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Administration

Technology Ready for Implementation

from the AASHTO Research Advisory Committee

to the AASHTO Steering Group for Technology Deployment

Study SD2001-00
Final Report

Prepared by
SD Department of Transportation
Office of Research
Pierre, SD

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DISCLAIMER

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16. Abstract

This report contains brief descriptions of technology that is ready for application in the transportation industry. Each description was provided by individual members of the American Association of State Highway & Transportation Officials (AASHTO) Research Advisory Committee in response to a request made by Mr. Joe Denault, Chief Engineer of the West Virginia Department of Transportation, on behalf of the AASHTO Steering Group for Technology Deployment.

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AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

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CONTRACTING METHODS

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Asphalt Pavement Warranties**

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Technology Ready for Implementation

Brief Description: In 1995, WisDOT and the Wisconsin Asphalt Pavement Association launched a pilot warranty program for asphalt pavements based on specific pavement distresses. The warranty period is five years and requires the contractor to perform remedial work if distress thresholds are exceeded. A total of 23 highway projects in all regions of the state have been built so far under warranty contracts. Early projects whose five-year warranties expired in the summer of 2000 had no remedial work required. Warranty highways are outperforming conventionally contracted projects, extending the expected life of the pavements from 18 to 23 years.

State of Development: In the 2001 construction season, Wisconsin plans to add seven more asphalt pavement warranty projects. Consideration is being given to extending the warranty period to seven years, including more lane miles, requesting bids on both a conventional and warranty basis and including concrete pavements.

Potential Payoffs: WisDOT estimates it can pay up to 7% increased costs for a warranty project and still be cost effective, due to reduced design and construction expenditures by the department, longer pavement life and reduced maintenance requirements. The pavement warranty program has been a catalyst for getting new technology quickly into use. Contractors have the flexibility and incentive to employ new mix designs and modified asphalts, to invest in the latest construction machinery and to provide additional training to their crews to assure high quality results.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes.

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Design-Build Contracting**

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Technology Ready for Implementation

Brief Description: Design-build has been shown to be an effective innovative contracting method in Utah for some types of transportation projects. Large projects, such as the reconstruction of I-15 in Salt Lake County costing $1.4 billion and smaller projects that meet certain criteria, can benefit by using design-build.

State of Development: The Utah DOT has been studying design-build and other related innovative contracting methods for four years. A great deal has been learned related to topics such as best value selection of a contractor, performance specifications, QC/QA, owner controlled insurance, innovative construction processes, public relations, methods to accelerate settlement of fills, and organizational structures. Reports and other information are available on many of these topics.

Potential Payoffs: Projects constructed using design-build can be competed in less time, since the design can be overlapped with the construction. This can result in savings to the traveling public due to reduced delays. The occurrence of claims is reduced by having the design and construction completed by the same contractor. The risk is shared more evenly by the owner and contractor.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

PAVEMENTS

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Comprehensive Asphalt Pavement Testing**

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Technology Ready for Implementation

Brief Description: An extensive laboratory and accelerated full scale testing program involving both the University of California, Berkeley and Caltrans has been completed. That program involved fatigue response of asphalt concrete and the development of a design methodology to mitigate fatigue cracking. Recommendations include a change from a relative compaction requirement to a maximum air void requirement based on ASTM D2041 ("Rice" specific gravity) and the use of tack coats between all lifts of asphalt concrete.

State of Development: The research results have been reviewed and are considered conclusive enough to adopt the recommendations as part of Caltrans' Standard Special Provisions. This will be implemented and monitored through additional investigations and reviews to further confirm the conclusions reached by researchers.

Potential Payoffs: Long-term performance in terms of failure from fatigue cracking, reflection cracking or rutting of the unbound pavement layers is expected to be substantially improved, increasing the life of flexible pavement and thereby resulting in substantial savings.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Polyolefin Fiber Reinforced Concrete Pavement & Whitetopping**

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Technology Ready for Implementation

Brief Description: In collaboration with 3M, the South Dakota Department of Transportation has designed and constructed several pavements and whitetopping overlays using concrete reinforced with polyolefin fibers. The fibers, which are 2" long and 0.025" in diameter, greatly increase the concrete's toughness, impact resistance, and resistance to cracking. Furthermore, the fibers restrain any cracks that do occur from widening enough to allow intrusion of liquids and chlorides. The cost of the concrete increases by about $50 per cubic yard, but otherwise, placement and finishing techniques are unchanged. Because of the added cost, the material is most suitable for urban whitetopping of streets and intersections to resist rutting. In whitetopping applications, traditional joint spacing of 15'-20' are used.

State of Development: The material properties of polyolefin fiber reinforced concrete have been fully characterized, design guidelines are fully developed, and the material has been successfully used on several pavements and whitetopping overlays. Fibers are commercially available from 3M. SDDOT and 3M have produced several professional-quality videotapes for technology transfer.

Potential Payoffs: In whitetopping applications, the material provides an economical, crack-resistant surface that resists rutting on streets and intersections. In paving applications, pavement thickness can be reduced to help offset additional costs. Ultimate benefit is longer-lived pavement.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? **Yes**

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Superpave Initiatives**
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Technology Ready for Implementation	
Brief Description: Superpave Initiatives 1. Regional Certification: A standard instruction and testing program to certify Superpave professionals. 2. Binder Workshops: Standard training program for Superpave binder testing procedures.	
State of Development: Both initiatives are now being used in the northeast region and are ready to be expanded to the national level.	
Potential Payoffs: The regional certification program expands the pool of Superpave professionals available to work on Superpave projects by eliminating the need for professionals to have individual state certifications. The binder workshops help to reduce testing variability by using standard procedures. The program supports specification development.	
Willingness to Champion	
Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes	

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Thirty-Year Portland Cement Concrete Pavements**

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Technology Ready for Implementation

Brief Description: Using "off-the-shelf-technology" the Illinois Department of Transportation developed an extended life (30-year) concrete pavement. Methods include improving the durability of pavement materials in the aggressive Illinois wet/freeze environment, requiring a bituminous concrete binder course, increasing pavement thickness, increasing steel reinforcement in CRC and the use of 1.75-inch dowels in jointed pavement. Improved construction methods include requiring a vibrator readout and monitoring devices on pavers, adopting pavement profile specifications to a smoother "zero" blanking band.

State of Development: Design guidelines have been developed and specifications have been issued for extended life PCC pavements. A 30-year Continuously Reinforced Concrete (CRC) pavement project is currently under contract and several more 30-year concrete pavement projects are planned for construction in the next 3 to 4 years.

Potential Payoffs: The major expected advantages of extended life pavements are less traffic interruption and long-term cost savings from delaying and/or reducing the need for major rehabilitation.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Whitetopping**
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Technology Ready for Implementation	
Brief Description: Whitetopping is the process of overlaying badly distressed, rutted asphalt pavements with concrete pavements. There are three classes of whitetopping, thin (4-8 inches), ultra-thin (2-4 inches), and full depth (over 8 inches). CDOT has been researching primarily the thin whitetopping as an asphalt pavement rehabilitation technique over the last decade and is in forefront of this technology. In 1998, through a study sponsored by ACPA, CPA and CDOT, a set of equations were developed to properly design thin whitetopping pavements. These equations are now being used to design thin whitetopping pavements in Colorado.	
State of Development: A mechanistic procedure was developed which allows for trial whitetopping thickness and joint spacing. A modified procedure was also developed incorporating an empirical approach, based on the number of ESALs. Efforts are underway to further fine tune and validate existing procedures.	
Potential Payoffs: A rehabilitation strategy that benefits the traveling public and transportation agencies by reducing time and delays related to frequent maintenance of asphalt surface. The ultimate payoff is cost-effective, longer lasting pavements.	
Willingness to Champion	
Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes	

TRAFFIC SAFETY & OPERATIONS

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Automated Bridge Anti-Icing Systems**

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Technology Ready for Implementation

Brief Description: Automated bridge anti-icing systems have been shown to be an effective way to keep bridge decks from becoming slippery due to the formation of snow and ice. Nozzles installed in the deck surface can spread a uniform film of anti-icing chemical to the deck surface exactly when it's needed to prevent moisture or precipitation from freezing. Bridges that benefit the most from these systems are long decks exposed to cold air, curved bridges that are difficult to negotiate when slippery, and decks in the path of canyon winds.

State of Development: The delivery system is in place and working effectively at an interchange on I-215 in Salt Lake County. This technology has also been installed in other states and countries. Standard RWIS software can be programmed to test against set criteria and communicate to the spray controller when to deliver chemical to the deck.

Potential Payoffs: The number of snow and ice related crashes have been reduced on the bridge. The timely delivery of the anti-icing chemical to the deck has decreased the time that traffic must cross the bridge under slippery conditions.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Automatic Traffic Cone Placement Machine**

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Technology Ready for Implementation

Brief Description: Caltrans and the Advanced Highway Maintenance and Construction Technology Center (AHMCT) at UC Davis have developed a machine that automatically places and retrieves traffic cones on the highway. Through the application of robotics and computer control a single operator drives the Advanced Cone Machine (ACM) and controls placement/retrieval of the cones. Operational speed is approximately equivalent to the present manual operation, but both safety and efficiency are improved since a second operator is no longer required to be positioned at the front or back of the truck to handle the cones. Applications include lane closures and virtually any situation where a line of traffic cones is needed.

State of Development: A demonstration machine has been built and has been demonstrated at numerous events including the annual Caltrans Roadeos and the 2000 Pacific Northwest Transportation Technology Expo. It has also been successfully field tested under actual roadway conditions several times by Caltrans and also by a paving contractor. Negotiations are in process for the commercialization of the ACM.

Potential Payoffs: Operation of the ACM requires one operator located in the vehicle cab and eliminates the need for a second operator riding on the exterior (outside the cab) of the vehicle to handle the cones. This results in improvements in both safety and efficiency, while also eliminating the need for manually handling the cones. Historically, the manual handling of the cones has resulted in a high rate of worker injury claims due to physical stress and strain.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Bicycle Friendly Shoulder Rumble Strips**

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Technology Ready for Implementation

Brief Description: Bicycle Friendly Shoulder Rumble Strips – This research was initiated to develop new rumble strip configurations that could alert inattentive or drowsy motorists and be safely and comfortable traversed by bicyclists. Thus, the objective of this research project was to develop new rumble strip configurations that decrease the level of vibration experienced by bicyclists when traversing rumble strips, while at the same time provide an adequate amount of stimuli to alert inattentive or drowsy drivers. *Please see the HIGH VALUE RESEARCH web site.*

State of Development: Based on the results of the motor vehicle testing and bicycle testing, two new "bicycle friendly" rumble strip patterns have been recommended for implementation along non-freeway facilities. This information is listed on the High Value Research web site.

Potential Payoffs: The results of this research project will greatly assist PennDOT in its effort to reduce crashes and fatalities by 10% by 2001. The benefits of this research include developing new rumble strip configurations that will alert inattentive or drowsy motorists and be safely and comfortably traversed by bicyclists.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Connecticut Truck Mounted Attenuator**
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Technology Ready for Implementation	
Brief Description: The Connecticut Truck Mounted Attenuator (CTMA) was designed to protect Connecticut DOT maintenance and construction personnel performing field duties. The Connecticut TMA is made up of the following three major components: 1) service vehicle guidance frame; 2) energy-absorbing cylinders, i.e., water pipe; and 3) impacting plate assembly. The CTMA is composed of four cylindrical members formed from straight steel plate sections. The cylinders are bolted together and attached to the rear of the carrying vehicle. He two channel sections are attached to the aluminum impacting plate to provide guidance for the system while it is collapsing.	
State of Development: The CTMA has been crash-tested as a TL-2 device in accordance with the recommended procedures of NCHRP Report 350. The CTMA has been approved by the Federal Highway Administration (FHWA) for use on the National Highway System (NHS). Fabrication plans and reports are available. State DOTs may fabricate the systems with their own forces, or contract with local fabricators.	
Potential Payoffs: The primary benefit of the CTMA is increased safety to maintenance and construction personnel, as well as the occupants of the impacting vehicle.	
Willingness to Champion	
Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? **Yes**	

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Freeway Performance Monitoring System**

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Technology Ready for Implementation

Brief Description: The Freeway Performance Monitoring System (PeMS) began as an experimental project conducted by the University of California-Berkeley (UCB) and Caltrans. PeMS collects historical and real-time data from freeway networks throughout the State and presents freeway performance measures in graphical and numeric outputs. The project's web site provides a wide variety of tools for transportation researchers and users to examine loop detector data (http://transacct.eecs.berkeley.edu/).

State of Development: PeMS has already moved beyond its research phases and into an operational mode. A functioning system currently operates that provides the Los Angeles area freeway network system performance. PeMS receives loop detector-based real-time streams of data from Caltrans Transportation Management Center (TMC) allowing users to generate real-time plots of the speed and use the system's real-time route-selection Graphical User Interface (GUI) for trip planning purposes.

Potential Payoffs: The users of PeMS can obtain live freeway travel time information based on the real-time loop detector data extracted through TMCs. In addition to gaining insight into the day-to-day system operation, a number of queries allow users to investigate long-term trends. The system generates a number of freeway performance measures reflecting how well the network is doing. Users can view these performance measures and compare them, download historical data, and investigate loop detector health.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**LED Traffic Signal Heads**
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Technology Ready for Implementation	
Brief Description: Light Emitting Diode (LED) Signals Evaluated methodology that provided data comparing LED signal heads to incandescent signal heads.	
State of Development: MoDOT has implemented a recommendation to utilize red and green LED's. District's are implementing by converting on an as needed method.	
Potential Payoffs: See RDT Brief attached or located @High Value research	
Willingness to Champion	
Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes	

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Research Investigation 96-023 February 2000

Light Emitting Diode (LED) Signals

Description:

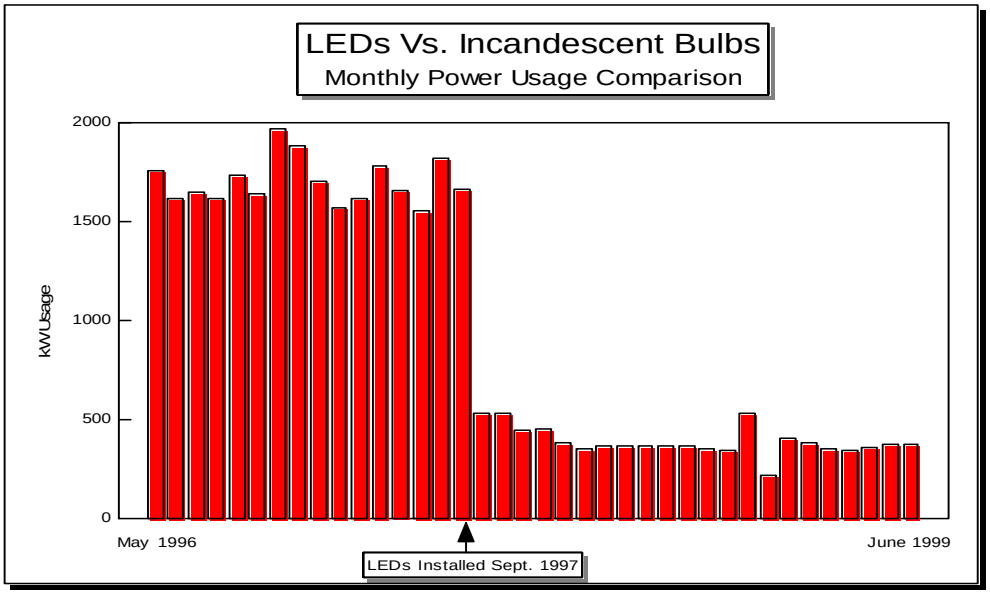
The Light Emitting Diode (LED) Signal Installation study consisted of a partnering between the Missouri Department of Transportation (MoDOT), the Federal Highway Administration (FHWA) and the Dialight Corporation. The FHWA Priority Technologies Program (PTP) funded $18,000 for the study, 51% of the total budgeted cost. The objectives of the study were to develop an evaluation methodology that would provide data comparing LED signal heads to incandescent signal heads and to accelerate the implementation of LED signal head technology within the State of Missouri.

Light emitting diodes are small semiconductor chips that emit light. Measuring just 1/100th of an inch long, they are encased in epoxy to protect them from shock, vibration and environmental contaminants. Vast amounts of research have been developed by the industry in LED applications in the area of signalized intersections. The LED signal indications utilize a combination of LEDs to provide the green, green arrow, red ball and amber indications. The Institute of Traffic Engineers (ITE) has approved green and red LEDs, but the yellow or amber LED has not yet been approved at the time of this study. For an LED to receive ITE approval, it has to meet lumen and color requirements.

Advantages/Disadvantages:

LED indications could address some concerns that arise with incandescent bulbs such as short life expectancy, possible insufficient lumen output, and inability to handle voltage variations and heat problems. The advantages of LED signal heads to incandescent bulbs include greater energy efficiency, longer signal life, less maintenance, increased signal intensity, improved motorist awareness, and actual dollar amount of benefits. The greater energy efficiency was documented with a 75% reduction at the intersection test location. Figure 1 shows the monthly kilowatt usage from May of 1996 to June of 1999. The LED indications were installed in September of 1997.

Figure 1 - Monthly Power Usage Comparison



Longer signal life and less maintenance have already been seen in the last 2 years. The expected life of an LED signal is projected to be seven years or more compared to one year for an incandescent bulb. Maintenance costs have been reduced by more than 90% from less outages and yearly relampings. From comments received, motorist awareness and signal intensity have increased. In addition, if the incandescent bulbs burn out the entire indication is lost whereas with LED signal heads, the loss of individual LEDs will not lead to a total loss of the indication. The only disadvantage found was the initial cost of the LED signals, which is the most expensive aspect of the LED indications. However, the cost of LED signals has already significantly decreased in two years. The red ball indications have dropped in price almost 30% and the price of green balls has decreased over 60%.

Cost:

The Life Cycle Cost Analysis (LCCA) gave an Incandescent Bulb/LED ratio of 1.36 (using 1999 costs). The factors used in calculating the benefit to cost ratio included the life cycle, power usage, installation, materials, maintenance and repair costs. This ratio would have been even higher if the intersection had been located farther from the signal shop. The greater the distance the maintenance crews have to travel for repairs and relamping, the more expensive incandescent bulb indications become compared to LED indications. In addition, the ratio will continue to increase as the price of LED signals is reduced.

Conclusions:

Overall, the study was considered a success. Based on the results of this study, MoDOT recommends using LED signal indications in lieu of incandescent bulb indications. Until this study was undertaken, no LED signals had been used on a statewide basis. Red LEDs have been implemented elsewhere in the state and are currently in the Missouri Standard Specifications. After this study, MoDOT will implement the use of green LEDs and will include green in Standard Specifications. The implementation of red ball, green ball and green arrow LED signals would save the department at least $1 million a year after all signals have been retrofitted. Decreasing costs of LED indications and increasing power costs over time will increase the savings to the department. The Department will consider the use of amber LEDs in some locations after ITE approval. Converting to red, green, and amber LED signals should provide for virtually maintenance free signals.

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AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Mobile Fog Dispersion System**
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Technology Ready for Implementation	
Brief Description: Fog dispersion can be a crucial activity for transportation agencies. Many highway facilities are located in areas that experience recurring fog events that pose a significant safety problem. The Utah DOT has been using a unique method to disperse super-cooled fog. Liquid carbon dioxide is released from a truck mounted system that results in the precipitation of the fog.	
State of Development: UDOT has been using this method since 1993, and the effectiveness of the technique has been reported. Equipment descriptions and costs are documented. Safety precautions for operating in limited visibility and handling liquid carbon dioxide are available.	
Potential Payoffs: Multiple vehicle crashes have occurred on many occasions in areas of Utah where warm water sources exist. This technique has been successful in eliminating the dense fog, and increasing the safe traveling speeds of traffic. The reductions in potential loss of life, vehicle damage, and congestion during an incident are considered to be significant.	
Willingness to Champion	
Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes	

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Narrow Connecticut Impact Attenuation System**

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Technology Ready for Implementation

Brief Description: The Narrow Connecticut Impact Attenuation System (NCIAS) was developed to protect errant vehicles when impacting narrow rigid objects, such as ends of roadside and median corners. The NCIAS consists of eight steel cylinders in a single row with two wire ropes along either side. The system also includes a backup structure for anchoring the wire rope and resisting collision forces. This design feature allows use of the attenuator to protect virtually any narrow object. All cylinders are 0.9m in diameter and 1.2m tall. Wall thicknesses ranging from 3.2mm to 9.5mm are used in the cylinders to achieve the design stiffness of the attenuator.

State of Development: The NCIAS has been crash-tested and evaluated as a TL-3 Redirective, Non-Gating Crash Cushion in accordance with the recommended procedures in NCHRP Report 350. The NCIAS has been approved by the FHWA for use as a TL-3 Redirective, Non-Gating Crash Cushion for use on the National Highway Systems (NHS). Fabrication plans and reports are available. State DOTs may contract with local fabricators to make the systems and spare parts.

Potential Payoffs: The primary benefit of the NCIAS is increased safety to the motoring public. A field evaluation of the NCIAS shows it to be successful in preventing serious injury to the occupants of impacting vehicles for a variety of impact conditions.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? **Yes**

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Noncorrosive, Environmentally Benign Deicer & Anti-Icer**

Contact

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Technology Ready for Implementation

Brief Description: The South Dakota Department of Transportation has developed a non-corrosive, environmentally benign material for highway deicing and anti-icing applications. Applied as a liquid, in rates as low as 30 pounds equivalent solid per lane mile, the material prevents formation of ice-to-pavement bond, permitting mechanical removal of accumulated snowfall. The liquid can also be used as a pre-wetting agent for solid deicers and abrasives. Applied as a liquid deicer, its performance compares to that of magnesium chloride. As a solid, the material is more effective at low temperatures than either salt or calcium-magnesium acetate.

State of Development: The material, based on a unique, patented composition derived from sodium acetate and sodium formate, has been licensed to FMC Corporation. FMC has produced bulk quantities of the liquid under the trademark IceShear. Production of solid material is contingent on demand. Ice-melting and penetration characteristics have been determined, and environmental and toxicological properties have also been characterized.

Potential Payoffs: The material functions as an effective deicer and anti-icer, but without the environmental and corrosive drawbacks associated with chloride-based materials. It is particularly suited for use in environmentally sensitive areas or where a high concentration of structures exists.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? **Yes**

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Recessed Thermoplastic Pavement Markings**

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Technology Ready for Implementation

Brief Description: Snowplow abrasion damages all pavement markings, especially thermoplastic markings, which are extruded onto the pavement at a 1/8" thickness. As part of a research project, thermoplastic skip lines were applied in recesses constructed on tangent, curve, and ramp sections of a dense friction course pavement. The recesses were effective in protecting the thermoplastic markings. The skip lines remain undamaged after more than four winters.

State of Development: Development is complete. The field installation was a success. A specification for traffic marking recesses has been written.

Potential Payoffs: On most pavements, traffic markings are the feature most visible and most important to the public. Protecting these markings will improve the safety and the perceived quality of our roads.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? **Yes**

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**RHODES Adaptive Traffic Control System**

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Technology Ready for Implementation

Brief Description: - RHODES is a real-time, adaptive control system. This system uses detector/sensor information to measure flows and control an intersection, a freeway/arterial diamond interchange, or an arterial. RHODES has the flexibility to optimize several measures of effectiveness, such as delays, stops, and queues. It has related applications to urban-arterial grid networks and to ramp metering as well.

State of Development: - RHODES detection, communication, computation and signal control were developed over several years culminating in a Field Test on the US 60 Superstition Freeway in Tempe, Arizona. The Rural Road arterial was instrumented with multiple detector systems for approximately one-quarter mile each way from the diamond interchange. The signal controller was integrated into Tempe's Traffic Operations Center and before-and-after tests were performed successfully. A limited field deployment is also currently in progress in Tucson, and further research will focus on using detector information for self-learning parameters, thereby decreasing effort for tuning the system.

Potential Payoffs: - RHODES offers benefits in traffic performance including smoothed flows and reduced emissions. It allows a decrease in operating and maintenance costs, and it may also have application in freeway ramp metering and transit, emergency, and rail interfacing.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**#SAFE Advanced Traveler Weather Information System**
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Technology Ready for Implementation	
Brief Description: In collaboration with the University of North Dakota, the North Dakota and South Dakota Departments of Transportation have established and operated the #SAFE Advanced Traveler Weather Information System. Since original deployment in 1996, the system has expanded to encompass the entire state highway systems of North Dakota, South Dakota, and Minnesota. Other states in the region have also expressed interest in adopting the system. #SAFE provides time- and location-specific weather forecasts and road condition information to travelers via cell phones for all cell providers in the three states, and via the Internet. Customized weather forecast information is also provided to state highway maintenance crews.	
State of Development: #SAFE has been deployed and operational since 1996, and was deployed statewide in North Dakota, South Dakota, and Minnesota in 2000. Planned enhancements include voice recognition for cell phone access. The system is operated year-round.	
Potential Payoffs: Actual payoffs include increased traveler safety and more effective maintenance activities.	
Willingness to Champion	
Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? **Yes**	

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Snowplow Cutting Edge Wear Indicator**
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Technology Ready for Implementation	
Brief Description: This detector is a small tube attached to the side of the snowplow moldboard with wiring attached to a high intensity flashing light within the cab of the truck. As the bits wear down to the minimum level, the detector wires will be cut notifying the operator that the bit needs to be replaced.	
State of Development: One has been installed, is being tested and evaluated. This innovative product was the result of work by Gordon McKeen and Ken Martinez, ATR Institute, University of New Mexico.	
Potential Payoffs: The potential is a substantial savings in repair cost due to damage of the moldboards.	
Willingness to Champion	
Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes	

STRUCTURES

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Broken-Back Culvert Analysis Program**

Contact

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Technology Ready for Implementation

Brief Description: A culvert is a hydraulic structure designed to convey water under a roadway. When one or more changes of grade occur within the culvert profile, it is called a broken-back culvert. Broken-back culverts are usually placed in areas where laying a straight culvert would require large excavations or where other site conditions dictate a break should occur. Broken-back culverts may also be intended to reduce outlet velocities when normal outlet velocities are greater than desired. A computer analysis model called the Broken-Back Culvert Analysis Program (BCAP) was developed for use as a method for hydraulic calculations.

State of Development: Has been implemented at the Nebraska Department of Roads and is ready to implement elsewhere. (See RAC "Highway Value Research" Web site.)

Potential Payoffs: The BCAP fills the void in broken-back culvert design by enabling designers to: 1) analyze existing installation, 2) educate designers about broken-back culvert hydraulics. 3) optimize design of broken-back culverts, 4) help recognize improper design of existing facilities, and 50 predict erosion and reduce risk and liability.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Carbon Composite Wrapping for Structures**

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Technology Ready for Implementation

Brief Description: Carbon composite wrapping has been used in Utah to rehabilitate and add seismic capacity to aging bridges. A demonstration of some placement methods was conducted in 1996, and laboratory testing showed significant enhancements to bridge columns and bents. In 1998 and 2000 destructive testing of full scale bridges was accomplished on the I-15 reconstruction project as part of the I-15 National Test Bed. The success of the technique lead UDOT to utilize it on bridges on I-80 scheduled for rehabilitation.

State of Development: The placement demonstration site has been monitored since 1996, and is performing well. The destructive testing demonstrated a significant increase in strength and ductility. For the recent placement on I-80 bridges, specifications and QC/QA methods were developed and are available.

Potential Payoffs: The use of carbon composite materials for bridge rehabilitation adds another option to extend the life of older structures. The method can be less costly when bid properly, and qualified contractors are available. Fewer delays to commuters can be achieved since no forms are needed and the operation can be easily moved in and out of lanes to avoid work during peak traffic hours. The lightweight material brings less mass to the bridge, which is beneficial during a seismic event. The wrap contains the concrete in the bridge components during lateral movement reducing the chance of collapse.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Fiber-Reinforced Polymer Bridges**
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Technology Ready for Implementation	
Brief Description: Fiber Reinforced Polymer (FRP) Bridges. FRP composite bridges and bridge decks have been constructed on public roadways in several states. Research is on going in Kansas to develop rail connections and crash test them at the University of Nebraska crash test facility. Future research to develop a portable detour bridge system is scheduled. The system developed in Kansas is now installed in three states (KS, MO, WV) with several more states planned this year. Other types of systems are also available.	
State of Development: The basic design concepts have been confirmed. Crash test results on rails are needed before widespread installations can be made but have been scheduled.	
Potential Payoffs: FRP composite decks are more expensive but weigh about 25% of conventional decks. The material is resistant to corrosion and the environment. Life is estimated to be 100 years. This lighter weight allows them to be used in a cost effective manner for deck replacements on narrow bridges, those with reduced design loads but still adequate substructures. The units for a short bridge may be placed on one truck and delivered to an installation site. Installation is done with light equipment and requires a much shorter time frame (typically one day).	
Willingness to Champion	
Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes	

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Polyolefin Fiber Reinforced Concrete for Bridge Decks**

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Technology Ready for Implementation

Brief Description: In collaboration with 3M, the South Dakota Department of Transportation has designed and constructed several bridge decks and deck overlays using concrete reinforced with polyolefin fibers. The fibers, which are 2" long and 0.025" in diameter, greatly increase the concrete's toughness, impact resistance, and resistance to cracking. Furthermore, the fibers restrain any cracks that do occur from widening enough to allow intrusion of liquids and chlorides. Other properties, including density and permeability, are unchanged from regular low-slump concrete. The cost of the concrete increases by about $50 per cubic yard, but otherwise, placement and finishing techniques are unchanged.

State of Development: The material properties of polyolefin fiber reinforced concrete have been fully characterized, design guidelines are fully developed, and the material has been successfully used on several bridge decks and deck overlays. Fibers are commercially available from 3M. SDDOT and 3M have produced several professional-quality videotapes for technology transfer.

Potential Payoffs: On new decks, fiber reinforced concrete reduces cracking and increases material toughness, increasing expected life. On deck overlays, the material provides high-quality overlays, even when the condition of the underlying substrate has been compromised.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? **Yes**

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Precast Bent System**
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Technology Ready for Implementation	
Brief Description: Precast Bent Cap System. In order to reduce construction time and reduce costs, TxDOT has begun using precast bridge bent caps on appropriate projects. Utilizing precast bent caps can result in significantly reduced construction time, since there are no delays waiting for conventional cast-in-place concrete bent caps to cure before forms can be removed, beams placed, etc. Precast bent caps are cast on the ground, under controlled conditions, resulting in improved quality and reduced safety hazard to construction workers. A grouted connection is used between the precast bent cap and cast-in-place columns. Precast bent caps are appropriate for use on projects with requirements for large numbers of repetitive bent caps, or structures over water, which require barge-mounted construction equipment. Precast bent caps are not appropriate for high-moment demand connections between cap and column. The usefulness of precast bent caps with cast-in-place concrete columns is evident in the IH45 Pierce Elevated construction that resulted in the largest-ever incentive award ($1.2M) paid to the contractor for completion ahead of schedule.	
State of Development: Ready.	
Potential Payoffs: Dramatically speeds construction. Safer construction and inspection.	
Willingness to Champion	
Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation?	

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Simplified Procedure for Design of Cantilever Structure End- and Base-Plates**

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Technology Ready for Implementation

Brief Description: In this study, a simplified procedure was developed for design of end-plates and base-plates of cantilevered structures supporting traffic signs, signals, and lights, and also for base-plates of span-wire-mounted traffic-signal structures. The procedure was based on beam-and-plate bending and torsion theories, and is intended for use when designing plates of square configurations supported by four bolts, one at each of its corners.

State of Development: Both development of the procedure and its spreadsheet program implementation have been completed. The program is very flexible and can be used for design of new plates or analysis of existing ones for overstress. Thirty five, randomly selected plates from five major suppliers of traffic poles in New York were analyzed using this program, and resulting plate thicknesses were compared with those based on other methods, including one that was based on full-scale testing and finite-element analysis.

Potential Payoffs:

1. Greater safety: The developed procedure is based on rational engineering mechanics concepts.

2. Standardization of plate design methods: This generally reduces design and review time.

3. Efficiency in plate design: The program should facilitate plate optimization as various design alternatives can be easily investigated and the optimal alternatives rationally selected.

4. Monetary savings to owning agencies: The time required for design and review will be substantially reduced, and optimized plate designs should result in material savings.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? **Yes**

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Texas U-Beam Concrete Bridge Girder**

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Technology Ready for Implementation

Brief Description: Texas U-Beam. The Texas U-Beam is a prestressed, trapezoidal concrete bridge beam that was developed by TxDOT and first used in the Houston area. It's being used or being considered for use in a number of other states and several other countries, either as-is or after some degree of modification. In addition to its use in normal-strength concrete applications, it can readily be used with high-strength concrete to stretch the span length or widen the beam spacing because it has ample room in the bottom flange for a large number of 0.5-inch or 0.6-inch diameter strands. It was developed to be the poor man's aesthetic beam, an aesthetic beam that is competitive in cost with conventional beams, and continues to be competitive in cost today.

State of Development: Ready.

Potential Payoffs: Economical yet aesthetically pleasing. Construction safety improvement over more traditional beams.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation?

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Use of Tire Shreds in Highway Applications**
Contact	
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Technology Ready for Implementation	
Brief Description: Use of Tire Shreds in Highway Applications, please refer to AASHTO RAC High Payoff Research site: http://www4.nationalacademies.org/trb/scor/states.nsf/all/maine	
State of Development: The engineering properties of tire shreds have been defined. Performance of shreds in different highway applications have been documented. Include lightweight fill, thermal layer to reduce frost heave and road thaw problems, drainage layer, retaining wall backfill to reduce lateral earth loads.	
Potential Payoffs: Recycling of millions of stockpiled tires into a useful, cost effective material for highway and bridge applications.	
Willingness to Champion	
Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes	

SURVEY & EVALUATION

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**DVD/LAN/WAN Photologging Image & Data System**
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Technology Ready for Implementation	
Brief Description: A Digital Versatile Disk (DVD) and Local Area Network/Wide Area Network (LAN/WAN) photolog roadway image and data retrieval system has been developed by and is operational at the Connecticut Department of Transportation (ConnDOT). The system's software structure is threefold. First, processing software prepares ground-based images and engineering data collected by photolog operations for desktop retrieval. Second, Waypoint-Based Linear Referencing (WBLR) software matches traditional linear referenced locations to van-collected GPS coordinates. Lastly, a software package called DigitalHIWAY enables users to view forward and side-facing roadway images with interactive links to engineering data and traditional linear reference locations. Additional mapping, horizontal curve analysis, and virtual measurement software are available. DigitalHIWAY is geared towards a broad traditional user base that includes traffic, planning, maintenance, construction, right of way, research, and incident management.	
State of Development: Image and data processing and retrieval software has been fully implemented and is its second year at ConnDOT. ConnDOT currently has ninety-seven PC's with DigitalHIWAY installed and working with 1999 and 2000 photolog images and data. Waypoint-based linear referencing is new and currently being implemented with GPS data acquired by ConnDOT's two photolog vans in 2000. A report documenting these new advances will be available in mid-2001.	
Potential Payoffs: States acquiring ground-based images and data for asset management can benefit from the mass distribution capability of DVD and LAN/WAN distribution. In its first year of implementation, ConnDOT's Data Services Section experienced a user increase of 300%. More desktop usage equates to reduced man-hours in the field, fleet vehicle cost savings, and increased staff safety. DVD mastering and replication costs are approximately 50% less than older media production costs, such as those associated with videodisc.	
Willingness to Champion	
Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? **Yes**	

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Global Positioning Systems in Design, Construction, and Maintenance**

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Technology Ready for Implementation

Brief Description: Global Positioning Systems (GPS) are being used more in project design, construction, and maintenance. Automating conventional surveying operations can accomplished through triangulation with satellites that can identify locations rapidly and accurately.

State of Development: The Utah DOT has conducted studies to measure the advantages of using this advanced equipment and methods, and has converted to this technology. Equipment has been acquired, training sessions conducted, standards adopted, and policies established.

Potential Payoffs: The use of GPS has resulted in better accuracy, increased person-hour productivity, and lower costs than traditional survey methods. Labor reductions of 60 to 90% can be achieved. UDOT has reorganized based on the implementation of this technology, resulting the shift of personnel to other tasks.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Ground Penetrating Radar**
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Technology Ready for Implementation	
Brief Description: Ground Penetrating Radar. Texas has benefited greatly from GPR technology. GPR has been used to determine pavement layer thickness non-destructively and also to identify the location of stripping or moisture problems in hot mix pavements. Measurements are made at highway speed. Software has now been developed to assist in data interpretation, and a training course has been prepared. Although GPR is a mature technology, it has not received widespread implementation at the national level. More widespread implementation would not only enhance State DOT non-destructive testing capabilities, but could also lead to improvements in GPR technology as more States became involved in its use.	
State of Development: Ready	
Potential Payoffs: Better decisions when planning pavement rehabilitations, thereby reducing costs and delays. Large reduction in the number of cores necessary to determine condition of underlying layers.	
Willingness to Champion	
Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation?	

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Ground Penetrating Radar for Bridge Deck Evaluation**
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Technology Ready for Implementation	
Brief Description: Ground Penetrating Radar (GPR) has been successfully utilized by the New Hampshire Department of Transportation (NHDOT) to identify areas of asphalt-overlaid bridge decks requiring repair. Earlier limitations in GPR technology (early 1990's) allowed for an estimate of repair quantities; however, the devices were not effective in delineating specific areas of distress. In 1998-99, several interstate bridge decks were surveyed using GPR. Color-coded contour maps were produced showing varying levels of distress. The condition of the decks was verified during subsequent rehabilitation and/or traditional bridge deck evaluation techniques.	
State of Development: Ready. Although GPR has been utilized in various transportation applications for years, recent developments have enhanced the value of the technology.	
Potential Payoffs: GPR technology has improved dramatically during the past decade. Current capabilities enhance the value of GPR by allowing effective bridge deck repair strategies to be based on non-destructive tests conducted through the asphalt overlay. Successful implementation of this technology provides added benefits to the transportation community by minimizing field data acquisition time.	
Willingness to Champion	
Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes	

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Ground Penetrating Radar for Measuring Bridge Deck Concrete Cover**

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Technology Ready for Implementation

Brief Description: During 1997-99, the New Hampshire DOT partnered with Geophysical Survey Systems, Inc. (GSSI) of Salem, NH to develop a ground-penetrating radar (GPR) system for measuring concrete cover on bridge decks and other structures. Modifying existing hardware and software shells, GSSI created a new data processing module and produced a portable ground-coupled unit for the required application. The NHDOT conducted a study to evaluate the accuracy and precision of the device, concluding that radar is an effective and accurate way to measure concrete cover. The project was funded through the FHWA Priority Technologies Program. For more information, go to: http://www4.nationalacademies.org/trb/scor/states.nsf/all/new+hampshire

State of Development: The NHDOT has fully implemented the above-described GPR technology to measure concrete cover as part of its QC/QA specification for new concrete bridge decks. The bridge deck contractor's payment is partially based on measurements obtained with the GPR device. A second unit was purchased by the Department in 1999. The radar system is easy to use and was quickly mastered by NHDOT technicians. Data acquisition time is considered reasonable for the intended use.

Potential Payoffs: Adequate concrete cover is essential in protecting the reinforcing steel from the adverse effects of environment, de-icing chemicals and traffic. Excessive cover is wasteful and can create problems as well, such as increased dead load and problems with finished grades. GPR is an innovative way to measure this cover.

Successful implementation of this technology provides benefits to the transportation community by promoting quality, reducing variability of test results, and minimizing field data acquisition time. Variability in actual cover values observed during the NHDOT study justifies the continued verification of concrete cover per the QC/QA specification. An available software module for performing condition surveys on existing (older) bridge decks enhances the overall value of the GPR device to the Department.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Robotic Total Station for Field Surveys**

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Technology Ready for Implementation

Brief Description: The Plats and Surveys Division of MSHA has been investigating Robotic Total Station technology to determine its feasibility for conducting field surveys for transportation projects. Field tests with a "Topcon 802-A Auto –Tracking Total Station" were conducted on three pilot projects. The concept of the equipment is based a radio communications link between the total station and the remote data collector to obtain field survey information. With a signal lock between the total station and the data collector many topographic surveys and stakeouts can be performed without the need for an instrument man. Tests of a Robotic Total Station from another manufacturer (Zeiss) is planned, this equipment will be tested, evaluated and compared to the Topcon instrument.

State of Development: Robotic Total Station survey equipment is now commercially available from several manufacturers. Previously, costs and technical drawbacks of early model instruments precluded widespread use in the public sector. The technology is now beginning to gain acceptance and usage.

Potential Payoffs: The main benefit in using the Robotic Total Station technology is the reduced manpower needed compared to conventional data collection methods. In most cases, only two people are needed to obtain the data. Traditional methods require three or four people to obtain the data.

When locating linear features, such as roadways, in open areas the Robotic Total Station allows the collection of data very quickly. As the prism unit is being moved to the next shot, the total station is locked on the prism, continuously updating the angle and distance data. Therefore, when the prism unit is placed on the feature to be located the data is recorded as soon as the key is pressed on the remote data collector. The prism unit is on the point be referenced for approximately one second.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

Maryland Department of Transportation
State Highway Administration
Plats and Surveys Division

DRAFT

EVALUATION OF

ROBOTIC TOTAL STATION

TO OBTAIN FIELD DATA

December 2000

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

INTRODUCTION

The Administration has experienced an increased level of funding in recent years. Based on the recently approved Consolidated transportation Program (CTP) this increase is anticipated continue for the next six years or more. This translates to a substantial increase in the number of projects along with potentially shorter project delivery time frames. At the same time, retention of experienced staff along with training and cultivating staff will be critical. It is recognized that there is an industry shortage of people entering this field of work. The challenge for the Plats and Surveys Division will be how to use available in-house and consultant resources to meet the increased program demands. Consideration for the use of technologies that reduce the time to obtain field data is a critical part of meeting the expected demands.

The Plats and Surveys Division has been investigating the Robotic Total Station technology to determine its feasibility as a means for conducting field activities on transportation survey projects. Many firms within the industry performing private and public work successfully use this type of equipment with smaller crew sizes and or less time to obtain data. In June 2000, a Topcon 802-A Auto-Tracking Total Station was leased from Caron East for a four month testing period. Messrs. Charles Mueller and Larry Price were chosen to oversee and obtain field data for three pilot projects using this instrument. Based on their efforts for the three pilot projects, the following information and recommendations supports this technology as one that can and will assist the division to meet the expected demand on its resources. They also conclude that the Robotic Total Station technology is suitable for use on many of the types of survey projects.

Based on the pilot project experience, it was suggested that the division test another supplier's equipment to determine dependability and functionality of equipment that might be considered for purchase. The division will lease a Zeiss Robotic Total Station for another four-month evaluation. The instrument tracks the prism using a different technology called QuickLock. This instrument will be tested, evaluated and compared to the Topcon instrument.

TECHNOLOGY

The Topcon 802-A Auto-Tracking Total Station is used in conjunction with a radio communication link, innovative track beam, and TDS Survey Pro software to enable many topographic surveys and stakeouts to be performed without the need for an instrument man. Sending and receiving data between the total station and the remote data collector is achieved by radio waves. One radio modem is connected to the total station and attached to a tripod leg. The other modem is connected to the remote data collector and attached to the prism pole or held by the other person.

The track beam maintains signal lock between the total station and the prism unit. The parameters for the horizontal and vertical search ranges and the track sensitivity can be set to be compatible with the environment of each project. The prism unit contains six reflective prisms configured in a 360-degree pattern. This ensures that the total station can follow the prism unit while the prism is in motion. The track beam is also used to track and search for the prism unit when signal lock is lost. Essentially, the total station will automatically search for the prism unit until it regains signal lock. In addition, using the arrow keys on the remote data collector at the prism unit the operator can re-establish a signal lock with the total station. This feature avoids the need for the operator to backtrack to a previous point or go to the total station.

PILOT PROJECTS

For testing purposes, three projects were selected to use for testing of this technology. The projects were selected as representative of the smaller types of projects that may benefit from the use of this technology.

- MD 346 from Forest Grove Road to Parsonsburg Road (FMIS No. AW536B27) The project consists of a traffic signalization consisting of two intersections approximately 900 feet apart.
- MD 88 at MD 833 (FMIS No. CL855A21) The project consists of a roundabout intersection and 1000 feet of roadway in four directions.
- I-695 at MD 45 (FMIS No. BA381A21). The project consists of an interchange improvement with the survey of approximately 450 feet along MD 45 in a heavy traffic area.

PERFORMANCE

The concept of the equipment is that data collection is performed remotely and, therefore, there is no need for an instrument person. The robotic total station technology is often advertised as a one-man operation. From our perspective, at least two people are needed for most of the types of survey projects performed by the division. In addition, safety of workers and the traveling public demands the use of at least two person crews in nearly all situations. In the event that a situation arises where only one person is available, we have the option to continue to perform the work. This step can be taken to maintain production in a safe environment for the worker and traveling public.

The Topcon 802-A works in conjunction with TDS Survey Pro software and the Husky 2500 data collector. The TDS field file can be converted to an ETSC field file format, making this system fully compatible with the division's data collection standards, policies and procedures.

The Topcon 802-A performed efficiently on all three projects. As with any new technology, there is a training period to be come familiar with and proficient with the equipment. After a short learning period, the number of times that the signal was lost decreased and the time to re-establish a signal lock was reduce. The MD 45 project was in a high-traffic area with many other obstructions such as signs and utilities. The instrument performed well in this environment with minimal loss of signal lock.

Although the MD 346 project was a traffic signalization, it is comparable to a small rural streetscape type project. There was low traffic volume and minimal obstructions on this project. The survey was completed in approximately the same time needed to perform the work using conventional means. The main difference and benefit was that all work was performed in the same number of days but with only two people.

The MD 88 project was an intersection survey with minimal planimetric features and some traffic, including large trucks. In most cases signal lock was regained quickly after being broken by moving traffic. The surveying of the roadways and roadside breaklines was performed extremely fast. This is because the Topcon 802-A continually knows the location of the prism unit. Consequently, when the prism is set on a desired point to be located, the shot is recorded almost instantly when it is initiated from the remote data collector. This survey of this project was completed with in less time with fewer staff. The work took 4 ½ days with two people, whereas it was estimated that 6 days with three people would have been required using the traditional methods.

One operational disadvantage in using the Topcon 802-A was experienced. The crew experienced frequent lose of signal lock. This typically occurs when the prism unit is at a distance of 30 feet or less from the instrument. However, we do not foresee this as a drastic issue of concern. When there are two people at this close distance, one person can quickly go to the instrument and manually regain signal lock with the prism unit or the person with the remote data collector can re-establish the signal.

BENEFITS

The main benefit in using the Robotic Total Station technology is the reduced manpower needed compared to conventional data collection methods. In most cases, only two people are needed to obtain the data. Traditional methods require three or four people to obtain the data. In some isolated instances where only one person if available, work can be done with appropriate safety precautions. This might become more common place when work is located away from traffic. However, working with one person near roadways is not desirable on higher volume roadways. When a one-person operation occurs, it is anticipated that some loss of production might occur.

When locating linear features, such as roadways, in open areas the Robotic Total Station allows the collection of data very quickly. As the prism unit is being moved to the next shot, the total station is locked on the prism, continuously updating the angle and distance data. Therefore, when the prism unit is placed on the feature to be located the data is recorded as soon as the key is pressed on the remote data collector. The prism unit is on the point be referenced for approximately one second.

These two benefits will help to increase production with the same number of personnel. When the need arises, a four people crew can operate two robotic total station crews instead of one conventional crew.

Although not tested a stakeout type project, a demonstration of this procedure from a Caron East representative suggests similar results. The Robotic Total Station seems to be very suitable for performing stakeouts (R/W, borings, etc.) with a two-person crew.

One last benefit and probably the most important is the flexibility of the robot total station. If a crew is on a project that is not practical to use the equipment in the tracking mode, the robotic total station can easily perform standard total station operations.

RECOMMENDATION

Based on field testing of pilot projects, Messrs. Mueller and Price highly recommend the purchase of robotic total station units for use on its survey projects. They believe that this technology will increase production for the division and aid the goal of meeting customers' project deadlines. The flexibility of this type of equipment further allows two methods of operation with one piece of equipment. The robotic total station can allow greater resource management given the increasing number of projects and resources to perform field surveys. Many consultant firms, particularly smaller firms, are also exploring this technology as a means to meet the needs of clients with fewer staff

The Division has approximately fifteen survey crews with an average of three people per crew. It is estimated that as much as 50% of the work performed is data collection type surveys. At any time, the division may have seven or eight crews performing data collection surveys. This requires the assignment of approximately 20 to 25 people. Using the Robotic Total Station technology, the same number of people could operate three or four additional crews or several other options. Multiple crews could be assigned to projects to reduce the field time using two type of equipment. Another option would allow us to assign crews to projects that were not yet assigned due to the lack of resources. The flexibility of using less staff resources and occasional 2 person crews is quite possible using robotic total stations. This flexibility of survey crews should enable us to effectively meet the anticipated project demands and significantly reduce the time needed to deliver projects to our customers.

The plats and Surveys Division recommends an initial purchase of four robotic total station units in calendar year 2001 to begin integrating this technology. The purchase of units should reflect the ongoing

ownership changes in the industry to avoid purchase of potentially obsolete brands or models. In addition and a s apart of this recommendation, the division will allow the use of this type of equipment by consultant firms chose this method of field data recovery

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**SURVEYOR Automated Distress Analyzer**

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Technology Ready for Implementation

Brief Description: Surveyor is the second generation of the ADAPT software developed for the FHWA LTPP program. The software allows automated distress analysis of digital pavement images. The software develops descriptive statistics for two major categories of cracking; load related and environmental cracking. It provides the total lineal feet of longitudinal and transverse cracking for each of the two categories as well as the distribution of cracking by crack width, in 1/8 inch intervals, for the two categories. The software also develops and prints scaled crack (i.e. distress) maps.

State of Development: The software has just recently been completed and is currently under beta testing by the AZ DOT. Many images have already been processed and no significant bugs have been found. The software runs on a PC in the Microsoft operating platforms. The ATRC is currently attempting to get digital images of its LTPP SPS-5 and 6 projects to conduct ten year evaluation studies using this software.

Potential Payoffs: The software allows field distress surveys to be conducted at highway speeds and analyzed in the office. This eliminates roadway-based field crews and traffic control typically necessary to conduct distress surveys. Elimination of the on-ground evaluations improves safety to both the workers and traveling public. Although developed as a research tool for evaluation of test section data, this software can be applied to Pavement Management Practices as well.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation?

GEOTECHNICAL

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Geofoam for Ultralight Fill**

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Technology Ready for Implementation

Brief Description: Geofoam has been used by the Utah DOT as ultra light fill in a number of embankments on the I-15 reconstruction project in Salt Lake County. The lightweight fill was used to eliminate settlement in areas where utilities would need to be relocated to prevent damage due to significant settlement. Relocation of the utilities would be very expensive, and would require many months of planning and acquiring permits. The geofoam fill was also used in fills where sufficient time was not available to obtain the required settlement, and to enhance slope stability in some areas.

State of Development: Geofoam fills have been in place on some sections of the I-15 project for two years. Eleven embankments include geofoam in the fills, and more than 100,000 cubic yards of geofoam were placed on the project. Four of the embankments have been instrumented to observe settlement, shift, and creep over time. Funding has been established to monitor the sites for 10 years, but the installations have shown to be stable to date. Other installations around the world have been under observation for many years.

Potential Payoffs: It is estimated that tens of millions dollars has been saved by leaving the utilities in place. Many months of settlement time was saved by using the geofoam where insufficient time was available. The design-build schedule was maintained by shortening the settlement time.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Geosynthetic-Reinforced Soil Walls**

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Technology Ready for Implementation

Brief Description: Colorado DOT successfully completed in July of 1999 the construction of the new Founders/Meadows Bridge structure south of Denver over interstate I-25. In this first of its kind application, geosynthetic-reinforced soil (GRS) walls supported both the footing of the two-span bridge and the approaching roadway structure. Results of comprehensive material testing, instrumentation, and monitoring programs of this unique structure suggested excellent short- and long-term performance and that CDOT's design procedure was overly conservative.

State of Development: Design and construction of GRS walls for this structure were thoroughly described. Field, loading, and limitations of this kind of this application were also presented. Basis for estimating the movements of similar applications are also presented. Additional details for construction of GRS abutments were published in 1997 by FHWA and AASHTO. Efforts are underway by NCHRP to further fine tune and validate AASHTO and CDOT design guidelines. CDOT engineers completed the design of two new bridges with GRS abutments.

Potential Payoffs: Potential for eliminating the bridge bump problem, avoid disadvantages associated with the use of deep foundations, and allow for construction in stages and within a smaller construction working area.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Geotechnical Database**

Contact

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Technology Ready for Implementation

Brief Description: Geotechnical Database of Kentucky (or any other state or other governmental unit). The Geotechology Section of the University of Kentucky Transportation Center (UKTC) developed the software and methodology for the Kentucky Transportation Cabinet. Data entry/retrieval Graphical User Interfaces (GUIs) are being built using PowerBuilder 7. Oracle 8i is used for the database, which is in a client/server environment and resides on a server in the Info Section of the Ky Transportation Cabinet in Frankfort, Ky. MapObjects is used to embed maps—GQs, Topo maps county maps,etc,. All data can be exported to ARC View—however, not everyone has this software and consequently the system is being developed for independent use. All twelve Highway Districts and several Central Offices of the Ky Transportation Center, as well as UKTC, are connected (Intranet) to the server. The database contains three major components: Rock slope data, landslide data, and hole/sample data. Also, statistical analyzers, security measures, some engineering applications, methods for storing electronic photographs, graphics, have been, or being built, into the system.

State of Development: More than four years have been years have been spent collecting and building the database and GUI screens for data entry and retrieval. Rock slopes are being rated using the Oregon (FHWA) Rockfall Hazard Rating System. Landslides are rated using a system devised by UKTC engineers. GUI screens for data entry and retrieval of rockfall, landslide sites, and soil/rock testing data have been built. Routines for storing electronic photographs have been built and some graphics have been completed. To insure that the Ky Transportation Cabinet gets the kind of program it needs for future operations in the geotechnical area, the Geotechnology Section of the Center developed its own programming skills. Portions that are under construction include GUIs for entering instrumentation data and schemes for “capturing” data as it is generated by the KyTC and consultants—eventually there will no need to entering historical data, which is a painstaking task. The Kentucky database contains attributes, including photographs, of some 2100 rock slope sites and about 1100 landslide sites. Additionally, soil/rock engineering test data is being collected roadways, dams, bridges, culverts, etc, Soil and rock data, including reports of the Geotechnical Branch of KyTC, will be available eventually on the Internet—this will have enormous benefits for economic development of Kentucky.

Potential Payoffs: A major strength of this program is that geotechnical engineers and geologists who understand the needs of the KyTC and Transportation engineers are developing it. Any number of users can "hit" the database at the same time. Viewers at several different locations in the state can view the same data (such as photographs of rockfall or landslide sites) at the same time. This has enormous potential benefits, since Central Office geotechnical engineers and field engineers can discuss by phone the actions that may be needed at a site while viewing the same site photos and data at the same time. Geotechnical engineering test data stored in the database will be beneficial for performing transportation corridor studies, earthquake studies, economical development, etc. Another great benefit--once data are stored in the database—is that less drilling in urban settings where tremendous traffic control problems exist today and will increase in the future.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes, with careful discussion, planning, and establishment of legal safeguards—and depending on personnel time requirements.

MATERIALS

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Concrete Additives for Low Permeability**

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Technology Ready for Implementation

Brief Description: Two new additives to concrete have been tested through the Connecticut Cooperative Research Program at the University of Connecticut, which is sponsored by the Connecticut Department of Transportation. The additives were added to ConnDOT's Class F 4,000 psi concrete for bridges. Cast lollipops were soaked in a 15% salt solution for four days, followed by a three-day drying period. One hundred of these seven-day cycles were completed. A variety of tests were performed. Essentially, no corrosion was observed in the experimental specimens, while the control mix specimens and mixes with two commercial additives had extensive corrosion.

State of Development: Disodium tetrapropenyl succinate and diammonium tetrapropenyl succinate, known respectively as DAS and DSS, are alkali metal and ammonium salts of an alkenyl-substituted succinic acid. Patent attorneys determined the chemicals couldn't be patented. The results from this research are being published and the cement additives industry is welcome to commercialize the use of these addititives. The final report is available and has been submitted to the National Transportation Library.

Potential Payoffs: Costs due to corrosion of reinforcement in concreted caused by deicing salts have been estimated at up to $1 billion per year in the U.S. alone. The DAS and DSS additives reduced permeability dramatically in ConnDOT's Class F concrete for bridges, preventing the movement of chlorides through concrete over a two-year, one-hundred-cycle testing period. The research results demonstrated that the DAS and DSS additives provided excellent protection of reinforcing steel in concrete. Performance far surpassed the performance of the control mix and two other mixes with commercial additives.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? **Yes**

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Eight-Hour Performance Graded Binder Classification Method**

Contact

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Technology Ready for Implementation

Brief Description: Eight-hour PG Binder Classification. Dr. David Jones, Trumbull Asphalt has presented an alternative method to MP-1 to obtain asphalt binder test results in an 8 hour shift rather than the 2 days currently required. This test method would not replace MP-1 but would supplement it. MP-1 would remain the referee test if needed. The 8-hour protocol uses the 4.5-hour microwave aging technique developed by Dr. Safwat Bishara, KS DOT and an offset (for RTFOT/PAV-aged) to stiffness curves using RTFOT-aged samples only since the curves are parallel.

State of Development: The protocol has been developed conceptually based on completed research and presented to the Superpave Committee Binder ETG. The microwave aging technique has been studied and verified on the SHRP reference asphalts. The stiffness curve shift has been documented. Dr. Jones has proposed the criteria for the single binder quality test. Ruggedness testing should be run to gain precision and bias results for multiple labs and operators. Test methods for microwave aging and quality test need to be approved by ETG, SCOM.

Potential Payoffs: Use of the 8-hour binder test protocol for production testing will save considerable lab technician time, allow shorter "hold times" while verifying binder grades and potentially reduce tank storage requirements for refineries.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Information Kit for Using Reclaimed Glass in Base Aggregate**

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Technology Ready for Implementation

Brief Description: Collaboration among the MN Local Road Research Board, the MN LTAP, Mn/DOT and the MN Office of Environmental Assistance led to the development of an information kit to promote the use of reclaimed glass in base aggregate. The information kit includes case studies, lists of suppliers and technical resources, a sample certification letter, charts showing allowable debris ratios, and information about a new Mn/DOT specification that allows aggregate mixtures containing salvaged/recycled materials. Some questions that are answered are how environmental impacts are addressed, what kinds of glass are recommended for use, what quality control steps need to be taken, and what safeguards can be taken to ensure meeting the specification. The kit is designed to be used by engineers, glass suppliers, solid waste administrators and aggregate suppliers.

State of Development: Research has shown that adding glass to gravel actually helped increase the quality of gravel. Under the right conditions, crushing and blending virgin aggregate with 10 percent reclaimed glass may help upgrade substandard gravel so that the final product then can meet specifications. More than 15 Minnesota counties have used reclaimed glass in aggregate mixes for road construction. A new Mn/DOT specification, issued in 1999 allows the use of 10 percent reclaimed glass in aggregate material for road base. The new specification, known as Class 7, represents aggregate mixtures that contain salvaged/recycled aggregate materials.

Potential Payoffs: Minnesota counties that use reclaimed glass in aggregate report several benefits. The use of reclaimed glass may help reduce the cost of road construction depending on the quality of virgin aggregate used. It provides a way to help recycle locally a portion of solid waste, thus eliminating landfill costs, as well as reducing the need for purchasing virgin material. Research and field results show that using reclaimed glass in the aggregate per the specification results in a product of equal or better quality. Reclaimed glass also enhances the permeability of the base.

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes.

AASHTO Research Advisory Committee Technology Ready for Implementation for the AASHTO Steering Group for Technology Deployment

Title:	**Rapid Hardening Concrete Repair Mix**

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Technology Ready for Implementation

Brief Description: NJ DOT through a contract with Rutgers University developed a rapid hardening concrete for repair of bridge decks. The concrete mix is not a patch material, but a concrete mixture that can be uses for thin, medium, and full depth repairs. The concrete mixture achieves 3000 psi strength in 2 hours with no shrinkage and little thermal heating. The material has been tested on Interstate 80, one of our busiest roadways.

State of Development: The material has been developed and tested in the laboratory and on actual bridge decks. We are further evaluating a self-leveling formulation that will allow the material to be placed and finished with no need for vibratory consolidation.

Potential Payoffs: The material is far more durable than patch material and it minimizes the time for lane closures

Willingness to Champion

Would your state be willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? Yes