TRANSPORTATION RESEARCH DIGEST

JANUARY 2008

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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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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

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Innovative Finance and Alternative Sources of Revenue for Airports, *ACRP Synthesis 1* by CINDY NICHOL, Jacobs Consultancy, Burlingame, California (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; http://gulliver.trb.org/bookstore) (2007)

Highlights

- This report is intended to provide information about alternative financing options and revenue sources that are currently available or that could be available in the future.

Airport capital needs are estimated at approximately $14 billion per year. Although the Airport Improvement Program (AIP) administered by FAA is at historically high levels, it totaled just over $3.5 billion in FFY 2006.

This report is intended to inform airport operators, stakeholders, and policymakers about alternative financing options and revenue sources that are currently available to airport operators in the United States, or that could be available in the future if certain developments occur to facilitate them. Information used for this study has been gathered through a literature review and selected interviews of airport operators and industry experts.

The principal sources of funds for airport capital projects include the following, from largest to smallest:

Proceeds of bonds and other forms of debt-Bond proceeds are the largest source of funds for airport capital needs. Debt service associated with bonds issued for airport capital needs can be supported by the overall tax base of the issuing entity, general airport revenues, passenger facility charge (PFC) revenues, revenues generated by the facility constructed with the bond proceeds, other revenues, or any combination thereof.

PFC revenues--A majority of large-, medium-, small-, and non-hub airports impose a PFC of between $1.00 and $4.50 per enplaned passenger to finance eligible airport-related projects. Airport operators must obtain an approval from FAA before they begin the collection and use of such revenues.

AIP grants from the Airport and Airways Trust Fund and administered by FAA-AIP grants administered by FAA are funded by aviation user taxes and are available to airport operators, subject to certain eligibility limitations and assurances.

Internally generated capital resulting from retained airport revenues-Certain airport operators are able to retain net operating income from each year to invest in capital improvements.

Security grants from the general fund and administered by TSA- TSA grants are available on a limited basis to airport operators to make terminal modifications to accommodate explosive detection systems.

State grants and local financial support-Certain states provide funding for airport and aviation-related projects in the form of outright grants or matching share for federal AIP grants.

Airport operators are major and regular participants in the municipal bond markets. Despite the financial challenges airports have faced since September 11, 2001, airports have maintained investment-grade ratings from credit rating agencies. To finance capital projects, airport operators have:

Airport operators have used, among others, general obligation bonds, general airport

revenue bonds, bonds backed by PFCs, bonds backed by customer facility charges (CFCs; fees paid by rental car customers), bonds to be paid with future AIP or state grants, and special facility bonds to finance capital projects.

In addition to bonds, airport operators have used commercial paper, bond anticipation notes, grant anticipation notes, pooled credit programs, and capital leases.

Airport operators have reduced interest rates on outstanding bonds and manage interest rate risk by entering into interest rate swaps with investment banks.

Although a majority of these financing mechanisms have been used by large- or medium-hub airports, greater capital market acceptance can create opportunities for other airports.

Nonairline revenues may be used to reduce airline payments, fund new capital projects, or develop airport equity and reserves. Airports nationwide have developed creative programs to maximize revenue sources such as:

Parking has long been a revenue source for airport operators and further opportunities exist to enhance parking revenues by offering premium parking services, implementing parking operational enhancements, and collecting off-airport privilege fees.

In addition to privilege fees and rentals, a CFC is collected at some airports by each rental car concessionaire from its customers and used to pay all or a portion of the operating and capital costs of a consolidated rental car area or structured facility, and may include the cost of transportation to the terminals.

Airport shoppers are recognized as a lucrative market, and airport retailing is evolving to meet that market. Concession sales have increased dramatically as airlines discontinue meal service and passengers arrive earlier. Airport operators have been able to maximize revenues through reinventing their terminal concessions programs by recognizing the customer, creating an inviting shopping experience, providing an accommodating dining opportunity, and branding.

With longer dwell times, airport customers now take the time to read advertisements. Modem airport advertising programs specialize in the sales and maintenance of advertising sites at airports by using technology, sponsorship opportunities, and nontraditional advertising locations.

Airport operators have generated revenue from a variety of revenue-producing leases from nonairline operations including manufacturing, warehousing, freight forwarding, and even farming on available airport land.

Most U.S. airports are operated as independent not-for-profit entities with oversight by a politically appointed authority or as a self-sustaining enterprise of a governmental entity such as a county, city, or state government. As it applies in the United States, privatization can refer to a broad range of activities that entail varying levels of private involvement in the operation of an airport including:

Airport operators have explored many ways of doing business that involve varying degrees of private-sector involvement in the management, capital investment decision making, financing, and pricing of airport facilities and services. Private involvement at airports nationwide includes airline involvement in capital decision making, contracting of services to private companies, master concessionaire agreements, and private terminal development.

Some airports in the United States have been developed, financed, and operated privately throughout their entire existence, including various general aviation airports around the country. Congress established an airport privatization pilot program to explore privatization as a means of generating access to sources of private capital for airport improvement and development.

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How Serious is the Global Warming Threat? by Roy W. Spencer, Principal Research Scientist, Earth System Science Center, University of Alabama in Huntsville (Institute for Study of Economics and the Environment, Lindenwood University, 209 South Kingshighway, St. Charles, MO 63301; Phone: (636) 949-4742; http://www.lindenwood.edu/academics/isee/docs/Spencer9-00-06.pdf) (Sep 2006)

Highlights

- There is still substantial uncertainty about mankind's influence on global temperatures.
- The main difficulty in "doing something" about global warming is the fact that inexpensive energy helps drive economic growth, human health and well-being.

There is a simple aspect of the climate system that argues against substantial future warming. It has been computed that, even though the natural greenhouse effect "tries" to increase the surface temperature of the Earth to about 140 degrees F, 75% of that warming is prevented from ever occurring.13 Weather is the result of the atmosphere's response to the warming rays of the sun, short-circuiting the Earth's natural greenhouse effect and greatly limiting surface warming. Thus, even though water vapor (through its greenhouse effect) keeps the Earth habitably warm, the same water vapor also represents heat removal processes that also keep the Earth habitably cool.

The heat absorbed by the water vapor is carried by convective air currents that transport the extra heat and water vapor upward, eventually causing clouds to form. This further cools the climate by shading some of the Earth from the sun. Some of the condensed water in the clouds returns to the Earth as precipitation, replenishing the surface water so that the whole process, called the hydrologic cycle, can start all over again. As a result of all of the cooling processes associated with weather systems, the average surface temperature of the Earth is about 55 degrees F, rather than a scorching 140 degrees F.

These processes are, however crudely, included in climate models. The point is that the net effect of clouds, water vapor, precipitation – in short, weather and the global hydrologic cycle – is to substantially cool the surface of the Earth below what the natural greenhouse effect would cause it to be for a given amount of incoming sunlight.

But how could climate models that predict large amounts of warming all be wrong? First, let us look at a feedback that is believed to be well understood: positive water vapor feedback. It is true that if the surface warms, there will be more water evaporated from the surface, and water vapor is the Earth's dominant greenhouse gas. But the average amount of water vapor in the atmosphere is not simply due to how much water is evaporated from the surface. That is only half of the story. If evaporation was to occur unchecked, the global atmosphere would become totally saturated with water within a matter of days or weeks. This does not happen. Instead, the average amount of vapor in the atmosphere is the result of a balance between the vapor source (evaporation) and the vapor sink (precipitation). Therefore, one cannot determine how atmospheric water vapor will change with warming without understanding precipitation systems and their response to warming.

And how will precipitation systems change in response to warming? No one knows. A minority of scientists contend that, until we understand how precipitation processes respond to warming, we really do not know whether water vapor feedback is strongly positive, weakly positive, or zero. Yet water vapor feedback is considered by many scientists to be a "solved" problem.

Clouds, in contrast, represent a feedback that everyone agrees is uncertain. It has been calculated that only a couple percent increase in low clouds would offset the warming effects of a doubling of atmospheric carbon dioxide from fossil fuel use. Because all of these processes (evaporation, clouds, precipitation) are interconnected, it really is misleading to treat them as separate feedbacks. They are all so intimately tied together, that climate models should treat them as a system, not individually.

Even if global warming proves to be a serious problem, it is not at all clear what should (or even can) be done about it. If it was easy to switch to fuels which produce little or no carbon dioxide, it would be foolish not to do so, given the potential risks of a 10 degree F rise in global temperatures by the end of this century. But policy choices invariably involve weighing costs and benefits. They also necessarily involve assumptions about where our future sources of energy will come from, and whether there will be any countries wealthy enough to fund new energy technology R&D if we mandate CO2 reductions by fiat.

The main difficulty in "doing something" about global warming is the fact that inexpensive energy helps drive economic growth, human health and well-being. Historically, those countries that build wealth through efficient use of natural resources have the lowest levels of pollution and population growth. The poorest countries have the worst environmental problems, and their high rates of population growth put additional pressures on the environment.

The concern that the richest countries of the world have the least sustainable environmental practices is contrary to the evidence. The relationship between an Environmental Sustainability Index and per capita gross domestic product for 117 nations of the world shows a statistically significant positive relationship between the two variables. Thus, on average, the wealthier the country, the more sustainable are its environmental practices.

Because alternative fuels are more expensive than fossil fuels, mandating their use through governmental controls will come at the expense of other portions of the economy. If there were alternative sources of energy that were cost-competitive with petroleum and coal, they would already be in widespread use. Any economic downturn resulting from punishing fossil fuel use will affect the poor the most. While the wealthy can absorb the extra cost of, say, a $2 increase in the cost of gasoline, many of the poor cannot. Moreover unskilled workers are more likely to become unemployed due to economic contractions.

Even if global warming ends up being a serious problem, it is not at all clear what should be done about it right now. Environmental activists today seem only interested in reducing fossil fuel use immediately. They appear unwilling to consider other approaches (e.g. intensive research into new energy technologies) that might actually accomplish the greatest reductions in the long term.

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Determining the Current Rates of Motor Fuel Tax Evasion for the State of Montana by Patrick Balducci, Mark Weimar, Susan Whitmore, Eihab Fathelrahman, and Laurie Scovell (Battelle); and Debra Johnson (Montana State University) (Montana Department of Transportation, 2701 Prospect Avenue, PO Box 201001, Helena MT 59620-1001) (Nov 2006)

Highlights
- Montana loses over $12 million/year from diesel tax evasion & nearly $3 million/year from gasoline tax evasion.

There are incentives to evade motor fuel taxes in the State of Montana. Montana has among the highest motor fuel tax rates as compared to all bordering states. Montana's gasoline excise tax rate, at 27 cents per gallon, is 7 cents per gallon more than the nationwide mean tax rate of 20.3 cents per gallon. Indeed, as of 2004 Montana imposed the fourth highest gasoline tax rate in the nation, notwithstanding any additional state sales taxes imposed on the sale of motor fuels. Montana's diesel tax rate is 27.75 cents per gallon.

Historic changes in legislation and increased enforcement and audit efforts have increased revenues deposited in Montana's Highway Special Revenue Account, yet fuel tax evasion is still considered to be a significant and persistent problem. The nature of the problem and the extent of the resulting revenue losses have been considered by the Montana Department of Transportation (MDT) but not in a quantitative and systematic manner as they have within this report.

Montana is not alone in its interest in curbing motor fuel tax evasion. State concern over motor fuel excise tax evasion has generated a concerted research effort over the past two decades, resulting in the detection of numerous evasion methods and the development of new approaches for measuring evasion and techniques for curtailing evasion. This study outlines numerous techniques that could be used to evade Montana motor fuel taxes, including:

- Border Schemes,
- Dyed Fuel Schemes,
- Alternative Fuels Schemes,
- International Fuel Tax Agreement (IFTA) Fraud,
- Refund and Credit Fraud,
- Daisy Chains, and
- Failure to File Schemes.

To compute motor fuel tax errors, omissions, and evasion (EOE) in the State of Montana, a model was used to estimate the amount of fuel consumed in the State of Montana and compare that amount to reported gallons in 2002, 2003, and 2004. The results for 2004 are presented in Table ES-l. To disaggregate the total amounts of evasion to specific evasion techniques (e.g., illegal use of dyed fuel), several estimation methods were used. For this study, an "evasion technique" is defined as an approach intentionally used to defraud jurisdictions of motor fuel taxes. For example, bootlegging would be considered an evasion technique. For this study, an "estimation method" is defined as a method used to estimate levels of EOE. Thus, estimation methods are used to estimate EOE levels resulting from evasion techniques. For example, analysis of on-road inspection data (an estimation method) may be used to estimate

EOE resulting from abuse of tax-exempt dyed fuel (an evasion technique).

Table ES-1 presents the results of the EOE analysis. Based on the results of the analyses presented later in this report, it is estimated that EOE of diesel taxes totals roughly 16.3 percent of total tax liability, an amount equal to 43.4 million gallons. This level of EOE represented a loss in revenue to Montana of approximately $12.1 million in 2004. Fraud perpetrated by distributors using cross-border evasion techniques and various forms of motor carrier EOE as detected through IFTA audits represent the most significant evasion techniques, collectively accounting for $4.9 million in lost diesel tax revenue in 2004. The data collected for this study suggest that gasoline tax EOE is not as significant, totaling roughly 2.1 percent of total tax liability: an amount equal to $2.8 million or 10.3 million gallons in 2004. Note that the consumption model estimated overall EOE levels and the other models prepared for this study attempted to attribute the overall EOE level to numerous evasion techniques. In both the gasoline and diesel tax EOE modeling process, the research team was unable to attribute 100% of the total EOE estimates to the evasion techniques. This result was expected due to the lack of available data to estimate EOE for certain evasion techniques (e.g., retailer fraud, illegal importation of dyed fuel reported as clear from Canada, illegal use of dyed fuel in pickup trucks, illegal blending schemes) and the inability to imagine every evasion technique deployed. Thus, the difference between the total estimated EOE levels and the EOE attributed to the major evasion techniques is identified in Table ES-l as EOE attributed to other schemes.

Table ES-l: Gasoline and Diesel Tax EOE in the State of Montana

Evasion Method	**Gasoline**	**Diesel**
False Refunds or Credit Schemes (thousand gallons)	2,700	
Loads Not Reported to MDT and Import Export Schemes (thousand gallons)	1,274	6,995
Evasion using Dyed Fuel (thousand gallons)		2,279
Motor Carrier Errors, Omissions and Evasion (thousand gallons)		10,511
Other Schemes (thousand gallons)	6,367	23,650
Total EOE (thousand gallons)	10,341	43,435
Total Gallons Taxed (thousand gallons)	493,719	223,636
Annual Lost Revenue ($ millions) EOE	$2,792	$12,053
Rate	2.1%	16.3%

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A Cost-Comparison Methodology for Selecting Appropriate Hot-Mix Asphalt Materials by Kevin K. McGhee and Trenton M. Clark, Virginia Transportation Research Council, 530 Edgemont Road, Charlottesville, VA 22903 (Virginia Department of Transportation, 1401 E. Broad Street, Richmond, VA 23219) (Jun 2007)

Highlights

- Annual pavement condition ratings can be used to project reasonable service life.
- Equivalent uniform annual cost comparisons are a good tool for screening expected initial costs of competing HMA alternatives.
- The total present worth analysis incorporates anticipated future maintenance costs and initial costs.
- Stone matrix asphalt outperforms dense-graded hot-mix asphalt under most conditions.

In 1997, the Virginia Department of Transportation (VDOT) began to adopt the Superpave mix-design system for the design of hot-mix asphalt (HMA) from the previously used Marshall methodology. The transition of the late 1990s started with the incorporation of performance-graded binders and later included aggregate arid volumetric characteristics. The 2 to 3 years it took for VDOT to implement this new system fully were important, as many of the early Superpave-designed mixes were coarse (too much large aggregate) and dry (low asphalt binder content) and consequently delivered service lives that were less than expected. By 2000, the first year of full Superpave implementation, VDOT was moving to mixes with finer gradations, increased asphalt binder content, and improved service life.

Predating the adoption of the Superpave system, VDOT began a highly selective application of stone matrix asphalt (SMA). Although the earliest VDOT SMA specification was circa 1993, by 2002, Virginia had placed only a little more than 600,000 tons on a few interstate highway projects. In the summer of2002, VDOT launched an initiative to implement SMA on high-volume truck and traffic routes across the state. Over the next several years, VDOT went to contract with nearly 1 million tons of SMA.

By late 2005, although having proven itself (at least anecdotally) as the "go to" hot-mix for high-priority facilities, the premium costs for SMA were beginning to claim noticeable portions of some district pavement construction and resurfacing budgets. As the costs for all construction materials continued to rise, the cost differential between dense-graded HMA and SMA appeared to broaden. By late 2005, some localities did not think they could afford SMA and simply opted for a conventional mix (i.e., dense-graded HMA) that would at least spread further in the short term.

VDOT's Road and Bridge Specifications lists 9 dense-graded HMA surface mixes (three aggregate gradations x three binder types) that could be used on Virginia's highways. The Special Provision for SMA provides 4 more surface mix options (two gradations x two binder types), for a total of 13 mixes. Although the specifications offer recommendations as to the type of facilities to program for each mix type, local conditions and experiences heavily influence the predominantly selected mix. Over the past 4

years or so, district pavement managers have routinely used only about 4 dense-graded HMA mixes and 3 SMA surface mixes. As material prices continue to climb without budgets doing the same, local circumstances are going to contribute more often to the selection of the less expensive mixes, especially as long as these managers lack a defensible rationale for specifying a more expensive option.

This report offers an economic analysis procedure to help field (i.e., district) pavement engineers select the most cost-effective asphalt paving mixture. The procedure is based on the expected performance for each mix. The performance predictions were developed using the 2006 "windshield" condition rating for all of VDOT's interstate and state primary roads. These ratings reflect the performance for at least 6 years ofVDOT's contemporary dense-graded mixes and for up to 11 years of SMA surface mixes.

Conclusions

Annual pavement condition ratings can be used to project reasonable service life expectations for Virginia's most common HMA types. Using average condition indices for each age and simple straight-line projections, the overall expected service life for each mix within a logical family (e.g., interstate only) of projects can be predicted.

Equivalent uniform annual cost comparisons are a good tool for screening expected initial costs of competing HMA alternatives. Given a predicted service life, an estimated per-ton price, and an assumed discount rate, simple engineering economics can be applied to determine the expected equivalent annual cost of alternative mixes. These annual costs can be compared in order to screen for justifiable first-cost differentials.

Total present worth (cost) analysis using VDOT's *Guidance on Life Cycle Costs Analysis for Pavements* provides a rational method for determining the relative cost-effectiveness of competing HMA alternatives. The total present worth analysis incorporates anticipated future maintenance costs and initial costs. A comprehensive analysis may also incorporate expected lifetime user costs.

Stone matrix asphalt outperforms dense-graded hot-mix asphalt in Virginia when placed in similar conditions. In most cases, a premium price for SMA is justified by the anticipated increase in performance.

SMA is the most cost-effective hot-mix material for use in maintaining pavements on Virginia's interstate system. This conclusion is based on a comparison of net present value costs for the most common hot-mix asphalt alternatives (as determined using 2006 condition survey data and 2006 unit price data).

VDOT's Maintenance Program appears capable of funding an adequate interstate resurfacing program through exclusive use of its most robust (i.e., SMA) hot-mix asphalt material. The planned spending for FY 2008 is sufficient to meet the flexible pavement needs for the interstate system as identified in the 2006 condition survey. Of course, the estimates generated in this report contain no project-level design or construction detail; they are based purely on high-level (reasonable) network assumptions.

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Influence of Hycrete DSS on Virginia Department of Transportation Class A4 Concrete Mix Designs by Stephen R. Sharp and Celik Ozyildirirn, Virginia Transportation Research Council, 530 Edgemont Road, Charlottesville, VA 22903 (Virginia Department of Transportation, 1401 E. Broad Street, Richmond, VA 23219) (May 2007)

Highlights

- Based on a life cycle cost analysis, with a 10% increase in the service life of bridge decks or structures, VDOT would save through the use of DSS.

To reduce the cost of corrosion chloride-induced corrosion in steel-reinforced concrete structures, various mitigation techniques have been proposed over the years, with some producing worthwhile results and others being proven to be ineffective.

To protect the reinforcement in concrete, intrusion of chlorides to the level of reinforcement should be prevented. To accomplish this goal, low-permeability concrete and sufficient cover depth are necessary. However, if the quality of the concrete is poor, the cover depth is inadequate, or cracking is sufficient to facilitate the intrusion of chlorides, then chlorides can reach the steel reinforcement. In cases where the chlorides reach the steel, corrosion-resistant reinforcing bars or means of mitigating corrosion at the bar are sought.

One proposed corrosion mitigation technique is the use of corrosion-inhibiting admixtures. Manufacturers of inhibiting admixtures suggest this approach reduces corrosion by influencing reactions at the surface of the steel, which results when sufficient quantities of inhibitor contact the reinforcing steel. The inhibitor evaluated in this study is "comprised of an alkali based salt of dioic acid" according to the patent application filed by the manufacturer. The admixture, named Hycrete DSS (DSS), is claimed to be effective against corrosion for two reasons. First, it attaches itself to the steel reinforcement and forms a monomolecular layer over the reinforcement, which protects the steel from corrosive environment. Second, it also blocks the penetration of water by attaching itself to polar particles in the concrete with and without cracks, which prevents the ingress of chlorides to the level of steel.

Findings

DSS with a defoaming agent achieved air contents within VDOT's specifications.

With the required air contents, concretes with and without DSS had high durability factors even though some of the specimens had high weight loss. Because of the high durability factors, the high weight loss is not expected to be a problem considering the severity of the test.

Long-term strengths were similar for concretes with similar air contents.

The rapid chloride permeability test did not show any benefit of adding DSS. The addition of Class F fly ash did result in low permeability. However, sorptivity was lower when the DSS was added.

The DSS will restrict moisture intake while the fly ash reduces the movement of moisture within the system, which restricts the chlorides movement into the concrete. This is based on the data from the rapid chloride permeability and rate of absorption tests in

conjunction with the effective diffusion coefficients information calculations.

The drying shrinkage values were acceptable for all mixtures tested.

The bond strength values were similar for all mixtures tested. Thus, DSS had no effect on the bond to concrete.

The addition of fly ash improved the resistance to alkali-silica reactivity, whereas the addition of DSS did not.

Outdoor exposure strongly affected the amount of charge passed in the cracked specimens, increasing the activity of those specimens that had minimal activity in the laboratory, which indicates DSS might be affected by the environmental influences that are found outdoors.

When cracks in concrete intersected the reinforcing steel, DSS did not prevent the initiation of corrosion.

Conclusions

VDOT's Class A4 concrete mix benefits from the addition of fly ash.

The addition of a sufficient amount of DSS to a mix containing fly ash can improve the Class A4 mix by further reducing the influx of chloride ions toward the reinforcing steel.

It is important that DSS not be used as a replacement for fly ash in the Class A4 mix.

Costs and Benefits Assessment

In assessing the cost-effectiveness of using DSS, its up-front material cost must be weighed against the benefit of enhanced corrosion resistance, which will be associated with cost savings accrued over the life of the structure. The premium paid when DSS is added to a Class A4 concrete mixture may range from 25% to 30% of the cost per cubic yard. However, this increase is less than 10%, considering the per cubic yard cost for in-place concrete. In the total cost of the bridge, the increase is much smaller, within a few percentage points. Therefore, if the field performance confirms the laboratory test results of this study, the use of DSS is expected to lead to extended service life and to aid in minimizing maintenance costs.

VDOT will spend approximately $15 million for new bridge decks this construction season. Based on a life cycle cost analysis, with a 10% increase in the service life of bridge decks or structures, VDOT would save $1.5 million dollars each year through the use of DSS.

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JANUARY 2008

Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities (Institute of Transportation Engineers, 1099 14th St., NW, Suite 300 West Washington, DC 20005-3438 USA Telephone: 202-289-0222; http://www.ite.org) (2006)

Highlights

- This report addresses the controlling elements of thoroughfare design, presents a context-based design process within the project development framework and provides specific design guidelines for the various elements that comprise the major urban thoroughfare.

This report advances the successful use of context sensitive solutions (CSS) in the planning and design of major urban thoroughfares for walkable communities. It provides guidance and demonstrates for practitioners how CSS concepts and principles may be applied in roadway improvement projects that are consistent with their physical settings.

CSS is the result of developing transportation projects that serve all users and are compatible with the surroundings through which they pass. Successful CSS results from a collaborative, multidisciplinary and holistic approach to transportation planning and project development. CSS in the transportation planning or project development process identifies objectives, issues and concerns based on stakeholder and community input at each level of planning and design (for example, network, corridor and project). This report provides guidance in how CSS principles may be considered and applied in the processes involved with planning and developing roadway improvements along urban thoroughfares.

This report provides guidance for the development of improvement projects on major urban thoroughfares, facilities that are typically classified as arterial and collector roadways in urbanized areas. While CSS is applicable to all types of transportation facilities, the guidelines in this report exclude high-speed limited access facilities (including freeways, expressways and parkways) and local streets. The report's chapters are focused on applying the principles of CSS in transportation planning and in the design of roadway improvement projects in places where community objectives support walkable communities-compact development, mixed land uses and support for pedestrians and bicyclists, whether it already exists or is a goal for the future. Many of the principles, concepts and design guidelines are directly applicable to urban thoroughfares in other contexts.

The principles, concepts and design criteria presented in this report are applicable to transportation planning as well as to thoroughfare design, and to construction and maintenance. The traditional term "thoroughfare" is used in this report instead of conventional names (street, roadway, or highway) to distinguish lower speed urban roadways from other types of roadways, and because some conventional names are used in this report to define different types of thoroughfares.

CSS is a different way to approach the planning and design of transportation projects. It is a process of balancing the competing needs starting in the earliest stages of project

development. It is also flexibility in the application of design controls, guidelines and standards to design a facility that is safe for all users regardless of the mode of travel they choose.

There are many definitions of CSS, but they share a common set of tenets:

- Balance safety, mobility, community and environmental goals in all projects;
- Involve the public and stakeholders early and continuously throughout the planning and project development process;
- Use an interdisciplinary team tailored to project needs;
- Address all modes of travel;
- Apply flexibility inherent in design standards; and
- Incorporate aesthetics as an integral part of good design."

Contents of This Report	
Part 1: Introduction	
1 - Foundation	The background behind this guidance, principles of CSS, definitions and an overview of the CSS process.
Part 2: Planning	
2 - Planning and Developing Context Sensitive Urban Thoroughfares	An overview of the transportation planning and project development process and how CSS is applied within these processes.
3 - Network and Corridor Planning	An overview of thoroughfare network types, characteristics of successful networks and network design guidelines. An overview of the corridor planning process and the role of CSS.
4 - A Framework for Urban Thoroughfare Design	An introduction into the design framework for context sensitive thoroughfare design, context zones, their characteristics and the features that create context, a description of thoroughfare types and their relationship with functional classifications, compatibility with context zones and general design parameters.
Part 3: Design	
5 - Thoroughfare Design Process	Process for using this report to design thoroughfares, how to design thoroughfares within constrained rights-of-way and flexibility in the application of design criteria.
6 - Typical Thoroughfare Designs	General design parameters for thoroughfare types, variations in the roadside and traveled way under varying conditions and example thoroughfare designs.
7 - Design Controls	A discussion of the engineering controls and level of flexibility critical in context sensitive design including design vehicle, roadway geometries and design speed.
8 - Roadside Design Guidelines	General principles, design considerations and detailed guidance for the design of the elements that comprise the roadside.
9 - Traveled Way Design Guidelines	General principles, design considerations and detailed guidance for the design of the elements that comprise the traveled way.
10 -Intersection Design Guidelines	General principles, design considerations and detailed guidance for the design of the elements that comprise multi modal intersections.
11 - Thoroughfares in Vehicle Mobility Priority Areas	General design parameters for thoroughfare design in single use areas and areas where vehicular mobility is a priority and comparison of conventional and CSS cross-section determination in these areas.

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Guidance for Cost Estimation and Management for Highway Projects During Planning, Programming, and Preconstruction*, NCHRP Report 574* by Stuart Anderson, Keith Molenaar, Cliff Schexnayder (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; http://gulliver.trb.org/bookstore) (2007)

Highlights

- This guidebook presents cost estimation management and cost estimation practice approaches to address the root causes of cost escalation and to support the development of consistent and accurate project estimates.

State highway agencies face a major challenge in controlling project budgets over the time span between project initiation and the completion of construction. Project cost increases, as reflected by budget overruns during the course of project development, are caused by factors that have been identified through a large number of studies and research projects. This guidebook provides appropriate strategies, methods, and tools to develop, track, and document realistic cost estimates during each phase of project development.

Agencies will have to do more than simply institute changes in estimation practices if they are to achieve consistent and accurate estimates. Project cost estimation management and cost estimation practice should be viewed as interdependent processes that span the entire project development process. This study led to the development of eight global strategies to address state highway agency estimation problems:

1. Management strategy-Manage the estimation process and costs through all stages of project development;
2. Scope and schedule strategy-Formulate definitive processes for controlling project scope and schedule changes;
3. Off-prism strategy-Use proactive methods for engaging external participants and assessing the macro environmental conditions that can influence project costs;
4. Risk strategy-Identify risks, quantify their impact on cost, and take actions to mitigate the impact of risks as the project scope is developed;
5. Delivery and procurement strategy-Apply appropriate delivery methods to better manage cost because project delivery influences both project risk and cost;
6. Document quality strategy-Promote cost estimate accuracy and consistency through improved project documents;
7. Estimate quality strategy-Use qualified personnel and uniform approaches to achieve improved estimate consistency and accuracy; and
8. Integrity strategy-Ensure that checks and balances are in place to maintain estimate accuracy and to minimize the impact of outside pressures that can cause optimistic biases in estimates.

In this Guidebook, these eight strategies are linked to over 30 recommended methods for implementing the strategies and to over 90 tools for executing specific methods.

Keys to Success

Disciplined cost estimation management and cost estimation practice should be applied in the context of the eight

global strategies. This research has determined that 10 key principles--5 cost estimation management principles and 5 cost estimation practice principles--must be focused on to ensure creation of consistent and accurate estimates. The key principles, in prioritized order, are as follows.

Cost estimation management

1. Make estimation a priority by allocating time and staff resources.
2. Set a project baseline cost estimate during programming or early in preliminary design, and manage to this estimate throughout project development.
3. Create cost containment mechanisms for timely decision making that indicate when projects deviate from the baseline.
4. Create estimate transparency with disciplined communication of the uncertainty and importance of an estimate.
5. Protect estimators from internal and external pressures to provide low cost estimates.

Cost estimation Practice

1. Complete every step in the estimation process during all phases of project development. 2. Document estimate basis, assumptions, and back-up calculations thoroughly.
2. Identify project risks and uncertainties early, and use these explicitly identified risks to establish appropriate contingencies.
3. Anticipate external cost influences and incorporate them into the estimate.
4. Perform estimate reviews to confirm that the estimate is accurate and fully reflects project scope.

Implementing new concepts involves facing the challenges that accompany change. State highway agencies must consider several challenges:

- Challenging the status quo and creating a cultural change requires leadership and mentoring to ensure that all steps in the cost estimation management and cost estimation processes are performed.
- Developing a systems perspective requires organizational perspective and vision to integrate cost estimation management and cost estimation practice throughout the project development process.
- Dedicating sufficient time to changing agency attitudes toward estimation and incorporating the strategies, methods, and tools from this Guidebook into current state highway agency practices is difficult when resources are scarce.
- Dedicating sufficient human resources to cost estimation practice and cost estimation management beyond the resources that have previously been allocated to estimation processes.

Meeting these challenges will ultimately require a commitment by the agency's senior management to direct and support change. The benefit of this commitment will be manifested in projects that are consistently within budget and on schedule and that fulfill their purpose as defined by their scope. This benefit will also improve program management by allowing for better allocation of funds to projects to meet the needs of the ultimate customer, the public.

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Urban Transportation Policy: A Guide and Road Map by Kenneth A. Small (Department of Economic University of California at Irvine, Irvine, CA 92697-5100; ksmall@uci.edu) (June 2007)

Policy Makers Should…

- *Encourage highway pricing innovations.*
- *Expand highway pricing to an entire corridor or area.*
- *Seek better tradeoffs between efficiency and public appeal for pricing schemes.*
- *Encourage private participation in highways with good franchise terms.*
- *Pursue highway designs that emphasize high capacity at moderate speeds and with an environmentally friendly footprint.*
- *Encourage niche transit.*
- *Break up large metro-wide transit providers by spinning off those serving lower-density areas.*
- *Configure federal capital-grant programs to encourage bus rapid transit.*
- *Use open-ended user-side subsidies to improve incentives for public providers to control costs.*

Policy makers can take advantage of the shifting terrain on which urban transportation operates through a number of steps. Taking any of them will help. Taking all of them would inaugurate a revolutionary change that would greatly improve urban life.

Encourage highway pricing innovations. In some cases, the direct benefits of a specific measure are not very large. For example, models of priced express lanes suggest that when the express lanes are kept operating at free-flow speeds, the net benefits are small compared to letting the same lanes operate as general-purpose lanes. But such express-lane innovations are typically improvements over the actual situation preceding them, which usually involved less capacity or express lanes restricted to carpools. Furthermore, these innovations are leading to more thorough-going proposals, including proposals to price all lanes in a corridor.

Expand highway pricing to an entire corridor or area. The same evidence just mentioned suggests that a fully priced corridor offers much greater benefits than a partially priced corridor. This remains true even if the price is set lower than optimal to meet political goals. Furthermore, cordon pricing of an entire downtown business district, along the lines of London and Stockholm, may be possible in a few US cities with dense downtowns, such as Manhattan, San Francisco, and Washington.

Seek better tradeoffs between efficiency and public appeal for pricing schemes. The pure express-lane policies tend to have small net benefits, whereas optimal congestion pricing has large benefits but high prices that inhibit public support. They offer a policy that prices all lanes, at differential rates, with the lower-priced lanes at a low rate designed to strictly limit the direct costs incurred by users. This type of policy may be the compromise needed to enable pricing to extend beyond just a few selected express lanes.

Encourage private participation in highways with good franchise terms. Private highway finance has entered the US in a big way, but most of it is for conventional toll roads. If franchise terms are made flexible, bidders will find ways to use flexible pricing to everyone's advantage. Innovative private operations will involve firms taking on demand risk, so it is important to give them enough

pricing flexibility to have some control over this risk. Regulation is still needed, but with a soft touch — allowing latitude for price differentiation while regulating overall revenues (or profits) to avoid abuse of monopoly power.

Pursue highway designs that emphasize high capacity at moderate speeds and with an environmentally friendly footprint. Urban road designers should be allowed to sacrifice free-flow speed and ability to handle large vehicles in favor of high throughput of passenger vehicles. If curves or lane widths present safety hazards at high speeds, they should be encouraged to offer options in which electronic speed control on these corridors is used in return for fast and reliable service.

Encourage niche transit. Private entrepreneurs have proven very adept at finding profitable transit markets, even when it is illegal for them to do so. Public transit authorities should be forced to encourage such competition with their systems, rather than to outlaw them or to drive them out of business using predatory tactics, as happened in Los Angeles in the early 1980s.

Break up large metro-wide transit providers by spinning off those serving lower-density areas. Low-density transit service is a drag on the finances of big-city transit operators. There may be reasons to subsidize such service, but any such decision needs to be taken on its merits and not as part of a *quid pro quo* for keeping the larger operator afloat. Services for low densities and for populations with special needs should look quite different from regular transit service, typically involving small vehicles with flexible scheduling, and therefore need not be provided by the same agency.

Configure federal capital-grant programs to encourage bus rapid transit. Currently the US Department of Transportation is doing just this, but it is a political decision that can easily change. Legislators tend to like big visible projects to showcase their accomplishments, and rail has served this purpose, but at great expense. Meanwhile many US bus operations are starved for funds. Bus rapid transit offers a solution by making visible and attractive improvements at modest cost.

Use open-ended user-side subsidies to improve incentives for public providers to control costs. Transit policy is caught on the horns of a dilemma, by which needed subsidies are hijacked through union wage increases and/or operator inefficiencies. One way to lessen this tendency is to make the subsidies proportional to ridership, thereby forcing the agency to do everything it can to keep riders happy.

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Rail Relocation Projects in the U.S.: Case Studies and Lessons for Texas Rail Planning by Curtis A. Morgan, Jeffery E. Warner, Craig E. Roco, Glenn C. Anderson, Leslie E. Olson, and Stephen S. Roop, Texas Transportation Institute, Texas A&M University System, College Station, Texas 77843-3135 (Texas Department of Transportation, Research and Technology Implementation Office P.O. Box 5080, Austin, Texas 78763-5080) (Mar 2007)

Highlights

- A table of options with their costs & benefits is shown.

Freight transportation by rail is a major component of the transportation activity within the metropolitan areas of Texas; however, conflicts between rail and highway routes are especially acute in and around urban rail facilities. Rail operations, as well as roadway traffic movement and efficiency, can be adversely affected by delay, increased emissions, and increased fuel use as a result of highway-rail traffic conflicts. Rail movement can also be impeded by the requirement to slow trains within urban areas in order to reduce the likelihood that accidents will occur-most often near at-grade highway-rail grade crossings.

These effects could potentially be minimized by relocating through-train operations to alternative rail corridors located outside the urban area or by consolidating rail operations from several urban routes into a single corridor that is grade separated or has other safety features that improve mobility and improve safety. Corridors within the urban core could be redeveloped as passenger rail or other transportation routes. New economic opportunities could also result as a variety of redevelopment projects and reduced urban sprawl.

Implementing certain types of rail relocation projects could also potentially improve the efficiency of the regional rail transportation system to the point that incremental but essential growth in truck-to-rail modal diversion could result. This diversion could be achieved if the alternative rail corridor is planned in a way that allows railroad companies to increase overall system speed by grade separating the new line from highway traffic without substantially increasing the distance traveled or changing the grade characteristics from existing rail routes. Railroad costs incurred due to increased distance or increased grades requiring additional locomotive power must be considered when evaluating new corridors. Another potential benefit of such routing could be gained by removing some hazardous material transport to routes outside the urban core.

Potential Options	Potential Benefits and Costs			
	Rail Operating Companies	Highway Users	Community and Neighborhoods	Urban Area
Grade separate to eliminate at-grade crossings	Increased operating speed results in lower operating costs & better service to customers	Reduced train-related delays and accidents	Less noise due to train blowing horns at grade crossings. Improved access provides better business climate.	Minor impact
Close streets to eliminate at-grade crossings	Same as above	Potential routes lost and increased safety	Less noise but may lose some access	Impact depends on functional class of street
Provide pedestrian bridges	Minor impact	Minor impact	Improved safety for pedestrians	Minor impact
Install crossings gates	Minor impact	Increased safety	Reduction in noise if train horns were no longer sounded	Minor impact
Install noise barrier or other aesthetic shielding	No impact	No impact if proper sight distances maintained at grade crossings	Reduced general train noise but only minor reduction of locomotive horn noise	No impact
Elevate rail lines	Minor impact	Reduced train-related delays and accidents	Increased barrier effect, noise reduction due to grade separation of crossings and installation of noise barrier	Extremely expensive
Depress rail lines	Physical problems due to grades and drainage facilities required	Same as above	Reduced barrier effect, reduced noise	Extremely expensive
Alter train operations -- reschedule trains (reduced operating hours)	Decreased operating speed and flexibility may increase costs and quality of service. Capacity problems	Reduced train-related delays and accidents during peak traffic hours	Less noise during late evening hours, improved safety for pedestrians	Minor impact
Remove under-utilized or redundant track	New operating procedures would have to be developed and learned; maintenance costs could be reduced, but there might be increased operating costs.	Reduced train-related delays and accidents	Possible removal of rail problem or at least stored cars	Redevelopment potential exists for land removed from rail service
Relocate operations into existing railroad corridors, into existing transportation corridors, or into new corridors	Increase distance but may also increase speed, may create physical operating problems due to steep grades or tight curves, lost service to some customers	Elimination of rail problem in an area	Elimination of rail problem in an area	Extremely expensive, but may open up valuable land for redevelopment; impact of right-of-way acquisition or other land use and highway plans must be considered
Reroute through traffic movements	Increased mileage and operating cost, increased interchanges, poorer service to customers	Reduced number of trains and thus reduced delays and accidents	Reduce noise and safety hazards	Minor impact
Relocate yard operations	Increase efficiency of railroad operations by reducing through part time and the number of employees	Elimination of rail problem in same areas but must be balanced against increased problems in other areas	Trade-off between reduced air pollution and noise in same areas and increases in others but net benefit because of more efficient operations	Large scale benefits due to re-use potential of redundant facilities, large cost
Provide centralized train control at critical interchange points	Reduced delays and blockages	Reduced train-related delays caused by blockages	Minor impact	Minor impact

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A Statistical Approach Will Better Identify Commercial Carriers That Pose High Crash Risks Than Does the Current Federal Approach (United States Government Accountability Office, 441 G Street NW, Room LM, Washington, D.C. 20548; Sidney H. Schwartz at (202) 512-7387 or schwartzsh@gao.gov, or Susan A. Fleming at (202) 512-2834 or flemings@gao.gov.; http://www.gao.gov/new.items/d07585.pdf) (June 2007)

Highlights

- Commercial motor carriers account about 13% of all highway deaths.
- The Federal Motor Carrier Safety Administration (FMCSA) has the primary federal responsibility for reducing crashes involving large trucks.
- FMCSA uses a model—SafeStat—to identify carriers that pose high crash risks.
- If FMCSA used a regression model, it could increase its ability to identify high-risk carriers by about 9% over SafeStat.

Trucks transport over 11 billion tons of goods annually, or about 60% of the total domestic tonnage shipped. There are approximately 711,000 commercial motor carriers registered, about 9 million trucks and buses, and more than 10 million drivers. Most motor carriers are small; about 51% operate one vehicle, and another 31% operate two to four vehicles. Carrier operations vary widely in size, however, and some of the largest motor carriers operate upwards of 50,000 vehicles. Carriers continually enter and exit the industry. Since 1998, the industry has increased in size by an average of about 29,000 interstate carriers per year.

In the United States, commercial motor carriers account for less than 5% of all highway crashes, but these crashes result in about 13% of all highway deaths, or about 5,500 of the approximately 43,000 highway fatalities that occur nationwide annually. In addition, about 106,000 of the approximately 2.7 million highway injuries per year involve motor carriers. The fatality rate for trucks has generally been decreasing over the past 30 years, but this decrease has leveled off, and the rate has been fairly stable since the mid-1990s.

The Federal Motor Carrier Safety Administration (FMCSA) has the primary federal responsibility for reducing crashes involving large trucks and buses that operate in interstate commerce. FMCSA decides which motor carriers to review for compliance with its safety regulations primarily by using an automated, data-driven analysis model called SafeStat. SafeStat uses data on crashes and other data to assign carriers priorities for compliance reviews.

Because the number of inspectors is small compared with the size of the motor carrier industry, FMCSA prioritizes carriers for compliance reviews. To do so, it uses SafeStat to identify carriers that pose high crash risks. SafeStat is a model that uses information gathered from crashes, roadside inspections, traffic violations, compliance reviews, and enforcement cases to determine a motor carrier's safety performance relative to that of other motor carriers that have similar exposure in these areas.

While SafeStat does a better job of identifying motor carriers that pose high crash risks than does a random selection, regression models GAO applied do an even better job. SafeStat works about 83% better than selecting

carriers randomly. SafeStat is built on a number of expert judgments rather than using statistical approaches, such as a regression model. For example, its designers decided to weight more recent motor carrier crashes twice as much as less recent ones on the premise that more recent crashes were stronger indicators of future crashes. GAO estimates that if FMCSA used a negative binomial regression model, FMCSA could increase its ability to identify high-risk carriers by about 9% over SafeStat. Carriers identified by the negative binomial regression model as posing a high crash risk experienced 9,500 more crashes than those identified by the SafeStat model over an 18-month follow-up period. The primary use of SafeStat is to identify and prioritize carriers for FMCSA and state compliance reviews. FMCSA measures the ability of SafeStat to perform this role by comparing the crash rate of carriers identified as posing a high crash risk with the crash rate of other carriers. Using a negative binomial regression model would further FMCSA's mission of reducing crashes through the more effective targeting of compliance reviews to the set of carriers that pose the greatest crash risk.

Late-reported, incomplete, and inaccurate data reported to FMCSA by states have been a long-standing problem. However, GAO found that late reported data had a small effect on SafeStat's ability to identify carriers that pose high crash risks in 2004. If states had reported all crash data within 90 days after occurrence, as required by FMCSA, a net increase of 299 carriers (or 6%) would have been identified as posing high crash risks of the 4,989 that FMCSA identified. Reporting timeliness has improved, from 32% of crashes reported on time in fiscal year 2000, to 89% in fiscal year 2006. Regarding completeness, GAO found that data for about 21% of the crashes (about 39,000 of 184,000) exhibited problems that hampered linking crashes to motor carriers. Having complete information on crashes is important because SafeStat treats crashes as the most important factor for assessing motor carrier crash risk, and crash information is also the crucial factor in the statistical approaches that we employed. Regarding accuracy, a series of studies by the University of Michigan Transportation Research Institute covering 14 states found incorrect reporting of crash data is widespread. GAO was not able to quantify the effect of the incomplete or inaccurate data on SafeStat's ability to identify carriers that pose high crash risks because it would have required gathering crash records at the state level—an effort that was impractical for GAO. FMCSA has acted to improve crash data quality by completing a comprehensive plan for data quality improvement, implementing an approach to correct inaccurate data, and providing grants to states for improving data quality, among other things.

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Elastomeric Concrete for Bridge Deck Expansion Dam Headers by Kenneth Urbanec, P.E; Mahiru Shettima, Ph.D., P.E. and Molly Scott, Jeff Zell Consultants, Inc., 1031 4th Avenue, Coraopolis, PA 15108 (Pennsylvania Department of Transportation, Bureau of Planning and Research, Commonwealth Keystone Building, 400 North Street. 6th Floor East, Harrisburg. PA 17120) (Mar 2007)

Highlights

- EC has provided various State transportation agencies with a useful tool for the construction and repair of expansion joint headers.
- Most of the problems reported to be associated with the use of EC in practice are linked to conditions existing before or occurring during installation of the product.

Jeff Zell Consultants, Inc. (JZC) was retained by the Pennsylvania Department of Transportation (PennDOT) to develop a specification for elastomeric concrete (EC) for bridge deck expansion dam headers. The scope of the work included: conducting a literature search, surveys, interviews and data review; the development of a testing program and evaluation of select EC products; the development of the specification; and a technology transfer session with appropriate course materials. The following is a summary of the work performed and the conclusions drawn from the experience:

1. EC, as is currently sold, is produced by mixing a two-component thermosetting binder and a filler material (aggregate). The product rapidly cures to form a solid, non-porous material with desirable mechanical properties.

2. EC was developed to address issues of leaking joints, crumbling joint headers and lengthy repair times experienced with rigid Portland cement concrete (PCC). Upon installation, the PCC was difficult to consolidate under the horizontal surfaces of the steel armor and was often left with voids. Water would collect and freeze in these voids causing the concrete to break. Also, PCC did not absorb the energy of impact, whether armored or not, as needed in this high impact area and therefore eventually cracked and crumbled.

3. EC, when installed with great care, creates few significant voids and has the flexibility and strength to absorb the energy of impact. The composition of the material, its ability to bond to surrounding materials and its ease of workability serve to address some of the issues associated with PCC joints. The material can be impermeable and can bond well with other joint materials included in the same joint system.

4. EC has provided various State transportation agencies with a useful tool for the construction and repair of expansion joint headers. Its use in joint systems reduces the time a roadway must be closed for repairs. EC cures sufficiently within hours and roads may be open to traffic, thus, reducing costs and risk to workers and drivers.

5. Most of the problems reported to be associated with the use of EC in practice are linked to conditions existing before or occurring during installation of the product. For this reason, users of the product typically require the presence of a trained manufacturer's representative during installation to ensure

adequate surface preparation, proper environmental conditions and workmanship.

6. In addition to adding some needed qualities to the joint system, EC must withstand conditions potentially existing in a roadway. EC must exhibit adequate strength, as well as resistance to impact, weather and chemicals in the field.

7. PennDOT currently has several manufacturer-specific EC materials approved for use as the header or nosing portion of various types of expansion dam systems. These products were approved based on satisfactory performance in field evaluations of the product. The three approved materials are (sold under the brand names) Delcrete, Silspec and Elastocrete.

8. No set of testing standards specifically designed to test EC was found. Furthermore, the unique composition of this polymeric-based material, including the presence of an aggregate of the manufacturer's specification, made it difficult to outright adopt existing standard test methods.

9. A laboratory testing program specifically designed for use in predicting the performance of EC (when used in a bridge deck expansion dam of a roadway) was developed by selecting closely related existing standard test methods and adjusting the procedures to apply to EC. The program included standards for characterizing the two-component binder and the aggregate and for determining key mechanical properties of EC. Each of these materials has its own unique binder formulation and a manufacturer specified aggregate.

10. The testing program was used to evaluate the three materials (Delcrete, Silspec and Elastocrete) demonstrated by PennDOT to have performed satisfactorily during field evaluations. With the knowledge of satisfactory performance of the approved products in field evaluations, laboratory evaluations sought to set requirements predictive of performance in the field by testing, in the laboratory, those approved products.

In summary, the three materials tested exhibited unique mechanical properties, with no apparent relationship to each other. Some materials are weak in areas where others are strong and vice versa. Assuming the materials were subjected to identical conditions during the field evaluations, the lack of relationship among products suggests that a balance of properties exists within each of the materials that makes it suitable for use as a joint header. Otherwise, the conditions under which the materials were tested in the field may not have been similar enough to reveal possible performance differences between the products.

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Evaluating Fiber Reinforced Polymer Repair Method for Cracked Prestressed Concrete Bridge Members Subjected to Repeated Loadings, Phase 2 by Kyle H. Larson, Hayder A. Rasheed, Robert J. Peterman, Kansas State University, 215 Durland, Manhattan, KS 66506 (Kansas Department of Transportation, Bureau of Materials and Research, 700 SW Harrison Street, Topeka, Kansas 66603-3754) (May 2007)

Highlights

- This work has developed an iterative design procedure relating the serviceability stress range level targeted to the strengthening index furnished.
- It is proven to be possible to design for and achieve high strengthening levels (70% and 113%) while still controlling stress range fatigue requirements.

This report documents the second phase of a research project conducted for KDOT. In the first phase, 30-year-old PC T-girders decommissioned from an actual bridge were strengthened and tested in static loading and fatigue. These girders showed success in strengthening up to a 50% increase in ultimate capacity over the original control beam design. However, they showed a limited success in fatigue performance. This was attributed to a combination of interacting factors including stress concentration at push down or hold down device to harp strands, strand corrosion due to excessive precracking, and a high strand stress range (37 ksi) for the strengthened girders. The latter should be limited to 10 ksi for harped strands and 18 ksi for straight strands as per the *AASHTO LRFD* 1998.

This follow-up study builds on the findings of phase I and isolates the variables to explore their effects. Accordingly, it focuses on studying the influence of stress range. Therefore, a series of five new precast, prestressed single-T girders with straight strands was constructed and tested. The girders are designed to have the same prestressing ratio as those of phase I. The research addressed two target average prestressing strand stress ranges. The first one related to the limit imposed by the AASHTO requirements and the second one tied to the stress range obtained in phase I (36 ksi). The beams were pre-cracked at a mid-span crack former to ensure high stress ranges at the cracked section.

This work has developed an iterative design procedure relating the serviceability stress range level targeted to the strengthening index furnished. The 18 ksi stress range beam design showed excellent fatigue performance after sustaining more than one million cycles (Beam 3). This beam also achieved the full ultimate strength and ductility of an identical specimen monotonically loaded to failure without cycling (Beam 2). This indicates that the fatigue life of Beam 3 under 18 ksi stress range may not have been exhausted by 1 million cycles of loading. This conclusion was further reinforced by strand tensile fatigue, in isolation, yielding 9 million cycles at the same stress range without breakage. The 36 ksi stress range beam design also showed a surprisingly outstanding fatigue performance. Beam 5 was cycled 3 million times at this higher stress range without showing signs of noticeable stiffness degradation. The beam, however, failed prematurely in static loading indicating that the ultimate strength of its CFRP or strand must have been significantly reduced by the 3

million load cycles. The results suggest that the strand is expected to have the reduced strength due to fracture of a couple of wires. The global stiffness response of Beam 5 matched that of Beam 4, monotonically tested to ultimate, indicating a fatigue impact on strength not stiffness degradation, which was the opposite in phase I. It is important to draw the following additional conclusions:

The excellent fatigue performance of the present CFRP strengthening designs for both stress range levels minimizes the influence of this factor in reducing fatigue life in phase I. That leaves the effects of stress concentration in harped strands and corrosion as the two factors to examine next.

It is proven to be possible to design for and achieve high strengthening levels (70% and 113%) while still controlling stress range fatigue requirements.

An interesting new phenomenon is observed and proven applicable through comparisons among various experimental results along with analysis findings. Due to its superior bonding to concrete across cracks, CFRP is seen to develop higher strains at critical sections than those recovered from strain compatibility. This is shown to reduce the strand stress range at such critical sections proving to be a beneficial bi-product of strengthening.

Recommendations

1. Testing the prestressing strand from these beams and CFRP coupons in tensile fatigue to assess their performance under 36 ksi stress range.
2. Cycling same beams under higher stress range (54 ksi and 72 ksi) to identify the limiting effects of this factor on fatigue life.
3. Examining the effect of harped strand combined with a lower level of stress range (lower than that experienced in phase I) of 18 ksi for limited strengthening levels.

Combining significant strengthening levels, harped strand, and lower stress range of 18 ksi through stress relief by over reinforcing.

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JANUARY 2008

An Integral Abutment Bridge with Precast Concrete Piles by Robert E. Abendroth, Lowell F. Greimann, and Michael D. LaViolette, Center for Transportation Research and Education, Iowa State University, 2711 South Loop Drive, Suite 4700, Ames, IA 50010-8664 (Iowa Highway Research Board, Iowa Department of Transportation, 800 Lincoln Way, Ames, IA 50010) (May 2007)

Highlights

- The research presented in this report documents the first use of PC piles to support integral abutments in Iowa.

The application of precast, prestressed concrete (PC) piles for the abutment piles of integral abutment bridges has not been widely publicized in the literature. There have been a few investigations, most notably by the University of Tennessee, but no widespread consensus on the behavior and long-term durability of these PC piles has been published in the reviewed literature. Moreover, the results of a survey of bridge owner agencies conducted as part of this study do not indicate a strong preference for this type of abutment construction.

The research presented in this report documents the first use of PC piles to support integral abutments in the State of Iowa. The subject bridge, located in Tama County, was constructed and opened to traffic in 2000. Following the bridge construction, a number of displacement sensors, strain gages, and thermocouples were installed on the bridge to monitor its behavior and help assess its long-term performance. The results of the instrumentation and monitoring of the subject bridge in Tama County are summarized as follows:

The overall bridge movement occurred primarily at the east abutment. The magnitude of these longitudinal movements fell into the low end of the expected range of movements for a bridge of this length. The recorded longitudinal movement at the west abutment was negligible. The bridge rotates in plan view due to the effects of the abutment skew, as predicted in previous integral abutment monitoring projects.

The recorded thermal gradients in the bridge deck and girders are in reasonable agreement with the published AASHTO guidelines. There were some interesting, and somewhat unexplainable, differences in the thermal data recorded at the east and west ends of the bridge. The installation techniques used for this network of thermocouple sensors may account for some of these differences.

The effectiveness of the carpet wrap at the top of the abutment pile is debatable. The intent of this wrap, installed before the concrete is cast, is to reduce the rotational restraint at the tops of the abutment piles and consequently create a pinned type of connection between the piles and the pile cap. However, a review of the pile strain data did not reveal how much freedom of rotation is available for this type of connection with a PC pile. Therefore, the researchers recommend that the pile tops with carpet wrapping should not be assumed to be in a pinned-end condition for future design applications.

The pile strain records for the center pile of the east abutment appear to indicate the formation of a crack in the PC pile sometime between October 12 and October 23, 2000. The

strain records for gages located at two different locations along the pile length indicate a distinct change in behavior during this time period.

Subsequent excavation of the center pile of the east abutment provided photographic evidence of the pile cracking. Because pile cracking may allow moisture penetration and subject the uncoated prestressing strands to long-term corrosion, the Iowa State University (ISU) researchers recommend periodic inspection of the abutment piles to detect any additional concrete cracking or deterioration.

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Estimating Toll Road Demand and Revenue, *NCHRP Synthesis 364* by David Kriger, Suzette Shiu, and Sasha Naylor, iTRANS Consulting, Richmond Hill, ON, Canada (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; http://gulliver.trb.org/bookstore) (2006)

Highlights

- The research literature cited in this synthesis largely focused on methodological issues.
- Those in the transportation community who are making investment decisions regarding tolled facilities do not always know what questions to ask.

Many of the problems that had been identified with the performance of traffic and revenue forecasts were related to the applications of the models, less so to methods and algorithms. In particular, assumptions regarding land use, network inputs, values of time, and other inputs; the process of reviewing models and their results; and the treatment of uncertainties and risks were most often cited in the literature in explaining why the performance problems occurred.

It is noteworthy that much of the literature that describes these problems in the context of toll road demand and revenue forecasts comes from the financial community, rather than the transportation modeling community. This suggests a disconnect between the two communities; the latter being the "traditional" users (and developers) of the models and the former representing the new users. The state of the practice in travel demand modeling has not kept pace with the issues that the models now must address. The disconnect is exemplified in different ways; for example, in the use of risk analysis (incorporating a range of outcomes) and stress tests (which assess extreme and multiple "shocks"); neither of which has been widely applied to transportation planning.

It is also incumbent upon the new users to understand how the models work and how to interpret their results, as well as their inherent limitations; and it is equally incumbent on the developers of the models and their data to provide this understanding. One traffic and revenue study reviewed for this synthesis noted that "professional practices and procedures were used in the development of the traffic and revenue forecasts included in this report" as a preface to its overview of the modeling process, which was brief and did not provide many details. Nonetheless, improvements in both aspects (application and method) are required to address the performance of the models in traffic and revenue forecasts.

Although the application of state-of-the-art methodological improvements into common practice--such as activity-based models and network micro-simulation--should be expected to improve the state of the practice, it is likely that these alone will not improve the performance of traffic and revenue forecasts.

Two important improvements to the travel demand modeling process are time-of-day choice modeling and the modeling of commercial traffic. The understanding of traveler behavior when faced with tolls continues to evolve and must be better understood, including values of time and willingness to pay when confronted with different factors (such as the toll collection method). The explicit incorporation of risk and

uncertainty in all aspects of the modeling process also is needed.

Those in the transportation community who are making investment decisions regarding tolled facilities do not always know which questions to ask of their modeling and forecasting efforts--in other words, the analytical and modeling capabilities available to them have not always kept pace with the needs. The problem is exacerbated by the "confidential" or "proprietary" nature of the forecasts and methods that are developed for toll roads, and also by "optimism bias" on the part of the sponsor, local elected officials, or other advocates of the proposed toll road.

Sufficient resources have not been devoted to procuring the required data or to updating older data, or to calibrating models to the level of detail that is required. The general practice in Europe, for example, is to prepare three sets of forecasts. This clearly requires an investment on someone's part. Intuitively, better data, more detailed models, and multiple forecasts should improve model performance. Similarly, it is intuitive that a stronger role for peer review should improve the performance; however, the literature review did not uncover any evaluations or specific assessments of the effectiveness of the peer review process for modeling in general.

It should also be noted that the comparisons in the literature focused primarily on the revenues as opposed to the demand (i.e., the traffic and its composition). The literature noted that revenue performance could be affected by changes in toll rates or by drawing on reserves, or other means; in other words, by actions that are not related directly to demand. Therefore, at least some of the available information does not accurately reflect the outputs of the travel demand model and, accordingly, the linkage between the demand forecasts and the revenue performance is not always completely direct or explicit. Accordingly, there is a need to measure the performance of the travel demand models in their own right, specifically examining how well the toll road demand models simulate each class of vehicle and traveler.

The research literature cited in this synthesis largely focused on methodological issues; notably, the understanding of the variables that affect the traveler's decision to use a toll road, consideration of probability distributions to describe these variables as a means of analyzing and managing risk, development of time-of-day choice models, simulation of value of time and the role of stated preference surveys in estimating value of time or on the development of value-of-time models based on historical data that are now becoming available.

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Miami Toll Truckway: Preliminary Feasibility Study by Robert W. Poole, Jr. (Reason Foundation, 3415 S. Sepulveda Blvd., Suite 400, Los Angeles, CA 90034; 310/391-2245; http://www.reason.org/ps365_miami_truckways.pdf) (Nov 2007)

Highlights
- Toll revenues could support about half of the cost of new exclusive truck highways from the Miami port.
- The truck tollways would increase roadway safety by shifting many east-west trucks from congested corridors onto their own separate right of way.
- It would reduce projected congestion on five principal east-west arteries.
- It would reduce truck-related emissions.

The Port of Miami is a major contributor to the Miami-Dade economy. But the Port's continued growth is threatened by present and projected congestion on the area's roadways. Since the large majority of incoming cargo has local destinations (for which rail is uneconomical), trucks will continue to be the principal means of transporting containers to and from the Port. Hence, additional roadway capacity for goods-movement is essential.

Because the majority of Port-related truck traffic moves east-west, the focus of this study is on an east-west truck-only roadway or "truckway," built mostly along existing rail and roadway rights of way. Because the cost of such a truckway is in the billion-dollar range, and conventional funding sources of that magnitude are unlikely to be available, the study makes a preliminary feasibility assessment of financing the cost of the truckway via tolls.

Four alternate east-west routes were examined. Each poses its own challenges, but each appears to be feasible. Any of the four would provide a barrier-separated two-lane roadway permitting nonstop, high-speed access from the planned Port Tunnel to the Florida East Coast intermodal rail yard west of Miami International Airport, and beyond that to the warehouse and distribution center area northwest of the airport in Doral and Medley. The western end of the truckway would connect to the Homestead Extension of Florida's Turnpike. Each alternative uses a combination of elevated, tunnel, and surface routes. The estimated costs range from a low of $1.1 billion to a high of $1.3 billion, in 2007 dollars.

The traffic analysis used recent (2005) data on truck traffic on five major east-west routes, two of which are toll roads (SR 112 and SR 836). "Low" and "High" estimates were made of total trucks that might shift to the truckway in order to save time. Then separate value-of-time-savings analyses were done for Port-related (drayage) truck trips and other truck trips. Dray operators would be able to make four round-trips per shift using the truckway, compared with only three under today's congested conditions. Since those operators are paid by the trip, it would be worth their while to pay a toll in order to generate more net revenue per day. A lower value of time savings (consistent with national studies) was used to estimate possible toll rates for non-dray trucking.

Truck traffic (dray and non-dray) and toll revenues were projected over a 40-year period. To assess the basic economic feasibility of the truckway, the net present value (NPV) of

40 years worth of toll revenues was compared with the NPV of truckway construction cost. That calculation showed that, under the assumptions made, toll revenues could support 54 to 58 percent of the project's cost. Toll rates and toll revenues could be higher if legal authority can be obtained to operate dualtrailer/dual-container rigs on the truckway, but quantifying that effect was beyond the scope of this preliminary study.

The toll truckway would be a good candidate for development as a long-term concession, as is being planned for the Port Tunnel and several other large Florida roadway projects. It would require a mix of public and private funds, and the study suggests several possible approaches to such mixed funding. Florida already has the necessary public-private partnership enabling legislation. The only other legal change that would be helpful would be federal and state permission to operate dual-trailer rigs on the truckway.

The toll truckway would produce significant benefits. It would enable the Port and the associated goods distribution industry to continue expanding, when that growth might otherwise be curtailed due to traffic congestion. It would increase roadway safety by shifting many east-west trucks from congested corridors onto their own separate right of way. It would reduce projected congestion on five principal east-west arteries, especially the Dolphin and Airport expressways. And by shifting many trucks out of stop-and-go congestion, it would reduce truck-related emissions. Therefore, the study recommends that further steps be taken to explore the feasibility of such a toll truckway in greater detail.

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Federal Transit Benefits Program: Ineffective Controls Result in Fraud and Abuse by Federal Workers (United States Government Accountability Office, 441 G Street NW, Room LM, Washington, D.C. 20548; Gregory Kutz at (202) 512-9505 or kutzg@gao.gov; http://www.gao.gov/new.items/d07724t.pdf) (April 24, 2007)

Highlights

- GAO estimated the amount of fraudulent transit benefits claimed during 2006 in the National Capital Region was at least $17 million.

The Government Accountability Office (GAO) investigation confirmed allegations that federal employees in the National Capital Region committed fraud by deliberately requesting benefits they are not entitled to and then selling or using these benefits for personal gain. These employees could be subject to prosecution for unlawful conversion under 18 U.S.C. §641. In addition, because the employees GAO investigated signed certifications stating that they will only use their transit benefits to cover actual out-of-pocket commuting costs, they could be subject to criminal prosecution under the False Statements Act, 18 U.S.C. §1001. As described below, case studies demonstrate abusive and potentially fraudulent activity by individuals employed at the Departments of Commerce, Transportation, State, Homeland Security, Defense, and the Treasury and at the Internal Revenue Service (IRS), the Patent and Trademark Office, and the U.S. Coast Guard.

After investigating just 3 days of sales on the Internet auction site eBay, GAO identified 58 individuals selling Metrocheks, selected 20 for investigation, and determined that these 20 were in fact federal employees. Collectively, these 20 federal employees have fraudulently sold more than $21,000 worth of Metrocheks on eBay over the past 2 years. In subsequent interviews with 13 of the 20 eBay sellers, GAO found cases where federal employees received parking benefits in addition to Metrocheks, were on extended leave from work, or did not even use public transportation to commute to work. One GS-14 information technology specialist for IRS drove to work, parked for free in agency-provided parking, and was still able to collect $105 per month in transit benefits—most of which he sold on eBay. In addition, none of the 13 individuals GAO interviewed reported income earned from Metrochek sales on their federal tax returns.

Posing as buyers, GAO investigators purchased $840 worth of benefits from three federal employees fraudulently selling their Metrocheks on Craigslist, a popular community Web site. For example, one of our investigators purchased $420 worth of Metrocheks for $350 from an Air Force captain who advertised on the site. The captain corresponded with the investigator using his military e-mail address and told the investigator that he would show up at the designated meeting spot in his "Air Force service dress uniform." The investigator tried to get the captain to sell him the benefits for less money, but the captain refused and told the investigator that his wife had gotten angry at him for accepting less than the agreed-upon fee the last time he sold his transit benefits. After the investigator completed the purchase, the captain explained that he usually "slugs" (i.e., rides for free with another driver, thus incurring no commuting costs) to work and therefore

does not use his transit benefits. He indicated that this was not the first time he had sold his benefits and he offered to enter into an ongoing "partnership" with the investigator to sell his benefits on a quarterly basis.

Further investigation at the agencies where the eBay and Craigslist sellers worked also demonstrated that federal employees are not using their transit benefits to cover actual out-of-pocket commuting costs. Through data mining of information submitted on transit benefit records, GAO found many employees who appeared to provide inaccurate and inflated commuting cost information on their transit benefit applications and GAO developed case studies on 23 of these individuals. Specifically, based on a comparison of their home and work addresses, these 23 individuals claimed more benefits than they needed to commute to work. During interviews, 11 admitted to deliberately falsifying their applications in order to obtain excess transit benefits for personal use. One GS-11 associate director at Transportation admitted to claiming the maximum transit benefit of $105 per month when his actual commuting cost was only $54 per month. This individual, who received his benefits on a SmarTrip card under the SmartBenefits program, admitted to using the excess $51 per month for personal travel.

Although GAO's objective was to investigate allegations related to federal employees, data mining revealed other troubling information related to the abuse of the transit benefit program by nonfederal employees. For example, GAO identified 28 individuals who have received transit benefits from federal agencies even though they do not appear to work for these agencies, 9 individuals who separated from the agencies, but did not return their unused benefits, and 4 former federal employees who continued to receive benefits after leaving their respective agencies. For example, one Commerce employee left the department in 2001, but records indicate that Commerce mailed her $65 per month in transit benefits until she moved to a new address in 2006.

Weaknesses in the design of program controls at Commerce, Transportation, State, Homeland Security, Defense, Treasury, IRS, Patent and Trademark, and the Coast Guard can be associated with the fraudulent and abusive activity GAO identified. Each of these agencies has its own process for management and oversight; there are no governmentwide policies or standards establishing internal controls for the federal transit benefits program. Although GAO did not conduct a comprehensive review of each agency's controls, the results from investigations illustrate flaws in the design of the controls. For example, GAO developed case studies on four employees who admitted that they continued to receive transit benefits even though they were on extended absences from work. However, none of the agencies adjust benefits because of leave or travel. In addition, GAO developed case studies on two employees who admitted that they receive both parking and transit benefits, but only three agencies established control procedures intended to ensure that transit benefit recipients were not also receiving parking benefits.

Finally, using transit benefits records from seven of the nine agencies reviewed, GAO determined that the amount of potentially fraudulent transit benefits claimed during 2006 in the National Capital Region was at least $17 million and likely more. This fraudulent amount could be millions more if a similar magnitude of fraud exists in the dozens of agencies GAO did not review, or if the other types of fraud GAO identified in this investigation could be quantified.

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Concepts for Managing Freeway Operations During Weather Events by Kevin Balke, Praprut Songchitruksa, Hongchao Liu, Robert Brydia, Debbie Jasek, and Robert Benz, Texas Transportation Institute, Texas A&M University System, College Station, Texas 77843-3135 (Texas Department of Transportation, Research and Technology Implementation Office P.O. Box 5080, Austin, Texas 78763-5080) (Feb 2007)

Highlights

- Statewide dissemination of weather information is recommended.
- The state should develop formalized consistent management practices for all types of weather events.
- The state DOT should implement operating agreements between districts as to what weather information should be disseminated and when.

Weather, and its impact on traffic operations, continues to be a concern to TxDOT and other operators of the transportation system. The goal of this research was to help TxDOT develop a structured, systematic approach for managing traffic during weather events. The focus in this research project was on common weather events -- such as fog, high winds, heavy rains, and snow and ice storms -- that impact traffic operations day-to-day. First, the researchers conducted a survey of selected TxDOT districts to determine what information TMC operators need to manage traffic operations during weather events. Through a review of the existing literature, they assessed systems and technologies that other states have deployed to manage traffic during weather-related events. They reviewed the current state of weather-related detection and monitoring technologies. Using historical traffic detector and weather information, they assessed the magnitude of the impact of different weather events on traffic operations. Using all this information, they developed concepts of operations for how TMC operators should respond to different types of weather-related events, including limited visibility conditions, ponding and flash flooding, high winds, severe thunderstorms, tornados, and winter storms. They developed a catalog of advisory, control, and treatment strategies (or ACTS) that operators could use to manage traffic operations during weather events. Specific criteria outline when TxDOT TMC operators should implement different types of responses. They proposed messages that TxDOT TMC operators can use on dynamic message signs to achieve different advisory and control strategies for different types of weather events. Finally, they provided a framework TxDOT can use to integrate weather information from the National Weather Service and other private weather providers into its TMC operations software.

Recommendations

TxDOT should consider expanding monitoring and dissemination of statewide weather information. While many districts have deployed weather monitoring technologies for specific purposes, there has been little effort to collect and disseminate this information on a statewide basis. TxDOT should strongly consider linking the various weather monitoring systems that have been deployed in individual districts throughout the state and disseminate this information through their

statewide Roadway Conditions Internet website.

Several TxDOT districts have developed strategies and deployed technology for managing traffic operations for specific weather events. These systems and management strategies have been developed to generally meet the needs of individual districts. So that driver expectation can be maintained throughout the state, TxDOT should develop formalized consistent management practices for all types of weather events. This research provided generic concepts of operations and a catalog of potential advisory, control, and treatment strategies that TxDOT can use as a foundation for developing statewide management practices.

As one of its new initiative areas, the Federal Highway Administration is placing a greater emphasis on road weather management. This new initiative, *Clarus* (which is Latin for "clear"), is to develop and demonstrate an integrated surface transportation weather observing, forecasting, and data management system, and to establish a partnership to create a *Nationwide Surface Transportation Weather Observing and Forecasting System*. The objective of *Clarus* is to provide information to all transportation managers and users to alleviate the effects of adverse weather (e.g., fatalities, injuries, and delays). TxDOT should continue to monitor and participate in this initiative.

Weather can have a far-reaching effect on traffic operations. Motorists in one district often require information about weather and travel conditions in other districts, particularly along routes used for intrastate and interstate travel. TxDOT has an obligation to provide these travelers with current, up-to-date alerts and warning information about developing weather situations, so they can make intelligent, informed travel decisions. TxDOT should implement operating agreements between districts as to what weather information should be disseminated and when. This includes determining what information is shared between district traffic management centers as well as what messages should be posted on DMSs under specific weather situations.

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Preemption of Traffic Signals Near Railroad Crossings (Institute of Transportation Engineers, 1099 14th St., NW, Suite 300 West Washington, DC 20005-3438 USA Telephone: 202-289-0222; http://www.ite.org) (2006)

Elements of preemption…
- When to preempt;
- Design elements; and
- Preemption operation and maintenance.

The intersection of a highway and a set of railroad tracks at grade is commonly called a highway-railroad grade crossing, or more simply a railroad crossing. Another term, chiefly used in conjunction with intelligent transportation systems (ITS), is highway-rail intersection.

When the term intersection is used in this report, it refers to the signalized junction of two highways adjacent to the railroad crossing. Where light rail transit (LRT) tracks are adjacent to railroad tracks, LRT crossings should be treated the same as railroad crossings, as described in this report.

Traffic signals are commonly used at highway intersections involving high volumes of traffic or substantial elements of conflict. Similarly, railroad crossing active warning devices (flashing lights with or without gates) are used to provide additional warning to road users at railroad crossings where high traffic volumes, limited sight distance, adverse roadway geometric alignment, or other safety concerns exist. Traffic signal control and railroad crossing active warning devices are considered the highest form of treatment at intersections and at railroad crossings, short of grade separation or closure.

Where a signalized highway intersection exists in close proximity to a railroad crossing, the railroad signal control equipment and the traffic signal control equipment should be interconnected, and the normal operation of the traffic signals controlling the intersection should be preempted to operate in a special control mode when trains are approaching. A preemption sequence compatible with railroad crossing active traffic control devices is extremely important to provide safe vehicular and pedestrian movements. Such preemption serves to ensure that the actions of these separate traffic control devices complement, rather than conflict with, each other.

The traffic engineer responsible for designing the preemption system must understand how the traffic signal controller unit operates in response to a call for a preemption sequence. The engineer must consult with railroad personnel who are responsible for railroad signal design and operations to ensure that appropriate equipment is specified and that both highway and railroad signal installations operate properly and with full compatibility. Continuous cooperation between highway and railroad personnel is essential for safe operation. Information concerning the type of railroad signal equipment that can be used is available from the operating railroad and from the *American Railway Engineering and Maintenance of Way Association (AREMA) Communications and Signal Manual*. In addition, state and local regulations should be consulted.

With the re-emergence of LRT, particularly in urban areas, at-grade crossings for LRT also need to be recognized. Some LRT

operations are similar to conventional heavy rail in that they operate on semi-exclusive right-of-way at high speeds and require exclusive right-of-way at the grade crossing. Concepts presented in this report would apply to light rail vehicles (LRVs) operating under the same conditions; however, designers of a railroad preemption system for LRT operations must also recognize that the crossing may be blocked more frequently as a result of short headways, but for less time per train because LRT trains are shorter. Virtually all LRT systems use electricity for propulsion power. Some motion sensing and constant warning time (CWT) devices may not operate properly in electrified systems, and special devices or track circuits might be required. Because there is typically little variability in train speeds on LRT tracks, CWT devices are often not necessary, or conventional circuitry, which approaches the performance of CWT for that location, can be installed. The same LRT line may become nonexclusive at' some locations, traveling within highway right-of-way and totally integrated with highway traffic flow. With such mixed-use flows, traffic signal operations must be treated differently because preemption may not be necessary. Where LRT and railroads travel on the same or adjacent tracks, the traffic control devices, systems and practices for railroad crossings must be used.

The operation of a traffic signal controller unit is described in Appendix A and an overview of railroad active warning system control is presented in Appendix B. A glossary of terms is included in Appendix C. Appendix D provides a brief outline of potential ITS applications at railroad crossings. Appendix E is a detailed explanation of the concept of advance preemption.

Preemption of traffic signals for railroad operations is a very complex task, and the preemption system must be designed and operated for a specific location, often with unique conditions. With the extremely large number of variables involved, it is difficult to simply quantify all the time and distance elements. The goal of this recommended practice is to identify as many elements as possible and provide references where feasible. Recommendations are therefore provided in the generic sense, with the expectation that applications will be designed for local conditions. The list of conditions requiring preemption is not intended to be complete, but should provide an awareness of the factors necessitating preemption of normal traffic signal operation.

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Roundabouts in the United States, *NCHRP Report 572* by Lee Rodegerdts, *et al.* (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; http://gulliver.trb.org/bookstore) (2007)

Highlights

- Roundabouts have improved both overall crash rates.
- Single-lane roundabouts have better safety performance than multilane roundabouts.
- Drivers in the United States use roundabouts less efficiently than is the case in other countries.

In general, roundabouts have improved both overall crash rates and, particularly, injury crash rates in a wide range of settings (urban, suburban, and rural) for all previous forms of traffic control except for all-way stop control, for which no statistically significant difference could be found. In addition, single-lane roundabouts have better safety performance than multilane roundabouts. The safety performance of multilane roundabouts appears to be especially sensitive to design details.

Intersection-level crash prediction models for the prediction of the overall safety performance of the intersection relate the crash prediction to the number of lanes, number of legs, and the average annual daily traffic.

Approach-level crash prediction models that relate common types of crashes (e.g., exiting-circulating crashes) to average annual daily traffic volumes and key geometric parameters were demonstrated to influence the prediction.

An updated comparison of the performance of roundabouts to other forms of traffic control were disaggregated to a greater extent than any previous study of U.S. roundabouts.

Currently, drivers in the United States appear to use roundabouts less efficiently than models suggest is the case in other countries around the world. In addition, geometry in the aggregate sense-number of lanes--:has a clear effect on the capacity of a roundabout entry; however, the fine details of geometric design-lane width, for example-appear to be secondary and less significant than variations in driver behavior at a given site and between sites.

Because driver behavior appears to be the largest variable affecting roundabout performance, calibration of the models to account for local driver behavior and changes in driver experience over time is highly recommended to produce accurate capacity estimates.

The recommended level of service (LOS) criteria are the same as those currently used for unsignalized intersections. The LOS for a roundabout is determined by the computed or measured control delay for each lane. The LOS is not defined for the intersection as a whole.

These models have been incorporated into an initial draft procedure for the *Highway Capacity Manual*, which the TRB Committee on Highway Capacity and Quality of Service will continue to revise until its eventual adoption.

This study produced a number of major geometric design findings:

- The application of acceleration and deceleration effects appears to significantly improve the ability to

predict 85th-percentile speeds entering and exiting a roundabout.

- The combination of the extensive field observations of critical gap' and the revised speed predictions may be used to refine the current intersection sight distance procedure presented in FHWA's Roundabouts: An Informational Guide. These findings should be considered interim until a more comprehensive study of sight distance needs at roundabouts can be completed.
- Anecdotal evidence suggests the importance of considering design details in multilane roundabout design, including vehicle path alignment, lane widths, and positive guidance to drivers through the use of lane markings.

This study produced a number of findings regarding pedestrian and bicyclist behavior at roundabouts:

- This research did not find any substantial safety problems for non-motorists at roundabouts, as indicated by few crashes being reported in detailed crash reports. In addition, no crashes and a very small number of conflicts were observed from video recordings of interactions between non-motorists and motorists. Because exposure data were not available from before a roundabout was present, it is unknown whether pedestrians have altered their travel patterns because of the presence of a roundabout.
- The ability of pedestrians and bicyclists to use the roundabout may be compromised if use of the roundabout by all modes and their subsequent interactions are greater than studied herein or if such interactions increase over time (i.e., as vehicle traffic and/or pedestrian traffic increases) .
- An emphasis needs to be placed on designing exit lanes to improve upon the behaviors of both motorists and pedestrians.
- Multilane roundabouts may require additional measures to improve upon the behaviors of motorists, pedestrians, and bicyclists.

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Impact of Behavior-Based Safety Techniques on Commercial Motor Vehicle Drivers*, CTBS Synthesis 11* by Jeffrey S. Hickman, *et al.* (Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001; (202) 334-3213; http://gulliver.trb.org/bookstore) (2007)

Highlights

- This synthesis documents current information on various Behavior-Based Safety (BBS) strategies to increase safety-related and decrease at-risk driving behaviors of commercial motor vehicle (CMV) drivers.

Although most CMV drivers are conscientious and generally employ safe driving practices, drivers may at times drive in ways that put themselves and others at risk for a vehicle crash and serious injuries. Some CMV drivers may habitually engage in such behaviors. A previous survey of motor carrier safety managers regarding major safety management problems found "at-risk driving behaviors" (e.g., speeding, tailgating) to be the single most important safety-management problem. Studies indicate that driving behaviors are a significant contributing factor of large truck crashes, and interventions aimed at increasing safe driving behaviors and reducing at-risk driving behaviors are likely to prevent many vehicle crashes.

BBS provides robust positive results when applied in organizations seeking to reduce employee injuries due to at-risk behaviors. However, almost all prior BBS research has been applied in work settings where employees can systematically observe the safe versus at-risk behaviors of their co-workers. Truck and bus drivers work alone in relative isolation and thus may require alternative BBS processes.

Driving vs. non-driving behaviors: Safety manager survey respondents generally rated the association between driving behaviors and crash and injury risk as much greater than the association between non-driving behaviors and injury and illness risk.

Ride-alongs: 59% of respondents indicated they currently perform ride-alongs to observe safety-critical behaviors.

Covert observation: 37% of respondents indicated they currently use covert observation techniques to observe safety-critical behaviors.

Comments from the public: 59% of respondents indicated they receive and use comments from the public to observe safety-critical behaviors.

Observation in general: 83% of respondents reported using some type of observation technique to observe the safety-critical behaviors of their drivers.

Intervention effectiveness: The highest-rated BBS technique was training and education programs directed at specific driving behaviors, while the lowest-rated was driver self-management self-observation.

Peer observation and feedback: 63% of respondents indicated the use of peer observation and feedback, most commonly performed monthly. 96% of respondents reported giving drivers feedback via one-on-one meetings. Most respondents (54%) give a combination of group and individual feedback.

Self-management/observation: 32% of respondents encourage their drivers to use safety self-management and self-observation.

Feedback to drivers is typically provided via one-on-one meetings or a combination of group and individual feedback.

Training on specific driving behaviors: All respondents use training and education sessions on specific driving behaviors, most often in quarterly sessions.

Training on specific non-driving behaviors: 72% of respondents indicated using training and education sessions on specific non-driving behaviors.

Incentives/rewards: 80% of respondents reported using incentives/rewards with their drivers. Typical rewards include safety awards (e.g., certificate, trophy), public recognition, and cash. Most of these respondents indicated using some type of outcome" measure (i.e., crash-free miles) to reward drivers, while few respondents indicated using process-based data (i.e., speed or brake).

Disincentives/penalties: 88% of respondents reported using disincentives/ penalties with their drivers. Most (88%) use a memo/letter in the driver's file. Most of these respondents indicated using crash data (93%) to punish drivers, while few respondents indicated using brake data (14%).

Content of new driver training: Most survey respondents (95%) focus on training new drivers how to conduct pre- and post-trip inspections of their vehicles (76%), while few focus on proper diet, exercise, or load securement (2%).

Content of refresher training: Most survey respondents (94%) focus on refresher training/ coaching experienced drivers to drive attentively (71 %), while few focus on diet, drugs, or load securement (2%).

Barriers to use of BBS: The highest rated barrier to the use of BBS was non-acceptance/lack of cooperation by drivers. The lowest rated barrier/problem was driver union (or other association) opposition to it.

The survey results from fleet safety managers did not always echo the results found in previously published studies. While BBS techniques have been successful in other industrial settings, few scientific studies have used these techniques with CMV drivers. Despite the widespread use and success of BBS in other industrial settings, systematic BBS programs have not been widely embraced by safety professionals in CMV operations. This synthesis shows that respondents indicated widespread use of specific BBS techniques but little use of more comprehensive BBS programs. This lack of comprehensive BBS programs may be due to the solitary nature of driving, the difficulty of capturing and documenting key safety-critical behaviors, and/or a general lack of fleet safety manager knowledge about BBS and its potential benefits. Clearly, a significant need is to develop a set of accepted practices and guidelines for implementing and using BBS techniques in CMV operations.