specifications for WCLs and BLs.
- Applications of BLs and/or WCLs in various jurisdictions are reviewed.
- Agency liability is discussed.
- WCLs and BLs: Experts debate their merits; the review examines the arguments of both sides.

Survey
- Thirty-three DOTs responded (63% of 52 DOTs contacted). This unscientific

sample revealed no overall bias for or against BLs or WCLs.
- Several officials reported that municipalities are responsible for planning bicycle facilities.
- Respondents called for all stakeholders to help plan bike facilities early enough to embed their proposals in the planning process.
- Respondents said space constraints guided selection of bicycle facilities.
- According to one respondent, limited space designated WCLs the only choice; another official stated that city authorities viewed BLs as "traffic calming" despite narrow roads.

Crash Analysis

- We searched 85 bicyclist/motorist fatal collision reports filed by Arizona police agencies in 2003 – 2006 for any relationship between crashes and bicycle facilities design.
- We believe that none of these fatal collisions was attributable to a WCL or BL, based on the evidence.
- Apparently, no crash resulted from road conditions or road design, with three possible exceptions: 1) A tricyclist traveling in "what appeared to be a small lane 2 to 3 feet wide;" the lane's width would not have met AASHTO guidelines for a BL. 2) A dedicated right turn lane was closed for construction; a motorist turned right from the number two lane, colliding with a bicyclist who may have expected the motor vehicle to proceed straight. 3) Ice on the road may have contributed to a bicyclist's loss of control when colliding with a motor vehicle.
- Crashes apparently followed human error, chiefly "failure to yield."

Conclusion

This study found no apparent relationship between fatal bicycle/motor vehicle collisions and type of bike facility. Consequently, there are no hard engineering data to support a recommendation on the type of facility that ought to be preferred. A significant handicap to any analysis of bicycle travel or safety is the paucity of reliable data. For roadway travel there are continuing and consistent efforts to count and classify the traffic. There are no similar programs for measuring or estimating the volume of bicycle travel. If we are to get serious about this mode of travel, steps to improve data collection are necessary if we are to make informed decisions on how cost-effectively to accommodate bicycle travel.

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Optimized Design of Concrete Curb under off Tracking Loads by Chul Suh, Soojun Ha, Moon Won, Center for Transportation Research, University of Texas at Austin, 3208 Red River, Suite 200, Austin, TX 78705-2650 (Texas Department of Transportation, Research and Technology Implementation Office, P.O. Box 5080, Austin, TX 78763-5080; http://www.utexas.edu/research/ctr/pdf_reports/0_5830_1.pdf) (Dec 2008)

Highlights

- Off tracking of truck loadings is the main cause of curb damage.
- The use of epoxy-grouted bars as the vertical reinforcement of the CCCG system is the best practically available option.

The following conclusions are made on the basis of the results of this study.

1) Most research studies in the PCC pavement area focus on addressing distresses related to pavement structure itself. As a result, the design and construction of other structural elements of the concrete curb and curb and gutter (CCCG) system have been overlooked and little research has been done in this area.

2) The literature search conducted shows that little research work has been done on CCCG structural design. Instead, most of the research effort has focused on the safety effectiveness of curbs and the use of curbs in conjunction with traffic barriers.

3) Visual inspection of damaged CCCG systems was conducted in the field. All damaged CCCG systems were the TxDOT Type II system and almost all damaged CCCG systems were found at U-turn curbs. It is concluded that the off tracking of truck loadings was the main cause of the curb damage. Failure occurred regardless of vertical tie bar spacing and joint spacing.

4) The FHWA's cost calculation model to upgrade roadways to accommodate off tracking includes widening the lanes for sharp curves and moving curbs back. Although these geometric changes of the curb design are the fundamental solutions for the off tracking failure, it is not feasible in most cases due to economic and space limitations.

5) The pullout tests for the dowel bars installed in the CCCG system were performed in order to investigate the ultimate bond strength of the vertical dowel bars. The manually inserted straight bar into the fresh concrete showed the least bond strength; the drilled and epoxy-grouted dowels showed the best performance in terms of bond strength. The use of epoxy-grouted bars as the vertical reinforcement of the CCCG system is the best practically available option for the new construction of CCCG systems.

6) Extensive finite element analysis was performed based on the new U-turn curb design of the TxDOT Houston district. Three design parameters were considered for calculations: the loading condition, the curb width, and the location of curb dowel.

7) From the results of finite element analysis, the following conclusions can be made:

a. Horizontal loading is the most critical loading condition when assessing the structural adequacy of a CCCG system.

b. The structural capacity of CCCG can be enhanced by increasing the curb width and/or by inserting the curb dowel farther from the inner surface of CCCG.

c. It is necessary to consider economic efficiency and constructability when designing the CCCG system because the curb width and the location of curb dowel are limited in their ability to enhance the structural capacity of CCCG.

d. The changes in the concrete stress are minimal if the curb widths of CCCG exceed 24 in.

e. The effect of the location of the curb dowel becomes insignificant when the distance between dowel and the traffic face of a CCCG exceeds 8 in. Based on the research efforts in this study, the following recommendations are proposed.

These recommendations could be used as guidelines for the new construction of CCCG systems for the areas experiencing off tracking load conditions.

1) The use of new U-turn curb design from the TxDOT Houston district is highly recommended to mitigate the effects of the off tracking of heavy vehicles.

2) Although the current dowel bar location of the new U-turn curb design is found to be structurally adequate, it is recommended to change the location of the curb dowel to be further from the traffic face of a CCCG system for better performance. A distance between the location of dowel and the traffic face of CCCG of 8 in. or higher is recommended.

3) Curb width of 24 in. or higher is recommended to provide adequate structural capacity.

4) It is also recommended to use an epoxy-grouted curb dowel instead of a manually inserted straight dowel bar to ensure better bond performance between dowel bar and concrete in a CCCG system.

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Customer Service at MVD Field Offices by Ian Tingen, David Lovis-McMahon (Arizona Department of Transportation, 206 S. 17th Avenue, Phoenix, Arizona 85007; http://www.azdot.gov/TPD/ATRC/publications/project_reports/PDF/AZ544.pdf; Ph. 602-712-3138) (Jun 2008).

Highlights

- Arizona is ahead of the curve in terms of documenting customer service methods.
- Arizona's practices are some of the best in the nation.
- Wait times at the MVD are greatly increased by a phenomenon known as social loafing.
- Customer factors play little, if any, part in increased wait times.
- Remediation of social loafing factors should be implemented to reduce current problems.

Arizona's Department of Transportation (AzDOT) has many things to be proud of – a strong dependence on statistical evidence, one of the most thorough data collection procedures in the nation, and a willingness to use those things to better processes. Before continuing too far, we also must reiterate the fact that there is little to compare Arizona to because of its reliance on good data and methodology. Few, if any, other states are even able to come close to the soundness of these processes. Because of this, the authors recommend using the best practices of this state against itself for benchmarking and measurement of success, all the while keeping the message of the Transportation Research Board (TRB) report at the forefront of future directions. At this point, Arizona has started down a great track. These next points are made while keeping this tradition in mind.

First, the phenomenon of social loafing is the most prevalent finding of this study. After carefully analyzing a bevy of factors ranging from customer traits to layout of the actual offices, the conclusion is clear. This is not something that is unmanageable in any way; in fact it is a rather common problem in workplaces, and one that can be remedied quite effectively, given the proper investment in looking at the sources of downturn unique to each group of workers. This problem is easy to generally identify, but specifics of each situation may vary widely.

That is why the next steps to reducing this problem are crucial. In order to effectively combat the diffusion of responsibility phenomenon, it is of the utmost importance to understand how it works uniquely in each situation. Differences can include, but are not limited to: visibility of personnel's individual contribution, visibility of group personnel efforts, ratio of personnel to supervisors, ratio of personnel to customers, length of shift, office design, etc. The next phase of this study should look at these and all other contributing factors in order to remedy the problem.

The future implications for this study and ones to follow it are rather straightforward: AzDOT Motor Vehicle Division (MVD) field offices have an affliction common to many large-scale workplaces. Through careful measurement and study, this problem can be at least partially nullified. We suggest a thorough study of the most highly trafficked MVD offices to understand how diffusion of responsibility affects each of them. From that study, proper incentive structures and remediation strategies can be developed and

implemented. This will benefit MVD in three poignant ways. First, wait times will be reduced greatly, and customer satisfaction should improve as a result. Second, MVD Customer Service Representatives (CSRs) will be encouraged in very organic ways to keep their level of service high. Third, Arizona will be a trendsetter yet again in providing the very best service available via a mix of social science and applied business practices.

General Remediation Strategies

In general, diffusion of responsibility can be remedied through increasing the identifiability of the individual's contribution to the group workload. In ideal situations, constant feedback is the best way to increase this. If such a strategy is not practical, then periodic updates of efficiency can help ameliorate the problem.

With especially large groups, another way to increase efficiency is to create smaller groups that are part of the whole. For example, splitting 20 people in to four smaller groups of 5 can help individuals realize their contribution to the whole. When used in conjunction with the identifiablity suggestions from above, this can prove to be a very useful tactic.

It should be noted that well-structured reward programs can also be incentives to improve performance, given that the path from individual performance to group performance to reward is made salient, and that the group is able to deal with freeloaders in a quick manner.

It should be stated again, however, that these strategies are general. Targeted, specific programs are always better at amelioration than "blanket strategies."

Recommendations

- An in-depth study of each of the highest volume offices is necessary to remedy the problem.
- General remediation strategies will yield some results, but if cost is an issue, targeted studies should be conducted
- Detailed data should be kept on CSR's and transactions at each MVD office.

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Assessment and Rehabilitation Methods for Longitudinal Cracks and Joint Separations in Concrete Pavement by Megan Stringer, Taylor Crawford, David Fowler, James Jirsa, Moon Won and David Whi, Center for Transportation Research, University of Texas at Austin, 3208 Red River, Suite 200, Austin, TX 78705-2650 (Texas Department of Transportation, Research and Technology Implementation Office, P.O. Box 5080, Austin, TX 78763-5080; http://www.utexas.edu/research/ctr/pdf_reports/0_5444_2.pdf) (Oct 2008)

Highlights

- Repair and new construction procedures for longitudinal cracking and joint separations in concrete pavements have been determined.

Longitudinal cracking and longitudinal joint separations in concrete pavements have plagued the state of Texas and have become an expensive maintenance endeavor. This uncontrolled cracking and joint separation at the longitudinal construction joint has often led to corrosion of the steel reinforcement and the erosion and pumping of the base layer due to moisture penetration through the cracks and joints. This then results in open cracks, spalling, and slab faulting, researchers examined the causes of the distress and developed and tested methods for repair and prevention. Email and phone surveys were distributed to TxDOT engineers, other state Departments of Transportation and industry organizations, and a literature review was conducted to determine the current state of practice. Field investigations were conducted on numerous concrete pavements throughout the state to determine the cause(s) of distress and to determine if anything has been successful in mitigating the distress. Finite element modeling was conducted to examine the relative magnitude of stress that proposed repair methods introduced onto the concrete pavement. Experimental tests were conducted to determine strengths and weaknesses of each repair method under various loading conditions encountered in the field.

Various sizes, spacings, shapes, and placement methods for transverse steel and tie bars were investigated and evaluated. Lastly, a field trial section was selected, so the findings from this research project can be evaluated. The field trial section will not only implement and assess slot stitching, but will also include leveling up depressed slabs with a latex modified concrete overlay.

Conclusions

Upon completion of the research project, the researchers have developed repair and new construction procedures for longitudinal cracking and joint separations in concrete pavements have been determined. Also tie bar and transverse steel designs have been developed. The Districts should monitor their pavements carefully, noting any longitudinal cracks or joint separations. Once cracks or separations have been identified, FWD tests should be performed on a representative sampling of locations, including the best and worst instances of the distress.

The following conclusions regarding longitudinal cracking and joint separations in concrete pavements have been made:

1. Longitudinal cracking in JCP is most often caused by shallow and possible

late saw cutting of longitudinal warping joints.

2. Longitudinal joint separations are caused by corrosion of tie bars in conjunction with dynamic traffic loading.
3. Longitudinal cracks should be repaired as soon as possible after identification to prevent further deterioration and separation. Repairing the cracks early saves money in the long term.
4. Cross stitching should be used to repair cracks/separations that are fairly tight. For wider cracks/separations slot stitching should be used.
5. Slot stitching is the most economical repair method for restoring load transfer, preventing separations, and improving performance of longitudinal joints and wide cracks.
6. Corrosion and shear were found in association with tie bar failures, therefore #6 bars should be used instead of the specified #4 bars.
7. In this study, there was no direct correlation found between DCP readings and the likelihood of longitudinal cracking or joint separations. But when lower modulus values were found, the possibility of problems with longitudinal cracking and joint separations was greater.
8. Voids were found under faulted slabs. An underseal should be inserted into the voids to re-establish uniform support for the slabs.
9. When taking LTE readings, the deflections associated with the LTE test locations need to be known to determine the condition of the pavement. A high or low LTE reading can be misleading; a high LTE reading does not necessarily mean the pavement is in good condition. However high measured deflections always means the slabs have low LTE.

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The Real Threat to America's Infrastructure by Randal O'Toole in *Liberty* (P.O. Box 20527, Reno, Nevada 89515; http://www.libertyunbound.com) (June 2009)

Highlights
- Planned spending on passenger rail will yield a poor return for America.
- Highways provide more transportation per dollar invested.

Most Americans believe we are suffering some sort of infrastructure crisis and that Obama's stimulus bill went far towards solving that crisis. Both these ideas are flat-out wrong. The crisis was entirely fabricated by special-interest groups seeking to attract more pork. Although the final stimulus bill totaled $787 billion, the vast majority of that money had nothing at all to do with infrastructure. Most of the bill goes for tax breaks or tax credits ($376 billion), health care ($154 billion, including aid to state Medicaid programs), state "fiscal stabilization" ($56 billion), and education ($51 billion).

Deducting these and a few minor programs from the package leaves about $142 billion, or 18%, for infrastructure -- although even some of this isn't really for that purpose. It is likely that most of the real infrastructure money will go for new projects, not repair or replacement of existing obsolete or deteriorating infrastructure. Nearly $51 billion is for wind-farms and other "green" energy projects. Another $7.2 billion is for broadband telecommunications. Some $25 billion goes to various federal agencies for things like new buildings and making existing buildings more energy efficient.

After all the hullabaloo about crumbling bridges, Congress did not specifically allocate a single dime to bridge repair. Instead, it dedicated $27.5 billion to highways. Most of this will go to metropolitan areas and cash-strapped states that are not likely to share much with the rural counties that own most of the nation's structurally deficient bridges.

Another $8.4 billion is for transit, most of which will be spent on new construction, not maintenance. Cincinnati, Milwaukee, Portland, Washington, and other cities have announced their plans to dedicate a large share of their funds to new streetcars or light-rail construction. Even if these rail lines are completely funded by federal stimulus funds, all they will do is obligate cities to divert funds from other worthwhile programs to pay for operations and maintenance.

This brings up a curious contradiction. When it comes to highways, the mantra of the anti-mobility crowd is "fix it first," meaning don't expand highway capacities until all maintenance needs are met. When it comes to transit, however; the same people want to spend money building new rail lines even when existing lines are in desperate need of repair.

Were it not for diversions to transit and resistance to toll roads (which is particularly strong from people who want no new roads at all), highway user fees would be more than sufficient to pay both for new roads and for the maintenance of existing ones. So there should be no reason to adopt a fix-it-first policy for roads.

Transit, particularly rail transit, is different. Like highways, rail transit lines must be completely rebuilt about every 30 years, but unlike highways, few transit agencies have the funding to do such reconstruction. Most rail

transit agencies are in desperate financial straights: New York City has only $13 billion of the $30 billion it needs to maintain its subways and commuter lines. Washington DC's subway riders have to deal with frequent breakdowns because the agency has none of the $12 billion it needs for rehabilitation. San Francisco's' Bay Area Rapid Transit (BART) has about half of the $12 billion it needs for reconstruction.

Given these dire conditions, you would think the agencies would adopt a fix-it-first policy. Instead, New York has started construction on the 8-mile Second Avenue subway line that will cost $16.8 billion - $2.1 billion per mile. Virginia twisted arms in the Bush administration to get approval for a $6 billion rail line from Washington DC to Dulles Airport. BART is building another $6 billion line to San Jose, a line which -- the agency's environmental impact report predicts -- will not save a single traveler a single minute of time during rush hours.

In addition to increasing the ratio of funds going to transit, the stimulus bill also included a surprise: $8 billion for high-speed rail This was specifically inserted at the request of President Obama, who said he wanted to make high-speed rail his "signature issue" in the stimulus package. Rather than keeping his promise to "rebuild America," it seems likely that Obama's true goal is to "re-socially engineer America" by heavily subsidizing transit and discouraging auto driving.

Given that the infrastructure crisis was entirely fabricated and that transportation and most other infrastructure should be able to pay for itself out of user fees, the stimulus bill was entirely unnecessary. If Congress really wanted to stimulate the economy, it should have offered state and local governments low-interest loans that would be repaid out of future user fees. This would have ensured that any infrastructure built from the loans was actually necessary.

What is the likelihood that high-speed rail and urban rail transit can transform America, as Obama and his supporters hope? The best answer can be found by looking at other countries that have built high-speed rail Japan has spent as much, and France has spent about half as much, *per capita*, on high-speed rail as we spent on the Interstate Highway System. The average American travels 4,000 miles a year and ships 2,000 ton-miles a year on the interstates. By comparison, the average residents of France and Japan travel only 400 miles per year on high-speed trains, which carry virtually no freight. While almost every American regularly uses interstate highways, it is likely that a few French and Japanese use high-speed rail a lot and most rarely or not at all.

Interstates paid for themselves out of gas taxes, and most Americans use them almost every day. Moderate or high-speed rail would require huge tax subsidies and would regularly serve only a small elite. Which is the better symbol for the America that President Obama wants to build?

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The Tensile Capacity of Welded Shear Studs by Joshua M. Mouras, James P. Sutton, Karl H. Frank, Eric B. Williamson, Center for Transportation Research, University of Texas at Austin, 3208 Red River, Suite 200, Austin, TX 78705-2650 (Texas Department of Transportation, Research and Technology Implementation Office, P.O. Box 5080, Austin, TX 78763-5080; http://www.utexas.edu/research/ctr/pdf_reports/9_5498_2.pdf) (Oct 2008)

Highlights

- Different configurations of the shear stud connections were evaluated to find alternate geometries with better strength and ductility characteristics.

Steel box girder bridges are fracture critical only if they are unable to support load after a fracture event. Key to bridge survival after a fracture is support of the fractured girder by the remaining structure through the transfer of load by the shear studs acting in tension. The ability of the shear stud connections to carry these tensile loads in a ductile fashion is vital to supporting a fractured girder.

The current TxDOT standard shear stud detail in a haunch has been shown to have both a very low tensile strength and virtually no ductility. Different configurations of the shear stud connections were evaluated to find alternate geometries with better strength and ductility characteristics. The effects of dynamic loading from a fracture event were also investigated, along with the effects of eccentric loading of the connections.

Conclusions

Tests on the 48 shear stud connection specimens produced several clear conclusions on the connection behavior:

1) If the studs are tall enough that their failure cones (which propagate at 45 degrees) enclose reinforcement in the breakout cone concrete, the connection will have a high tensile strength and substantial ductility.
2) For connections with studs tall enough to engage the reinforcement, longitudinal spacings of the shear studs less than three times their effective stud height apart develop the most ductile behavior. Studs spaced longitudinally greater than three times their effective stud height apart have a higher strength than a similar number of studs in a group failure, but with less ductility. Once studs are spaced less than three times their effective stud height apart, their failure cones overlap and closer stud spacings will not increase connection strength. Therefore, the most efficient spacing is exactly three times the effective stud height. The full engagement of multiple bars of reinforcement also helps increase the strength. Once studs are spaced within the distance needed to create cone overlap, additional studs will not significantly increase a connection's strength.
3) For connections with studs tall enough to engage the reinforcement, transverse spacing of the studs can develop both strength and ductility, though not as much as for studs spaced longitudinally. This limited benefit is due to transverse studs only being able to engage rebar near the edge of the breakout cone,

making the rebar more prone to separation at large displacements.

4) Connections without studs tall enough to engage the reinforcement have lower strengths and little to no ductility compared to configurations that do engage the rebar. This lack of ductility applies regardless of whether the studs are spaced longitudinally or transversely.
5) For connections with ductile behavior, the presence of a haunch can improve strength by reducing flexural cracking around the shear studs. This lack of cracking prior to peak load allows monolithic concrete cone breakout. For connections that exhibit brittle behavior, the haunch is detrimental. For brittle connections with studs spaced longitudinally, the haunch does not contribute any ductility to the connection, while for brittle connections with studs spaced transversely, the haunch reduces strength and ductility.
6) Dynamic loading of shear stud connections in tension increases the strength of the connection, with the level of increase related to the configuration of the studs in the connection. Longitudinal stud spacings have a dynamic strength factor between 1.15 and 1.18, while transverse and single stud spacings have a dynamic strength factor between 1.29 and 1.43. Dynamic loading slightly reduces the ductility of connections, but otherwise does not change their behavior from static loading conditions. Eccentric loading of shear stud connections reduces the strength from concentric loading, but causes only a small reduction in the ductility.

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Enhancing Transit Safety and Security with Wireless Detection and Communication Technologies by Sean Barbeau, Miguel Labrador, Phil Winters, and Nevine Labib Georggi, National Center for Transit Research, at the Center for Urban Transportation Research, University of South Florida, 4202 E. Fowler Ave. CUT100, Tampa FL 33620-5375 (Florida Department of Transportation, 605 Suwannee Street, MS 30, Tallahassee FL 32399http://www.nctr.usf.edu/pdf/77714.pdf) (Nov 2008)

Highlights

- This report describes a low-cost wireless sensor networks based system that monitors and notifies of intrusions in remote and unattended facilities of a given transit agency.

This report describes a low-cost wireless sensor networks (WSN) based system that monitors and notifies of intrusions in remote and unattended facilities of a given transit agency such as a parking garage or yard. The WSN-IRNS (intrusion and remote notification system) prototype is equipped with infrared sensors and magnetometers to detect person and vehicle intrusions. Further, upon the detection of an intrusion, the system takes a picture and sends a notification to the appropriate designated security personnel via a multimedia message to a cellular phone or an email to a regular email account.

WSN-IRNS was developed using off-the-shelf commercially available hardware. The prototype was tested and evaluated on the University of South Florida (USF) campus as well as outside the Pinellas Suncoast Transit Authority (PSTA) facility in St. Petersburg, FL. These tests demonstrated the need for system tuning and customization according to the place of installation. Every environment has different physical characteristics that affect the propagation of the signals and sensitivity of the sensors, which can potentially cause the system to report an excessive amount of false-negatives or false-positives. Therefore, *insitu* tuning is of utmost importance to guarantee appropriate performance of the system. For example, during initial field tests at PSTA a nearby metal pipe caused the system to issue multiple false positive alerts as a result of the readings from the magnetometer. After the field tests at PSTA, further threshold tuning was performed in a similar environment at USF and the alert logic was adjusted to only issue notifications when the infrared sensor detected motion, which yielded much better performance with far fewer false positive alerts.

During the life of this project, the WSN intrusion detection kit utilized in this research was discontinued in anticipation of the commercial release of updated technology. Therefore, it is imperative to build a similar system using individual parts available in the market. New sensors need to be found and connected to regular off-the-shelf motes. Although the connection of new sensors to the motes will imply software modifications, these are expected to be minor in scope. The availability of new sensors will require additional investigation efforts.

During testing at PSTA's facilities, the transit agency identified the bus garage main gate as an area where a WSN system such as WSN-IRNS could bring benefits to many transit agencies. Future work, outside of this project contract, will focus on fine-tuning this

system to identify person intrusion detection at the agency's bus garage main gate while allowing buses to pass through without triggering alarms. These modifications will include altering the alert-triggering logic and sensors thresholds in the WSN software appropriately so that an alert is triggered only when the infrared sensor detects movement and the magnetometer does not detect a vehicle, instead of the current configuration which always issues an alert when the infrared sensor detects movement. This modified system will allow the facility to increase the efficiency of operations and avoid equipment malfunctions by leaving the physical gate open for arriving and departing buses while protecting the property from intrusion by an individual on foot.

For extremely time-sensitive applications, the end-to-end time delay of approximately 40 seconds observed in prototype testing between sensing an intrusion and the receipt of the notification at the mobile phone could potentially be reduced by relying on IP-based communication between the application server and the mobile phone instead of messaging protocols such as SMTP and MMS. These modifications are likely to significantly reduce the largest time delay in the system. However, this alternate architecture would require a mobile WSN-IRNS software application to be developed and installed on the mobile phone as well as more sophisticated WSN-IRNS application server software that would communicate directly with the mobile phone software. Possible performance tradeoffs resulting from this different system architecture would also have to be examined. This work could be accomplished in future research projects.

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Implementing a Statewide Rideshare and Vanpool Program in Arizona by Eric N. Schreffler, Jennifer Gregory, Wendy Morgan, Peter Valk (Arizona Department of Transportation, 206 S. 17th Avenue, Phoenix, Arizona 85007; Ph. 602-712-3138; http://www.azdot.gov/TPD/ATRC/publications/project_reports/PDF/AZ610.pdf) (Jun 2008).

Highlights

- Rideshare programs and services are typically funded and managed at the regional or local level and not at the state level.
- An implementation plan was developed for rideshare and vanpool programs in non-metropolitan areas.

The purpose of SPR 610 - *Implementing a Statewide Rideshare and Vanpool Program in Arizona* is to investigate the potential of a statewide rideshare and vanpool program in Arizona. The project involved the following task deliverables: a literature review, a survey of state departments of transportation (DOTs), a needs assessment, and an implementation plan.

For the first task, the literature review, the team examined existing information on effective rideshare and vanpool programs, such as incentives to try and to use carpools and vanpools, work hour flexibility for rideshare users, and easy-to-use services to find rideshare partners. The team also examined relevant research on the logistical operations of rideshare and vanpool programs, such as organizational structure, staff roles and responsibilities, and vanpool formation and fares.

Using the information collected in the literature review as a guide, the team then developed and administered a survey to DOT agencies across the country. The survey gathered data on the current role of state DOTs in the implementation and delivery of rideshare programs and services. Nine DOT agencies or similar organizations participated in the survey. The findings revealed that rideshare programs and services are typically funded and managed at the regional or local level and not at the state level. State DOTs that are involved in ridesharing programs largely focus their efforts in several key areas, including: vanpool fleet acquisition or loans, pooled insurance, and statewide contracts; referral of calls to a statewide phone number for an appropriate regional or local program; and integration of ridesharing into state-wide plans or policies.

In the next step, the team gathered information on the need and support for ridesharing and vanpooling services in key areas around the state outside of Maricopa and Pima Counties. After identifying, contacting, and interviewing people in a select number of areas throughout the state, the team identified two target areas—Flagstaff and the Kingman/Bullhead City/Lake Havasu City area—as most suitable for the development and deployment of rideshare and vanpool programs.

The final task was to develop an implementation plan for AzDOT to follow. The plan that was developed has the following four recommendations:

1. Flagstaff – The team recommends that Arizona Department of Transportation (AzDOT) assist with the start-up of a ridesharing initiative in the Flagstaff area. The team recommends that the Flagstaff Chamber of Commerce undertake employer outreach and

help coordinate ridesharing services offered by the Flagstaff Metropolitan Planning Organization (FMPO) and the local transit authority. This action will provide the needed marketing for the ridematching system acquired from Valley Metro in Phoenix. The new partnership between the Chamber, the Flagstaff MPO, and Northern Arizona Intergovernmental Public Transportation Authority, (NAIPTA) can also promote and form vanpools for commuters with long distance commutes.

2. Kingman/Bullhead City/Lake Havasu City area – The team recommends that a more detailed feasibility study be conducted for these three cities in Mohave County. While the need for ridesharing services is fairly apparent, the means to coordinate and provide these services are not. Therefore, the team recommends conducting a feasibility study and pilot project to test the demand for commuter services.

3. Identification of Future Priority Areas – The team recommends periodic assessments be made with local chambers of commerce, key local agencies, and AzDOT district offices to determine if conditions warrant the offering of ridesharing services to address congestion and mobility issues in key corridors or areas.

4. Role of AzDOT in Fostering Statewide Services – Several supporting activities are available for AzDOT to undertake to facilitate the growth of carpooling and vanpooling in non-urban areas. First, AzDOT can support a statewide ridematching service similar to that provided by Valley Metro to Tucson and Flagstaff. AzDOT can also assist with new vanpool acquisition. Furthermore, AzDOT can provide technical assistance, guidance and start-up funding to areas interested in creating a new ridesharing program. AzDOT can also convene ridesharing program managers from around the state for networking, training, and technical assistance.

These general recommendations, pilot study, and implementation plan provide AzDOT with a guideline to implement rideshare and vanpool programs in non-metropolitan areas of Arizona as well as engage in new activities to support the implementation of statewide services. With this plan in place, AzDOT should have the proper tools and guidance to increase services to commuters, reduce traffic congestion, and improve air quality in Arizona.

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Field Tests and Analytical Studies of the Dynamic Behavior and the Onset of Galloping in Traffic Signal Structures by Micah J. Florea, Lance Manuel, Karl H. Frank, Sharon L. Wood, Center for Transportation Research, University of Texas at Austin, 3208 Red River, Suite 200, Austin, TX 78705-2650 (Texas Department of Transportation, Research and Technology Implementation Office, P.O. Box 5080, Austin, TX 78763-5080; http://www.utexas.edu/research/ctr/pdf_reports/0_4586_1.pdf) (Jun 2008)

Highlights

- Modifying a traffic signal structure's aerodynamic properties is the most effective method to eliminate galloping.

The research documented in this report was part of a joint project with Texas Tech University aimed at investigating the load effects caused by galloping. The work performed on this topic at The University of Texas at Austin was broken up into two concentrations: analytical modeling and field tests.

A computer program created from the analytical model developed was utilized in parametric studies and to investigate the galloping potential of the structures at the specific field test sites. The analytical model showed that modifying a traffic signal structure's aerodynamic properties is the most effective method to eliminate galloping potential. This can be achieved by attaching traffic signals that only have positive aerodynamic damping potential, or by attaching a damping wing (also known as a sign blank) to the tip of the mast arm to counteract the negative aerodynamic damping of the signals. The latter option appears to be more desirable because it could be implemented on traffic signal structures already in service, and it would allow for back plates to be attached to the traffic signals, which is TxDOT's currently adopted practice. Although some insights on effective placement and length of damping wings were gained through parametric studies, limited data was available to perform the studies. Additional tests need to be run to determine the aerodynamic properties of variably oriented wings to be able to efficiently design them. The wings that have currently been installed on many signal structures throughout Texas tend to be very short and are attached directly to the mast arm. These attachments, in general, are probably not reducing the galloping potential of the structure at all, and a more effective application of the damping wings should be investigated and implemented.

For the field tests, three different sites, chosen because of the history of prior observed large amplitude displacements there, were instrumented and monitored for a total of 9 months. During this time, some large-amplitude displacements occurred, but no sustained galloping events took place. These findings underline the fact that galloping is an infrequent occurrence. In fact, galloping is not even possible for many traffic signal structures, and therefore it is not necessary to design all structures to resist galloping forces. However, one must determine which structures will not gallop in order to know which structures do not need to be designed for galloping. Thus, both the aerodynamic properties of signals and damping wings need to be investigated in more detail.

During the field tests, some unexpected behavior was also observed. The first observation was that at all three sites, the largest amplitude vibrations were caused by wind not directly perpendicular to the mast arm, but occurring at an angle to the arm. The possibility of this wind condition producing the worst-case scenario for galloping has typically not been included in past research, and should be taken into consideration in future work. Another observation in the field was that the strains near the welded connection of the mast arm to its base plate were unpredictable and appeared to have concentrations at various locations. This phenomenon has been detected in previous research, but the stress concentration has never been explored in the field. These stress concentrations, unique to each structure, may be a key factor in traffic signal structure failures since quite often nearby signal structures have experienced similar loading conditions but have not failed. The stress concentrations near the connection should be considered in future research studies of traffic signal structures.

Suggested Revision to AASHTO Specs

With specific reference to the design equation for galloping in Section 11.7.1 of the AASHTO Specifications, no actual galloping events were recorded in the field tests of the present study from which one can assess the acceptability of the equivalent static pressure used for design. However, on the basis of the analytical studies conducted as part of the present study, it was shown that the forces induced by galloping depend on the location of the attachments (signals, panels, etc.) on the arm. Greater forces are expected at locations closer to the tip of the arm. The expectation is that the Specifications should probably recognize that a panel of the same area at different locations along the arm will likely not experience the same vertical shear range. Additional work in this area is suggested so that the design equation may be appropriately modified in the future.

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Seattle's Long-Range Plan To Beat Traffic Congestion by Samuel Staley (*Puget Sound Business Journal*, 801 2nd Ave # 210, Seattle, WA 98104; ph. (206) 583-0701; http://reason.org/news/show/1007412.html) (Apr 24, 2009)

Highlights

- Relieving congestion over the next 20 years throughout the Seattle-Tacoma-Bellevue urbanized area would cost between $5 and $10 billion, but add as much as $13 billion to the regional economy.

The Seattle-Tacoma-Bellevue urbanized area ranks among the nation's most congested places, a result of strong growth, geography and a failure to keep its transportation network on par with the needs of the region's rising wealth. In fact, the area is on track to match current-day Los Angeles levels of congestion if major upgrades to the road network aren't implemented now, even with the fall in demand triggered by last summer's gas prices and the current global recession.

The good news is that Puget Sound isn't necessarily destined for a congested future. It will, however, take leadership, cutting-edge technology, and a willingness to meet the needs of a globally competitive, service-based economy that values mobility.

Fortunately, the region is ahead of the curve. Washington has at least acknowledged the problem through the state auditor's study "End Congestion Now." State and local policymakers have committed to a deep-bore tunnel to replace the Alaskan Way Viaduct, and an Urban Partnership Agreement with the federal government will help underwrite the replacement of the SR 520 bridge.

On the other hand, these investments won't be nearly enough to meet the challenges of a booming region that wants to remain competitive. The Alaskan Way tunnel will reduce road capacity from six lanes to four. Without upgrades to other arterials and highways, motorists will face even more clogged roads and mobility will fall as a consequence.

Congestion is a time tax that few businesses or employees tolerate in higher income cities. The economic consequences are not just theoretical. Reason Foundation Transportation Policy Analyst David Hartgen estimates that relieving congestion over the next 20 years throughout the Seattle-Tacoma-Bellevue urbanized area would cost between $5 and $10 billion but add as much as $13 billion to the regional economy. The Seattle central business district would see its economy boosted by nearly $5 billion as a result of improved access. Reducing congestion in Seattle could generate new output of over $13 billion. Tax revenues from increased commercial activity alone could be two to three times the construction costs.

The Seattle urbanized area has to focus on reducing congestion below current levels as a policy goal if it wants to achieve the economic benefits of higher mobility. With current and emerging technologies in transportation, free-flow travel is achievable if strategies and programs are integrated into a long-range transportation plan.

First, transportation planners need to expand the road and transit network to keep pace with the increase in travel demand. This means adding highway capacity as well as improving the efficiency of local roads through

traffic signal timing, adding left-hand turn lanes, and removing local bottlenecks.

Second, policymakers need to embrace tolling. This would not be our great-grandfathers' toll booths, but a seamless 21st century "boothless" network. Travelers would be guaranteed free-flow travel throughout the region by linking these "priced" lanes into a network called a high-occupancy toll, or HOT, network. This technology, along with Washington's pilot program on Highway 167 between Renton and Kent, is now used in places such as Orange County, California, San Diego, Minneapolis, and Denver. It allows prices to be set by time of day and traffic volume so that free-flow travel is guaranteed 24-7 on the lanes and roads that use it.

Third, regional policymakers need to embrace private capital. Tolling creates a revenue stream that prioritizes projects based on willingness to pay. It also creates non-tax dollars that can leverage private capital to finance new infrastructure. These private funds simply can't be tapped through traditional tax financing.

A world-class city of the 21st century nurtures nascent global businesses. These businesses thrive by tapping into a skilled, knowledgeable, and productive workforce. A regional transportation policy strategy focused on improving mobility plays in increasing important role in nurturing this productivity and, ultimately, profitability. Failing to acknowledge this role puts the entire regional at economic risk.