VIRGINIA TRANSPORTATION RESEARCH COUNCIL

Annual Report

FY 04
JULY 1, 2003 - JUNE 30, 2004

Bringing Innovation to Transportation

UNIVERSITY of VIRGINIA

VDOT
Virginia Department of Transportation

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http://www.virginiadot.org/vtrc/main/online_reports/pdf/05-r14.pdf.

MEMORANDUM TO COMMISSIONER SHUCET, THE COMMISSIONER'S STAFF, AND VDOT DIVISION ADMINISTRATORS

I am pleased to present you with the Research Council's *FY04 Annual Report*. The report provides a detailed review of the Council, our staffing and resources, and our accomplishments for the fiscal year beginning July 1, 2003, and ending June 30, 2004. In addition, it spotlights four new initiatives: our First Place Strategy for Research; our Knowledge Management Office; our Online Library; and our Enhanced Pavement, Structures, and Roadside Assets Research Program.

Let me provide just a few highlights:

- *We continue to make major strides in improving design and construction.* In one such effort, we are investigating the feasibility of using precast concrete deck panels to expedite construction. The panels will be very high quality, since concrete quality and fabrication tolerances are significantly better in a precasting yard than in the field. The decks will be stiffer under service loads and more resistant to corrosion-inducing chlorides and water. In addition, the precast decks can be constructed more rapidly than can conventional decks, which will reduce construction time and user costs related to traffic slowdowns and detours.

- *Our research has led to improved materials with associated cost savings for VDOT.* Based on our life cycle cost analysis, using stainless steel–clad bars in new concrete bridge decks could save VDOT more than $1 million per year. In addition, our project evaluating shrinkage of VDOT-approved concrete mixtures yielded a performance-based specification to reduce the probability of cracking due to drying shrinkage. This could reduce VDOT's costs for maintenance, repair, and rehabilitation of concrete structures by $12 million per year.

- *We continue to help VDOT "put safety first."* As chair of NCHRP Project Panel 17-25, we are helping to oversee a project to develop a set of crash reduction factors for different types of engineering improvements that VDOT and other states can use in their safety programs. Crash reduction factors are useful because they give engineers a computationally simple and quick way of estimating crash reductions when they need to compare a variety of possible treatments in many different locations.

- *We continue to place high importance on stewardship of our environment and our historic resources.* In response to increased environmental concerns, we demonstrated the feasibility of using shredded tires in constructing highway embankments. In this effort, we placed 1.7 million discarded tires in an embankment constructed near Williamsburg. After 10 years of monitoring the site, we can recommend this application as a viable option for disposing of discarded tires in an environmentally responsible way.

- *We continue our commitment to increase mobility and reduce congestion.* With the grant we applied for and received under the Federal Highway Value Pricing Pilot Program, we are investigating issues related to implementing value pricing in Northern Virginia and Hampton Roads. As congestion continues to increase and the ability to construct additional lane miles of roadway decreases, value pricing provides another option for motorists. Priced lanes provide reliable travel times by limiting the number of vehicles using the lanes to a level that ensures a minimum level of service. Value pricing implementations do not come without challenges, however, and this effort will work to identify potential difficulties and determine solutions prior to design and implementation.

- *We continue to provide extensive on-call consulting to VDOT in a multitude of areas.* Our review of Virginia's license plate sheeting specifications requested by the Secretary of Transportation yielded new specifications that allow for more open competition from prospective bidders in the marketplace. In our work for the Commissioner's Staff, we reviewed economic approaches for assessing proposals under the Public-Private Transportation Act and the potential impacts of particular candidate PPTA projects on Virginia's economy. Through a series of contracts with the University of Virginia's Center for Risk Management of Engineering Systems, we are assisting VDOT with its ongoing efforts to protect critical transportation infrastructure from willful threats.

- *We continue to be dedicated to helping VDOT enhance its transportation planning and its financial and administrative management.* The Project Cost Estimation System we developed for VDOT in FY03 became a fully operational Intranet-based system last October. We continue to provide support on an as-needed basis. Our ongoing analysis of VDOT's Cash Flow Model will allow VDOT to project its monthly cash flows more accurately, thus leading to improved financial management.

- *Through our website, we continue to be in the forefront as a source of information and state-of-the-art technology in transportation internationally.* Our website recorded 620,697 web pages viewed and 39,489 downloads of our reports in FY04.

- *We continue our role in developing future transportation professionals.* Our support for graduate transportation students remains strong, averaging eight full graduate fellowships each year.

- *We continue to strive to improve our service to VDOT and the citizens of the Commonwealth:*
  - — Our First Place Strategy for Research Initiative will help us achieve our vision of being the best in class among transportation agency research organizations. More important, it will ensure the best use of public resources in our mission to help VDOT provide the Commonwealth a safe, effective, and efficient transportation system to "Keep Virginia Moving."
  - — Our new Knowledge Management Program will help VDOT identify, organize, and disseminate the right knowledge to the right people at the right time. Sharing knowledge will save time, support efficiency, and ensure consistency within VDOT.
  - — Our Online Library Initiative, which converted our manual systems to computerized systems, will allow Virginia, national, and international transportation professionals to search the holdings of our library as well as 19 other key transportation libraries in the United States.
  - — Our Enhanced Pavement, Structures & Roadside Assets Research Program will aid VDOT's asset management, materials, and structure & bridge divisions as they carry out Virginia's Six Year Transportation Improvement Program.

I am proud of the work the men and women of the Research Council do each day to fulfill our mission to "Bring Innovation to Transportation." The source of strength for our transportation research program is the close tie between our staff and the division and district staff. These dedicated employees serve on our advisory committees and project panels, critique our work, and implement the findings of our research. We appreciate their support and the support provided by you and the Commissioner's Staff, for this truly makes transportation research in Virginia a team effort.

Gary R. Allen, Ph.D.
Chief of Technology, Research & Innovation

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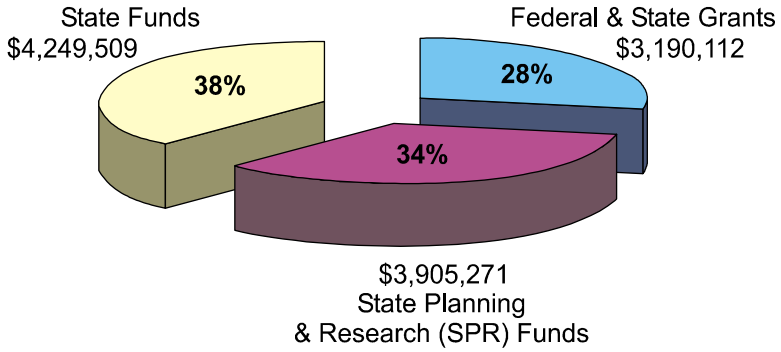
INTRODUCTION

The Virginia Transportation Research Council is a joint venture of the Virginia Department of Transportation and the University of Virginia. As an operating division of VDOT's Central Office, we foster innovative research and implement improved practices in transportation. Formed in 1948, we support VDOT's mission to "Keep Virginia Moving" by "Bringing Innovation to Transportation." We accomplish our mission by conducting formal research studies, providing technical assistance to sponsors, supporting and conducting knowledge management and technology transfer activities, and providing education and training programs for transportation students. Our offices and laboratories are located in the Tilton E. Shelburne Building on the Grounds of the University of Virginia in Charlottesville. Our Knowledge Management Office, including the Virginia Transportation Technology Transfer Center, is located in their new office at 1230 Cedars Court, Suite B, in Charlottesville.

REVENUES & THEIR SOURCES

Our total revenues for FY04 were $14,475,234. Our core program revenues come from three main sources: (1) state planning and research (SPR) funds, (2) state funds, and (3) federal and state grants. Ancillary revenue sources are as indicated.



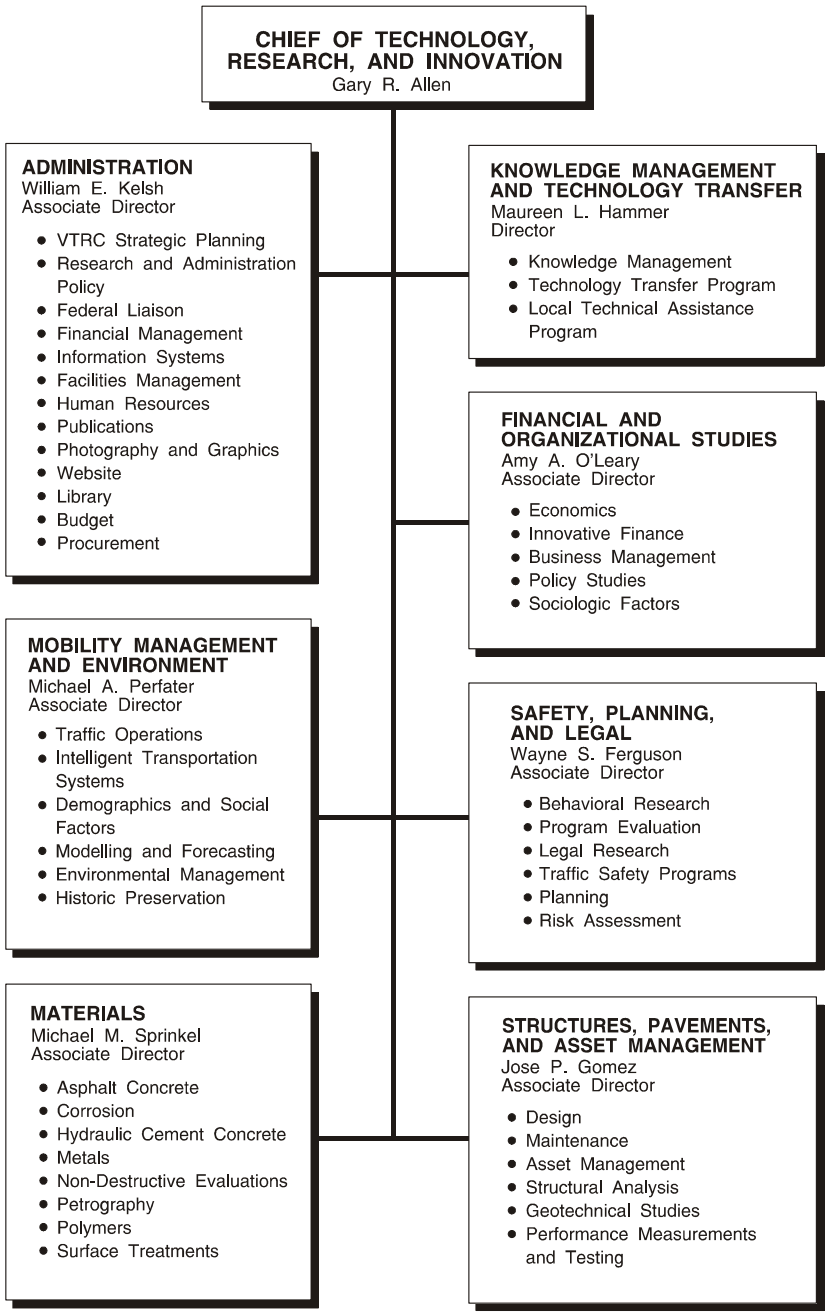
Ancillary Revenues

Local Technical Assistance Program (LTAP)	$ 280,000 (based on 2004 calendar year)
Contributions to FHWA Pooled Fund Studies	100,000
National Cooperative Highway Research Program	781,043
Transportation Research Board Correlation Service	141,075
TEA-21 Smart Road Program	1,238,224
Smart Road Management Agreement	350,000
Mid-Atlantic University Transportation Center Match	
To University of Virginia	120,000
To Virginia Polytechnic Institute & State University	120,000

ORGANIZATIONAL STRUCTURE

VTRC is organized into five research teams, an administration team, and a knowledge management and technology transfer team as shown in the organization chart. The research teams are divided into five fields of study: Financial & Organizational Studies; Materials; Mobility Management & Environment; Safety, Planning & Legal; and Structures, Pavement & Asset Management.

VIRGINIA TRANSPORTATION RESEARCH COUNCIL ORGANIZATION CHART



STAFFING

VTRC has approximately 104 staff members. The 59-member full-time classified staff comprises 8 managerial staff, 27 research scientists, 11 technicians, and 13 administrative and support staff. The full-time staff includes 3 technicians and facilities maintenance workers employed by the University of Virginia and 2 full-time information technology professionals employed by the Virginia Information Technology Agency (VITA). The 45-member part-time staff is composed of 7 UVa faculty members; 17 research, technical, and administrative personnel; 16 student research assistants/associates; and 5 graduate research assistants. Employment levels in these categories vary throughout the year because of staff turnover and seasonal hiring, so these numbers represent the typical staff composition.

Of particular note, in May 2004, we hired a full-time contracts and grants administrator to provide oversight and coordination for our university contracts and federal and state grants. In recent years, we have experienced significant growth in our grant-funded revenue, particularly from federal sources. As of June 30, we were administering 38 grants with a lifetime value of more than $10 million. In addition, we have seen substantial increases in our volume of university contracts—75 as of June 30.

STUDENT PROGRAMS

For more than 50 years, VTRC has supported graduate students in transportation engineering and related fields at the University of Virginia through its Graduate Research Assistant Program. The founders of VTRC realized the importance of employing students to conduct research studies, and it soon became clear that such a program had compelling mutual benefits for the students, the university, VTRC, and VDOT. Support for master's degree candidates is provided up to a maximum of two full academic years, including the intervening summer. Support for doctoral degree candidates may also be provided for up to a maximum of three academic years beyond the master's degree, including the intervening summers.

In FY04, we provided support for eight graduate students in this program:

- *Changseok Baek, a doctoral student, is working on VDOT's legislatively mandated Safety Corridors Program.* He assisted in analyzing crash data for Virginia's interstate highway system and is currently developing a procedure for identifying the optimal length for corridor study analyses.

- *Andrew G. Beacher, who obtained his master's in May 2004, worked on a project to evaluate the late merge work zone traffic control strategy.* The project obtained data to determine whether use of the late merge strategy resulted in higher throughput volumes and the traffic and geometric conditions under which it could be beneficially implemented.

- *David B. Ellington, who obtained his master's in May 2004, worked on a project to determine the influence of highway investments on population and traffic growth in Fairfax County, Spotsylvania County, and Newport News.* The effort examined comprehensive plans spanning several decades and compared what planners wanted to accomplish with what actually happened, thus leading to conclusions regarding how comprehensive plans can be made more realistic.

- *Arkopal K. Goswami, a doctoral student, worked on a project to examine the number of vehicle trips generated by various residential developments in Virginia.* He is currently working on

an expedited process for coordinating transportation and land use planning and is developing a set of course notes that examine the feasibility of using offsite terminals to help airline passengers access the airport.

- *Rahul Khandelwal, a master's student, is working on the evaluation of red-light camera enforcement in Virginia.* An interim report will be provided to Virginia's Secretary of Transportation and the 2005 Session of Virginia's General Assembly.

- *Vijayendra R. Lakkundi, who obtained his master's in May 2004, worked on a project to develop guidelines for installing left-turn lanes for signalized and unsignalized intersections.* The new guidelines were based on the application of well-validated event-based simulation programs.

- *John A. Pegues, a master's student, is working on a project to identify and develop measures for monitoring the performance of Virginia's Smart Traffic Centers.* This will assist VDOT in documenting the benefits of the investments made in the centers and will identify operational areas where improvements, expansions, upgrades, and enhancements are needed. The Hampton Roads Smart Travel Center is serving as the case study location.

- *Matthew R. Tilley, who obtained his master's in May 2004, worked on a project supporting the FHWA Curved Girder Bridge Study designed to develop design equations based on full-scale laboratory investigations of the behavior of curved girder structures.* He focused on the dynamic characteristics of the curved girder bridge prior to and after placement of the deck. Understanding the dynamic characteristics will result in more refined design assumptions and equations, particularly for such structures in a seismically active geographical area.

As already noted, we also employ students as research assistants (primarily undergraduate students) or research associates (primarily graduate students). Students include those from UVa's Department of Materials Science & Engineering, Department of Civil Engineering, Department of Urban & Environmental Planning, Department of Economics, School of Law, Colgate Darden Graduate School of Business Administration, and many other departments. During the summers of 2003 and 2004, we also employed students from Virginia Commonwealth University and Virginia Polytechnic Institute & State University.

RESEARCH ADVISORY COMMITTEES

Research advisory committees are essential to VTRC's program. They provide a sounding board for new ideas for research, offer input to help prioritize research needs, and provide a direct line of communication to the sponsor administrators and decision makers who are able to implement research results. The Appendix provides a listing of the research advisory committees active in FY04 and their members.

HIGHLIGHTS OF INNOVATIONS & COST SAVINGS

REDUCING CRASH RISK & SAVING LIVES

- *In a joint effort with VDOT's Mobility Management Division, we identified specific locations for implementing Virginia's Highway Safety Corridor Program using the framework we developed in 2003.* We analyzed the crash history of Virginia's entire interstate system to define specific locations where safety could be improved through increased enforcement, improved public education, and low-cost engineering improvements. The results were used by VDOT, the Virginia State Police, and the Department of Motor Vehicles to select specific locations to be designated as safety corridors. As a result of this work, the first corridor was established on I-81 near Roanoke in January 2004. Preliminary crash data indicate a reduction in the number and severity of crashes. We continue to work with the Mobility Management Division to identify additional corridors on Virginia's interstate and primary systems for ongoing implementation.

- *In a joint effort with the University of Virginia's Department of Civil Engineering, we provided the FHWA with a report that addressed safety issues associated with having different speed limits for passenger cars and trucks on rural interstate highways.* Data from nine states were placed into four policy groups based on the type of speed limit employed during the 10-year study period: a uniform speed limit (USL), a differential speed limit (DSL), a change from a USL to a DSL, and a change from a DSL to a USL. Neither the USL nor the DSL had a greater effect on safety. Mean speed, 85th percentile speed, median speed, and crash rates tended to increase for both systems. Further examination suggested that the relationship between crashes and traffic volume cannot be generalized but instead varies by site within a single state.

- *We continue to serve as chair of NCHRP Project Panel 17-25. This project will develop a set of crash reduction factors (CRFs) for different types of engineering improvements that VDOT and other states can use in their safety programs.* The panel, composed of representatives from several states and the FHWA, is overseeing contract work by the University of North Carolina to develop CRFs for ITS improvements. A CRF is a single number that gives an estimate of the reduction in a particular type of crash, e.g., rear-end crashes, that will occur with a specific type of improvement, e.g., installation of a left-turn lane. Although many factors may contribute to a crash, CRFs are useful because they give a computationally simple and quick way of estimating crash reductions when engineers need to compare quickly a variety of possible treatments in many different locations.

- *As part of the our continuing relationship with the Department of Motor Vehicles' Traffic Safety Program, we conducted three safety restraint surveys, two measuring safety belt use among adults and one measuring safety and booster seat use among children under 16 years of age.* Safety restraint use has long been shown to reduce injuries and fatalities. Although Virginia's child safety seat use rate has been in the 90% range for several years, its adult belt use rate has been considerably lower, in the low-to-mid 70% range. In the most recent survey, Virginia's safety belt use rate rose to just under 80% for the first time in the history of these surveys.

- *In 2003, we staffed the Governor's Task Force to Combat Impaired Driving (including both alcohol and drugs), which issued a number of legislative recommendations.* This work continued into the 2004 Session of the General Assembly, which passed landmark legislation including enhanced penalties for drivers with high blood alcohol concentrations, vehicle forfeiture and

longer license suspension for multiple offenders, and reinstitution of the habitual offender program.

- *We are determining the visibility needs of motorists during wet night conditions.* Findings from this study will be used to develop performance measures for evaluating wet night retroreflectivity of pavement delineation devices. These performance measures will lead to the development of a performance-based specification derived from the actual measured visibility needs of motorists under wet night conditions. Improving wet night delineation of pavement markings should reduce collisions that occur under such conditions.

- *Together with the Virginia Tech Transportation Institute, we continue to participate as a member of the Intersection Collision Avoidance/Decision Support System Consortium.* Virginia is working to identify countermeasures that would reduce the incidence of straight crossing path collisions at intersections. A technology demonstration of active warning systems was conducted, and extensive testing of these systems is occurring on Virginia's Smart Road. This project is expected to lead to a field operational test upon its conclusion in April 2005.

MANAGING ASSETS WISELY

- *We received a grant from the FHWA Innovative Bridge Research and Construction Program to replace the concrete deck on a historically significant truss bridge in Covington.* The deck system is manufactured from fiber-reinforced polymeric material and is significantly lighter than the existing concrete deck. Once the deck is replaced, the bridge will be posted to a higher capacity that will allow for safe passage of emergency vehicles.

- *Our study to develop guidelines for pavement maintenance using milling and grinding without squaring up at the end of each day will lead to an increased paving rate and decreased unit costs, but safety issues associated with the drop-off and rough surface must be addressed.*

IMPROVING MATERIALS, DESIGN & CONSTRUCTION

- *As the result of a $1 million award by Commissioner Shucet, we developed an Enhanced Pavement, Structures & Roadside Assets Research Program.* After the award was made, we held discussions with our research advisory committee members and field personnel in the particular technical areas to develop a list of proposed projects. The projects selected will lead to more cost-effective pavement and bridge plans and designs; plans and designs that speed construction; roadways that yield minimal defects; improved roadway shoulders; and more cost-effective and efficient maintenance and operations.

- *We took steps to augment our asphalt research program by adding new staff and devoting more financial resources to this research area.* We recruited an additional researcher in hot-mix asphalt technology and an additional lab technician. In addition, a significant portion of the budget for our Enhanced Pavement, Structures & Roadside Assets Research Program was devoted to asphalt. VDOT uses approximately 2 million tons of asphalt per year at a cost of $35 per ton, for a total of approximately $70 million per year. Additional research on asphalt can increase the service life of a typical overlay. With just small increases in the life of an overlay, VDOT could save several millions of dollars per year using improved asphalt.

- *We also undertook several research projects of particular interest to Virginia's asphalt industry:*

— *A study of VDOT's ride specification.* Staff participated in and observed the "Profiler Rodeo" in Blacksburg. Refining the ride specification should provide smoother riding pavements at a lower unit cost.

— *A study to evaluate the StripScan equipment, a device developed to allow for determining the quantity of anti-strip admixture in asphalt.* Staff met with the manufacturers' representatives to discuss suggested changes to the equipment and procedure. The quantity of anti-strip admixture in asphalt affects the life and therefore the life cycle cost of asphalt pavements.

— *A retrofit for the Asphalt Pavement Analyzer that will allow us to test cores rather than beams.* Cores are more representative of pavement than are beams. Testing cores should allow us to develop more rut-resistant pavements. Rutting can affect the service life and therefore the life cycle cost of asphalt pavements.

— *A study of specification changes for stone matrix asphalt.* This project included drafting a technical memo: *Flat and Elongated Aggregates for Stone Matrix Asphalt (SMA): Discussion and Preliminary Findings from 2003 VTRC Field Testing.* The specification for SMA affects the service life and cost of pavements.

— *Work on an asphalt drainage layer project that led to the adoption of a new drainage layer specification.* The new specification was used for the Route 288 project. Users of the new drainage layer noted the ease of construction. Drainage can affect the service life and therefore the life cycle cost of asphalt pavements.

- *Our study on concrete shrinkage performance resulted in the development of a new specification and an associated test procedure.* Based on the results of this study, the limits on the percentage length change should be 0.0300 at 28 days and 0.0400 at 90 days for portland cement concrete mixtures and 0.0400 at 28 days and 0.0500 at 90 days for supplemental cementitious material mixtures. These limits will aid in reducing the probability of cracking due to drying shrinkage, which could increase service life. This in turn would reduce the costs of maintenance, repair, and rehabilitation of concrete structures. The cost savings could be around $12 million per year.

- *Our study on the application of 316L stainless steel–clad bars in new concrete bridge decks revealed no significant problem with the use of clad bars as a direct substitute for the currently used black steel and epoxy-coated bars.* The research supplemented a laboratory evaluation that confirmed the predicted high corrosion resistance of these cost-effective bars. Even though the initial cost of the clad bars is slightly higher than that of the currently used bars, the life cycle cost for the deck is lower than for one built with either of the other bars. Results were used to update specifications for stainless steel–clad bars. We recommended that the clad bar specified in ASTM A615 be used in the construction of new concrete bridges in Virginia. This could save VDOT more than $1 million per year based on a life cycle cost analysis.

- *Our study on the resistance of several new metallic reinforcing bars to chloride-induced corrosion in concrete bridge decks had promising results.* This study evaluated stainless steel–clad carbon steel bars; bars made of an MMFX-2 "micro-composite" steel; bars made of a new "lean" duplex stainless steel called 2101 LDX; a carbon steel bar coated with a 2-mil layer of arc-sprayed zinc and then epoxy; two solid stainless steel (304 and 316LN) bars; and an ASTM A 615 carbon steel bar. We recommended using MMFX-2 or clad bars, or even the zinc/epoxy-coated bars (pending further research), for concrete bridges exposed to heavy salting, such as those on urban highways and heavily traveled primary and interstate routes. We recommended using MMFX-2 bars or the currently used epoxy-coated bars for concrete bridges on low-volume highways that will not to be salted too heavily.

- *Our study on the corrosion-protection service life of epoxy-coated reinforcing steel assessed the additional corrosion protection service life provided by epoxy-coated reinforcement (ECR). The corrosion service life extension attributable to ECR in bridge decks was found to be approximately 5 years beyond that of bare steel and, therefore, ECR is not a cost-effective method of corrosion prevention for bridge decks. Removing the requirement for ECR would save VDOT approximately $845,000 per year.* Our study compared ECR and bare steel bars in concrete cores from 10 Virginia bridge decks built between 1981 and 1995. Laboratory nondestructive monitoring during exposure to chloride-rich solution occurred over 36 months. The time of corrosion initiation and cracking and the chloride content of the concrete were used in the analysis. The resulting service life projection procedure predicted that less than 25% of the Virginia bridge decks built in accordance with specifications in place since 1981 should corrode sufficiently to require rehabilitation within 100 years, regardless of bar type.

- *Using the new web-enabled VDOT Statewide Geotechnical Database Management System will save time and money in planning, engineering, and constructing the Woodrow Wilson Bridge Replacement Project.* The tool, an application on VDOT's server, offers historic and new geotechnical information at a glance and geotechnical profiles in less than 1 minute. Specifically, the tool provides a quick and effective means of sorting and accessing historic and new geotechnical data. Engineers can use these data to plan future soil explorations, which can cost as much as $10,000 per day. During construction, the data will be used to compute pile lengths, among other applications. The next phase of the project will extend its implementation to the I-81 widening project. We collaborated with several VDOT divisions, Old Dominion University, and the U.S. Army Corps of Engineers in developing the tool. The team received the Commissioner's Award for Excellence for this project. The tool may be viewed at http://gis.virginiadot.org/.

- *We continue to push the implementation of high performance concrete structures.* This past year two technologies were successfully implemented in the design of bridge structures. One involved the use of lightweight high performance concrete in prestressed concrete girders for the bridge carrying Route 33 over the Mattoponi River. This concrete reduces the dead load weight of the structure, thus allowing for longer spans and a reduced number of piers, thereby reducing initial costs. The other project used ultra high performance concrete in prestressed girders for the bridge carrying Route 58 Business over the Route 58 Bypass. This concrete has 8 to 10 times the strength of traditional concrete and is significantly more durable. Cost savings are expected from the use of fewer girders per bridge and reduced maintenance costs.

- *We are developing an enhanced performance specification as a means to produce high-quality embankments.* VDOT spends hundreds of millions of dollars each year on earthwork, and much of that is spent on embankment construction. Embankments that are stable against vertical and lateral deformations can support roadways and pavements to provide a good ride quality and remain safe, with limited requirements for maintenance expenditures over time. The concept of enhanced performance specifications is to provide the earthwork contractor with as much freedom as possible to control construction operations and, associated with that freedom, to make the contractor responsible for the performance of the embankment. This approach is in contrast to more prescriptive specifications, which require full-time inspection to provide quality assurance. Enhanced performance specifications can produce a good result with less demand on VDOT's limited number of construction inspection personnel.

- *We are investigating the feasibility of using precast concrete deck panels to expedite construction.* The project objective is to develop comprehensive design and construction recommendations for a full-width, full-depth prestressed concrete bridge deck panel system. The system has many advantages over conventional cast-in-place concrete bridge decks. The panels will be very high quality, since concrete quality and fabrication tolerances are significantly better in a precasting

yard than in the field. The decks will be prestressed in both directions, which will make them stiffer under service loads and more resistant to the ingress of corrosion-inducing chlorides and water. In addition, the precast decks can be constructed more rapidly than can conventional decks, which will reduce construction time and user costs related to traffic slowdowns and detours.

- *In response to a technical assistance request from the Public Works Department of the City of Bristol, we conducted a forensic investigation to determine the cause of extremely unusual distortions that appeared in the paved asphalt surface of Old Airport Road. The results of our analysis afford VDOT an opportunity to avoid costly similar problems in future construction.* The distortions, which were observed directly above pipe culverts, eventually became so severe that ride quality and surface drainage conditions were dangerously compromised. The cause of the distortions was expansive heave of the black pyritic shale used to backfill culvert trenches. In addition, significant structural damage to culvert pipes resulting from excessive heave expansion pressures was discovered during the investigation. Although this represents the first documented occurrence of damage to civil infrastructure in Virginia caused by the expansive heave of pyritic shale, our work here enhances our understanding of this extremely damaging phenomenon.

- *Implementing a traffic data program we developed in a joint effort with VDOT's Materials Division and Mobility Management Division would save VDOT an estimated $50,000 to $250,000 annually over the first 5 years.* The traffic data plan was developed for VDOT's new *Pavement Design Guide.* Traffic data comprise an important element for mechanistic-empirical pavement designs. The proposed traffic data program for pavement design takes advantage of the flexibility permitted in the *Traffic Monitoring Guide* and the availability of weigh-in-motion data from the Department of Motor Vehicles to keep program costs at a minimum. A traffic data plan and a phased approach to implement the plan were proposed.

- *At the request of Virginia's Secretary of Transportation, we undertook a review and assessment of Virginia's license plate sheeting specifications. As a result, the new specifications allow for more open competition from prospective bidders in the marketplace.* The review was focused on the five test methods or specifications called into question, i.e., cold temperature resistance, solvent resistance, gasoline resistance, ISO 9002 registration, and directional warranty mark. As a result of our review, a number of changes to the Commonwealth's license plate sheeting contract specifications were recommended to bring them up to date. All recommendations were implemented, making Virginia's specifications for license plate sheeting performance-based rather than product-specific.

INCREASING MOBILITY & REDUCING CONGESTION

- *We developed new guidelines for installing left-turn lanes at signalized and unsignalized intersections that will enhance operational efficiency and safety on Virginia's roadways.* In this project, we developed an event-based simulation model VDOT engineers can use to determine the need for a left-turn lane. This model was validated using data collected from a number of signalized and unsignalized intersections around Virginia and thus reflected real-world traffic flow more accurately than did previous guidelines. The simulation was used to update existing guidelines for left-turn installation at unsignalized intersections and to create new guidelines for signalized intersections. The proposed guidelines corrected many of the flawed assumptions of earlier models and provide more guidance to the engineer as to when a turn lane should be installed.

- *We applied for and received a grant under the Federal Highway Value Pricing Pilot Program to investigate issues related to the implementation of value pricing in Northern Virginia and Hampton Roads*. As congestion continues to increase and the ability to construct additional lane miles of roadway decreases, value pricing provides another option for motorists. Priced lanes provide reliable travel times by limiting the number of vehicles using the lanes at a level that ensures a minimum level of service. As demand increases, so does the price to use the lane until an acceptable level of use is reached. Value pricing implementations do not come without challenges, however, and this effort will work to identify potential difficulties and determine solutions prior to design and implementation.

- *We completed Build 3 of ADMS Virginia on time and under budget.* ADMS Virginia is an archived data management system developed and deployed as a result of a grant from the FHWA entitled "Traffic Management Center Applications of Archived Data Operational Test." The project, focused on system operations data for the Hampton Roads region, was delivered in three incremental builds, providing stakeholders with basic access to the data through a web-based interface in Build 1; adding additional data sources, a map-based interface, and more advanced tools in Build 2; and providing a complete system in Build 3. The funds remaining in the project at the completion of Build 3 were determined to be sufficient to bring data from Northern Virginia into the system, providing the functions currently available for Hampton Roads in Builds 1 through 3. The Build 4 effort is due for completion in December 2004. ADMS Virginia is currently available for use by VDOT and local government agencies needing detailed traffic data.

MANAGING THE ENVIRONMENT & HISTORIC RESOURCES

- *Our study to validate the post processors used to estimate speeds for the purpose of air quality conformity analyses could help VDOT's Environmental Division perform these analyses with in-house staff.* This work, in conjunction with other VDOT initiatives, could lead to cost savings for VDOT of $1.3 million by the end of FY05. Data collected at 15 sites in Richmond and Charlottesville helped determine the accuracy of three post-processing techniques (methods for estimating vehicle speeds once long-range planning models have forecast future traffic volumes). On average, the mean absolute errors for the post processors were relatively similar and can be reduced to 5 mph by judiciously adjusting some of the assumptions in the model.

- *We demonstrated the viability of using shredded tires in constructing embankments.* Approximately 1.7 million discarded tires were placed in an embankment constructed in the Williamsburg area. The site was monitored for more than 10 years. The results indicate that this application is a viable option for disposing of discarded tires in an environmentally responsible way.

- *We put 19 pre-2001 volumes of our Historic Roads of Virginia Series into an electronic format. These publications, some dating back to the 1970s, are now on our website and will be available in CD format soon.* The volumes include the road orders (18th century Virginia records pertaining to transportation) and our published road histories, which are highly regarded resources in constant demand by historical and cultural resource researchers. As some of these volumes are lengthy (several exceed 300 pages), their electronic availability will save VDOT the cost of reprinting and binding literally tens of thousands of pages each year.

- *Responding to the increased state activity on the environmental impacts of highway runoff on underground sources of drinking water and habitats of sensitive aquatic species, we summarized regulations and available literature concerning karst areas.* In the event that new requirements regarding highway runoff are enacted that would affect VDOT's construction and maintenance

activities in karst areas (characterized by caves and sinkholes), this report summarizes the research findings and regulations VDOT will need to determine its position on these issues. Findings suggest that highways are not major contributors of non-point source pollution of karst aquifers compared to other land uses, and the literature does not currently support the need for more stringent regulatory controls than those already in place.

- *At the national Workshop on the Preservation and Management of Historic Bridges, held in Washington, D.C., in December 2003, Virginia's Historic Bridge Management Plan was cited as one of the two best historic bridge management plans in the United States.* The principal investigator for this plan is on our staff. This workshop was funded by the FHWA's Office of Project Development and Environmental Review and was organized by the FHWA, AASHTO, the National Trust for Historic Preservation, the Historic American Engineering Record (National Park Service), and the SRI Foundation.

IMPROVING PLANNING & FINANCIAL & ADMINISTRATIVE MANAGEMENT

- *In October 2003, the Project Cost Estimation System (PCES) we developed in FY03 became a fully operational Intranet-based system for VDOT.* The PCES can help VDOT planners develop project costs that are reliable, credible, and realistic. The PCES is composed of three elements: a cost estimation tool, an improved scoping process, and a project development website. Responsibility for maintaining and modifying the PCES was turned over to VDOT's Scheduling & Contract Development Division. We continue to provide support on an as-needed basis.

- *We conducted an extensive analysis of VDOT's Cash Flow Model to resolve discrepancies between forecast and actual monthly payouts.* We are also refining data elements that will be used to update the factors that comprise the model's monthly factors component. These efforts will allow VDOT to project its monthly cash flows more accurately, thus leading to improved financial management.

- *As part of several technical assistance efforts for the Commissioner's Staff, we reviewed and explained economic approaches for assessing proposals under the Public-Private Transportation Act and the potential impacts of some PPTA projects under consideration on the state's economy.* The more fully and carefully PPTA proposals can be evaluated, the better the decisions will be regarding their acceptance. These proposals are highly complex, so the insights of our economics staff can be very useful to those in VDOT who review them.

- *We continue to work with VDOT's central office and field staff to develop an approach for measuring the number of hours VDOT staff spend in several development review activities for localities.* This information has never been available to VDOT. As part of this initiative, we conducted a number of meetings with staff in all nine VDOT districts. The result of this effort will allow VDOT to measure the true costs of providing their land development review service.

- *Our investigation of options for improving the coordination of transportation and land use planning documented legislative and technical assistance practices VDOT staff could use to assist localities with quantifying transportation impacts of different land development strategies.* Requested by the 2003 Virginia General Assembly, the resulting report identified steps VDOT could take to meet particular policy goals selected by the General Assembly or the locale. VDOT is now actively pursuing one of the practices on a pilot basis: helping counties quantify the transportation impacts of proposed land development alternatives. A second product of the

report—a description of alternative sources of transportation funding—was distributed to various planning district commission staff and VDOT district planners and was well received.

- *Through a series of contracts with the University of Virginia's Center for Risk Management of Engineering Systems, we are assisting VDOT with its ongoing efforts to protect critical transportation infrastructure from willful threats.* The objective of this effort is to develop methodologies for risk analyses of critical highway infrastructure at the system and asset levels. In FY04, the second phase, Risk Assessment and Management of Critical Highway Infrastructure, was concluded. The project evaluated and prioritized elements of the infrastructure using a sizeable inventory of assets. Eight detailed case studies of selected VDOT sites were conducted, and a prototype computer tool for use by VDOT security analysts was developed.

- *We are continuing to assist VDOT's Transportation & Mobility Planning Division and the Office of Virginia's Secretary of Transportation in the development of VTRANS 2025: Virginia's Statewide Multimodal Long-Range Transportation Plan.* The development of the VTRANS 2025 plan complies with the requirements of House Bill 771, passed by the 2002 Virginia General Assembly. In conjunction with the University of Virginia's Center for Risk Management of Engineering Systems, we are playing a key role in data collection and analysis for the plan, methodologies for project prioritization, and the analysis of multimodal investment networks. The work is ongoing.

TRANSFERRING TECHNOLOGY

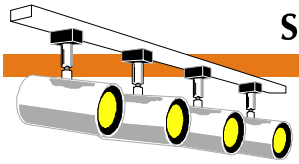
- *As part of its reorganization within the newly created Knowledge Management Office, the Virginia Transportation Technology Transfer Center was moved to a new location.* As a result, the center now has the latest in videoconferencing and smart board technology in its conference and training rooms.

- *Our workshops and conferences included 23 workshops with 574 attendees (a 30% increase over FY03) throughout the Commonwealth.* Highlights included the 26th Annual Public Works Cities and Towns Conference and workshops on topics such as Work Zone Traffic Control for Local Governments, Effective Technical Writing, Patching Techniques and Surface Treatments, Tort Liability, Urban Drainage Design, Winter Maintenance, Site Impact Analysis, Construction Mathematics, Introduction to GIS, and Database Management.

- *We distributed 447 publications, 142 videotapes, and 5,088 newsletters using standard mailing procedures. In addition, we used email to distribute our quarterly newsletter and workshop brochures to more than 2,200 VDOT personnel and 400 city, town, and county transportation professionals in Virginia.*

- *We continue to maintain the most comprehensive mailing list of transportation-related professionals and agencies in the Commonwealth.* The list currently contains more than 3,800 contacts covering federal, state, and local transportation agencies.

- *We are developing a relationship among VDOT's Maintenance Training Academy, the Virginia T² Center, and Tidewater's Public Works Academy.* Promising progress has been made, and it looks as if this will be a major accomplishment for us next year.



SPOTLIGHT ON FOUR NEW INITIATIVES

OUR "FIRST PLACE STRATEGY FOR RESEARCH" INITIATIVE

As part of the charge to his staff for the new year, VDOT Commissioner Shucet asked the Chief of Technology, Research, and Innovation to develop a "First Place Strategy for Research." The strategy was to be based on the quality of Virginia's contribution to research on a national level. As Commissioner Shucet elaborated: "The first place strategy is not about direct competition; it is about the best use of public resources."

To build upon the foundation of excellence developed during our first 50 years, the First Place Strategy for Research will comprise a series of definitive actions to take VTRC to increased levels of service to VDOT and the citizens of the Commonwealth through research, technology, innovation, knowledge deployment, and research implementation. These actions will also enhance the knowledge level of transportation innovation for the nation and the international transportation community.

In late spring, we defined our First Place Strategy as "a diverse and dynamic business plan to achieve our vision of being the best in class among transportation agency research organizations." Our mission in this initiative is "to assist and support VDOT through applied research, innovation, and technical assistance in providing the Commonwealth of Virginia a safe, effective, and efficient transportation system."

Key steps in our journey to develop our First Place Strategy for Research include:

- Review and summarize current and future research needs and trends for VDOT and their relationship to national agendas.
- Ask selected national transportation leaders to participate in a peer exchange effort to evaluate our research program.
- Assess our strengths and weaknesses.
- Identify major state research organizations and the niches they dominate as compared to VTRC, thus defining opportunities for our growth.

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- Identify, rank, and adopt parameters and goals by which achievement of a First Place Strategy will be measured in quantifiable outcomes.
- Establish procedures to update goals annually.
- Develop a Business Practices Improvement Program.
- Evaluate our financial, human, and physical plant resources.
- Raise our professional profile.

We will present the draft business plan to our staff and VDOT management for their review and feedback in early October and the final plan to Commissioner Shucet soon thereafter.

OUR KNOWLEDGE MANAGEMENT OFFICE

In 2003, we created the Knowledge Management Office to support VDOT in identifying, organizing, and disseminating the right knowledge to the right people at the right time. Sharing knowledge will save time, support efficiency, and ensure consistency within VDOT. Specifically, the office:

- identifies and captures critical business knowledge
- develops and provides tools and techniques to support knowledge creation, identification, and sharing across VDOT
- facilitates learning from the past and from each other
- develops and shares best practices in project management and critical business processes.

The office also encompasses the Virginia Transportation Technology Transfer Center established in 1986, which administers Virginia's branch of the FHWA's Local Technical Assistance Program. As a component of VTRC, the Knowledge Management Office is committed to supporting research implementation and communication of current research projects in its interactions with VDOT's districts and divisions.

Specifically, the Knowledge Management Office assists VDOT's districts and divisions in identifying, prioritizing, and capturing critical business knowledge; supports the capture and dissemination of lessons learned; facilitates communities of practice; and provides tools and techniques for managing knowledge. This information will reside on the new VDOT intranet, InsideVDOT. In addition, the director serves on advisory committees for the VDOT intranet and for VDOT's Learning Center.

In January 2004, a community of practice for VDOT managers of major projects was formed to facilitate the capture of lessons learned to disseminate to all project managers in VDOT. This group meets quarterly to share knowledge concerning such projects as the Springfield Interchange, the Woodrow Wilson Bridge, Route 288, the I-81 Corridor, the Coliseum Project in Hampton Roads, and the Coalfields Expressway.

A pilot project launched in the Staunton District in January maps tacit knowledge networks and captures unique knowledge from functional experts in critical knowledge areas. District staff identified their critical knowledge areas and prioritized them with regard to future plans and knowledge risk level, such as expected retirements and single-person departments. Knowledge management staff are interviewing identified experts in the knowledge areas to determine their areas of expertise and their knowledge networks. The second phase will allow us to map the networks across VDOT and to identify possible knowledge gaps within VDOT by determining what knowledge we consistently go outside VDOT to find.

In another initiative, the office sponsored a research project conducted by the American Productivity and Quality Center in Houston to study the transfer of best practices within an organization. The study offers recommendations about how to transfer best practices between employees who have a history of working together and between those who do not normally interact. The report can be obtained from APQC without charge to VDOT employees.

Future plans include hiring three project managers to be project leads for organizing and facilitating communities of practice and collecting lessons learned.

OUR ONLINE LIBRARY INITIATIVE

The VTRC Library made advancements in FY04 as the long-awaited retrospective conversion from manual to computerized systems began as the first of many innovations for the library. The innovations involved new technology, facility and policy changes, and an emphasis on national networking and collaboration—all designed to advance an ambitious new vision for the library as an important part of our First Place Strategy for Research.

The prime objective for FY04 was to implement modern library automation systems. Planned in FY03 and articulated by the Library Advisory Committee in FY00, the conversion had several components. Collectively, they comprised a "retrospective conversion" from the manual systems use to acquire, organize, and circulate holdings, which had been used since the library was founded in 1950.

The plan for the conversion included cataloging 14,000 items in the library's collection using records retrieved by OCLC Online Computer Library Center, a nonprofit organization that provides computer-based library services to more than 50,000 libraries around the world; switching classification scheme and call number systems from the Bureau of Public Roads to the Library of Congress; creating a web-searchable online catalog of holdings; and creating a library barcoding/circulation/tracking/statistics package.

The actual conversion began in May 2003. Work to install the system's server, to customize software, and to map the new record structure for the library's databases progressed until January 2004, when it was time to begin the physical part of the conversion. This involved a 75-day effort to locate books, apply barcodes and new call numbers, and reshelve all items in their new locations. At the close of FY04, rather than the 14,000 items anticipated, the library had more than 25,000 volumes in circulation, representing more than 18,000 item records in OCLC, making it the fourth largest DOT library in OCLC. With its circulation, tracking, and statistics packages now fully operational, the library staff has commenced work on 200 additional boxes of research materials still in storage. An early version of the library's online catalog can be found at: http://rclibrary/dbtw-wpd/textbase/catalog1/basic.htm.

As a result of the retrospective conversion, our library was selected to participate in the Transportation Libraries Catalog, or TLCat, an online resource that provides one-stop searching of the holdings of 20 key transportation libraries in the United States. TLCat represents a major new level of collaboration among transportation libraries, and our library was selected as a charter member of this group. Promotion of TLCat has progressed well and included a demonstration for the Commissioner's Staff at the March 2004 meeting with FHWA officials. Statistics for the first few months show that our TLCat account has the second highest in-house usage of all 20 participating institutions.

TLCat can be used online at http://ntl.bts.gov/link.cfm.

OUR ENHANCED PAVEMENT, STRUCTURES & ROADSIDE ASSETS RESEARCH PROGRAM

In the summer of 2003, Commissioner Shucet awarded $1 million to VTRC to enhance our research efforts in structures, pavements, and all other roadside assets. This award was the result of his thinking that VTRC was underfunded in these areas given the percentage of VDOT's total operating budget devoted to these areas.

After the award was made, a managing board for the program was formed: the division administrators of VDOT's structure & bridge, materials, and asset management divisions and the associate directors of VTRC's materials team and structures, pavements & asset management team comprised the membership. Then, we held discussions with our research advisory committee members and field personnel in the particular technical areas to develop a list of proposed projects. The managing board then prioritized the proposed projects. The following projects were selected for the program:

Cost-Effective Plans and Designs

- Expanded Application of VDOT's Special Provision for Rideability
- Stabilization of Soft Clay Subgrades in Virginia: Phase I Laboratory Study
- Punching Shear Capacity of Thin Ultra–High Performance Concrete Plates
- Evaluation of the Strength of Cement Treated Aggregate for Pavement Bases
- Performance Specifications for Embankment Construction

Plans and Designs That Speed Construction, Mitigate Traffic Congestion, and Improve Traffic Flow

- Detail and System Development for Full-Depth Precast Concrete Bridge Deck Panels

Roadways That Yield Minimal Defects

- Development of Nondestructive Methods for Measurements of Slab Thickness and Modulus of Rupture in Concrete Pavements
- Development of Premium Pavement Design
- Development of Permeable Asphalt Mixtures for Use in Pavement Subsurface Drainage Systems
- Development and Installation of a Durable Fiber-Optic Strain Sensor for Instrumentation of New Pavements
- Development and Validation of a Testing Procedure to Estimate In-Situ Properties of Hot-Mix Asphalt

Acceptable Condition of Roadway Shoulders

- Investigation of the Type and Frequency of Shoulder Maintenance Problems Encountered on the VDOT-Maintained System

Cost-Effective and Efficient Maintenance and Operations

- Determination of Remaining Service Life of Aluminum Sign Panels
- Integrated Inspection and Light Servicing System for High-Mast Light Poles
- Evaluation of Stabilizers for Unpaved Roads

COMPLETED PROJECTS

REDUCING CRASH RISK & SAVING LIVES

Project No. 57323: Safety Impacts of Differential Speed Limits on Rural Interstate Highways

Principal Investigators: Nicholas J. Garber, John S. Miller, Xin Sun, and Bo Yuan

In this project, the safety effects of a uniform speed limit (USL) and a differential speed limit (DSL) for cars and heavy trucks were compared for rural interstate highways in 17 states for the period 1991 through 2000. Data from 9 of the states were used such that they could be divided into four policy groups based on the type of speed limit employed during the study period: maintenance of a USL only, maintenance of a DSL only, a change from a USL to a DSL, and a change from a DSL to a USL. Neither the USL nor the DSL had a greater effect on safety than the other. Mean speed, 85th percentile speed, median speed, and crash rates tended to increase over the 10-year period for both systems. Further examination suggested that although the data did not show a distinction between the effects of DSL and USL on safety, the relationship between crashes and traffic volume cannot be generalized but instead varies by site within a single state.

Project No. 60703: Estimation of the Demand for Commercial Truck Parking on Interstate Highways in Virginia

Principal Investigators: Nicholas J. Garber and Hua Wang

This project developed and applied a methodology for estimating the demand for commercial truck parking on Virginia's interstate highways in 2010 and 2020 and the additional parking spaces that will be required to meet the increase in demand. The results indicate that significant shortfalls in parking spaces for commercial trucks exist along I-81 and I-95 and the situation will worsen by 2010 and 2020. Although the shortfall along other interstates is not so severe, the results also suggest that there will be major shortfalls in 2010 and 2020 along these highways as well.

Related Publication: VTRC 04-R10: Garber, N.J., and Wang, H. *Estimation of the Demand for Commercial Truck Parking on Interstate Highways in Virginia*

Project No. 62564: Urban Safety Restraint Use by Infants and Children Under 16 Years of Age in Virginia: The 2002 Survey Results

Principal Investigators: Cheryl W. Lynn and Jami L. Fisher

A total of 2,823 children were observed during the 2002 survey—594 under age 4 and 2,229 aged 4 through 15. In 2002, total child restraint use for metropolitan areas and mid-size cities combined was 93.2% and correct use was 70.8%. Total seat belt use among children aged 4 through 15 years in metropolitan areas and mid-size cities combined was 65.6%, and correct use was 55.4%. Although the sites used in the survey are not selected at random and the survey results cannot be used as estimates of statewide infant and child restraint use, the results can provide a snapshot of restraint use in the metropolitan areas and mid-size cities surveyed.

Related Publication: VTRC 04-R1: Lynn, C.W., and Fisher, J.L. *Urban Safety Restraint Use by Infants and Children Under 16 Years of Age in Virginia: The 2002 Survey Results*

Project No. 63829: Use of Police in Work Zones on Highways in Virginia

Principal Investigator: E.D. Arnold, Jr.

This project documented current practices regarding the use of police in work zones in Virginia and determined if any enhancements could be made. The research effort consisted of literature reviews to establish the background for police enforcement in work zones, discussion with and input from VDOT and Virginia State Police (VSP) personnel, and the administration of a questionnaire survey to personnel in VDOT, VSP, and VMS, Inc., concerning the effectiveness of using police in work zones and the work zone enforcement practices being used. The use of police in work zones was almost unanimously felt to be effective in reducing speeds and improving safety, and few adverse effects were noted. Recommendations were made regarding the development and implementation of training in basic work zone operations, the development of a standard agreement for possible use with local police agencies, the use of more than one police officer, the promotion of the maximum $500 fine for speeding in work zones, the requirement that police officers wear safety vests when outside their vehicle in a work zone, and the development of a standard pay practice for cancellations.

Related Publication: VTRC 04-R9: Arnold, E.D., Jr. *Use of Police in Work Zones on Highways in Virginia*

Project No. 65278: Governor's Task Force to Combat Impaired Driving

Principal Investigator: Cheryl W. Lynn

As part of VTRC's ongoing work for the Governor's Task Force to Combat Driving Under the Influence of Drugs and Alcohol, VTRC staff prepared a literature review and "talking points" for the patrons of legislation designed to impose "enhanced penalties" on drivers convicted of DUI who have long-term drinking problems and who do not respond to the usual first and second offense penalties. Previously, enhanced sanctions were imposed if the offender's blood alcohol concentration was 0.20% or higher. The legislation passed in the 2004 Session of Virginia's General Assembly lowered the threshold for enhanced penalties to 0.15% BAC. In addition, based on an evaluation of the motor vehicle and boating drinking and driving laws, the 2004 session made changes to bring all DUI laws into compliance.

Project No. 67981: Safety Belt and Motorcycle Helmet Use in Virginia: The Summer 2003 Update

Principal Investigators: Cheryl W. Lynn and Jami L. Kennedy

In the summer 2003 survey, Virginia's 2003 safety belt use rate was 74.6% and its motorcycle helmet use rate was 98.7%. For passenger car drivers and right-front passengers in the 11 previous surveys, use rates varied from 67.1% in 1997 to 73.6% in 1998. The summer 2003 safety belt use rate of 74.6% is the highest rate since Virginia began using the NHTSA methodology.

Related Publication: VTRC 04-R8: Lynn, C.W., and Kennedy, J.L. *Safety Belt and Motorcycle Helmet Use in Virginia: The Summer 2003 Update*

Project No. 68576: Alternatives for Identifying Shoulders

Principal Investigator: Benjamin H. Cottrell, Jr.

To assist VDOT's Mobility Management Division in their study of Virginia's Shoulder Rumble Strip Program, as mandated by the General Assembly, VTRC led the effort to identify and assess means of identifying shoulders other than the use of rumble strips. Several alternatives were identified: wide edgelines, profiled tape, a chevron marking pattern, a pavement marking line applied to a continuous shoulder rumble strip, an internally illuminated marking, and raised pavement markers. Their estimated costs, service life, and life cycle cost were examined. VDOT is currently examining the use of 6-inch edgelines on the interstate and developing performance specifications for pavement markings. It is recommended that field staff be allowed the flexibility of maintaining edgelines and markings.

Project No. 71028: Safety Belt and Motorcycle Helmet Use in Virginia: The December 2003 Update

Principal Investigators: Jami L. Kennedy and Cheryl W. Lynn

Virginia's December 2003 Safety Belt and Motorcycle Helmet Use Survey marks the second consecutive year that both winter and summer surveys were conducted. The winter survey was initiated in December 2002 solely to evaluate the effectiveness of programmatic efforts aimed at increasing seat belt use carried out in the fall. The survey found that in December 2003, Virginia's safety belt use rate was 73.1% and its motorcycle helmet use rate was 100.0%. Over the past 11 years, safety belt use rates for drivers and right-front passengers aged 16 years and older have varied from a low of 67.1% in 1997 to a high of 74.6% in summer 2003. The December 2003 use rate of 73.1% represents a slight decrease from the summer use rate and an increase from the December 2002 use rate of 71.1%.

Related Publication: VTRC 04-R15: Kennedy, J.L., and Lynn, C.W. *Safety Belt and Motorcycle Helmet Use in Virginia: The December 2003 Update*

Project No. 71063: Urban Safety Restraint Use by Infants and Children Under 16 Years of Age in Virginia: The 2003 Survey Results

Principal Investigators: Cheryl W. Lynn and Jami L. Kennedy

A total of 2,452 children were observed during the 2003 survey: 353 children under age 4 and 2,099 children aged 4 through 15. In 2003, total child restraint use for metropolitan areas and mid-size cities combined was 91.1% and correct use was 89.3%. Total seat belt use among children aged 4 through 15 years in metropolitan areas and mid-size cities combined was 65.1%, and correct use was 53.5%. Although the sites used in the survey are not selected at random and the survey results cannot be used as estimates of statewide infant and child restraint use, the results can provide a snapshot of restraint use in the metropolitan areas and mid-size cities surveyed.

Related Publication: VTRC 04-R23: Lynn, C.W., and Kennedy, J.L. *Urban Safety Restraint Use by Infants and Children Under 16 Years of Age in Virginia: The 2003 Survey Results*

MANAGING ASSETS WISELY

Project No. 21561: Evaluation of the In-Service Performance of the Tom's Creek Bridge Fiber-Reinforced Polymer Superstructure

Principal Investigators: W.D. Neely, T.E. Cousins, S.P. Phifer, J.L. Senne, S.W. Case, and J.J. Lesko

This project evaluated the use of fiber-reinforced polymer (FRP) composite girders as main load-carrying members in a bridge structure. Such girders show great promise because of their high strength-to-weight ratio. The Tom's Creek Bridge is a small-scale demonstration project in Blacksburg. As a result of discussions among Virginia Tech, Strongwell, VDOT, and the Town of Blacksburg, the deteriorated superstructure of the bridge was replaced with a glue-laminated timber deck on 8-inch-deep pultruded FRP beams. The project addressed two issues. First, by calculating bridge design parameters such as the dynamic load allowance, transverse wheel load distribution, and deflections under service loading, the project will aid in modifying current AASHTO bridge design standards for use with FRP composite materials. Second, by evaluating the girders after they are exposed to controlled laboratory and service conditions, the project has begun to answer questions about the long-term performance of such beams when used in bridge design.

Related Publication: VTRC 04-CR5: Neely, W.D, Cousins, T.E., Phifer, S.P., Senne, J.L., Case, S.W., and Lesko, J.J. *Evaluation of the In-Service Performance of the Tom's Creek Bridge Fiber-Reinforced Polymer Superstructure*

Project No. 21694: Evaluating a Bridge Deck Anti-Icing System in Virginia

Principal Investigator: Daniel S. Roosevelt

The need for this project originated with VDOT's plans to widen and replace a number of bridges along Route I-95. Many of the bridge decks in the new facilities will be in the shade, which will increase the probability that maintenance crews will have to respond to icy conditions. Various anti-icing technologies have shown promise, but most still require personnel to travel to the site of icing problems to treat them. Fixed automatic spray technology (FAST) is an exception. FAST is the application of a liquid chemical freezing-point depressant using an in-place, mechanical, spray system. The report recommends that VDOT consider FAST an option for initial delivery of deicing chemicals to road and bridge travel lanes and develop criteria for prioritizing FAST installations that consider savings for reduced accidents and congestion. Recommendations are also made for nozzle and surface sensor design and location based on lessons learned from the pilot project.

Related Publication: VTRC 04-R26: Roosevelt, D.S. *A Bridge Deck Anti-Icing System in Virginia: Lessons Learned From a Pilot Study*

Project No. 60476: Risk-Based Asset Management Methodology for Highway Infrastructure Systems

Principal Investigators: R.Y. Dicdican, Y.Y. Haimes, and J.H. Lambert

This study developed a method to help VDOT manage the maintenance of Virginia's roads and highways. Specifically, a systemic risk-benefit-cost modeling and analysis methodology was developed and tested on available VDOT data. The project made use of existing and evolving databases (PMP, Pontis, and ICAS) so that VDOT employees can make better maintenance management decisions from existing sources of information. The work developed a process that considers all assets in a risk-cost-benefit methodology and requires data about assets that are not now available and developed a prototype tool that requires additional research and development before it can be employed as a working model.

Related Publication: VTRC 04-CR11: Dicdican, R.Y., Haimes, Y.Y., and Lambert, J.H. *Risk-Based Asset Management Methodology for Highway Infrastructure Systems*

Project No. 61139: Appliqués for the Maintenance of Lead-Based Painted Bridges: A Laboratory Assessment of Field-Performance Characteristics

Principal Investigators: S. Ray Taylor, Christopher R. Standridge, and Michael M. Sprinkel

Approximately 3,500 bridges having steel superstructures in Virginia are coated with lead-based paints. Many of these bridges are in need of paint maintenance. This study evaluated appliqué technology, an alternative to the conventional paradigm of bridge paint maintenance in which the lead-based paint is removed and the structure repainted. The results indicate that the barrier properties, self-cleaning characteristics, chemical stability, and thermal stability of the 3M 5004 Paint Replacement System are superior to those of conventional industrial maintenance paints. In addition, its use as a method to refurbish lead-based painted bridge structures would reduce the quantity of lead introduced into the environment and lead exposure to workers. The cost of the system in pre-production is approximately $10.41 per square foot. Recent costs to remove lead-based paint and repaint typical bridges are approximately $8 per square foot. As a consequence, the project was terminated before the proposed work was completed. The report provides test results that should be useful if the appliqué were to become economical.

Related Publication: VTRC 05-R4: Taylor, S.R., Standridge, C.R., and Sprinkel, M.M. *Appliqués for the Maintenance of Lead-Based Painted Bridges: A Laboratory Assessment of Field-Performance Characteristics*

Project No. 64363: Modernizing Bridge Safety Inspections with Process Improvement and Digital Assistance

Principal Investigators: Thomas H. Mills III and Ronald R. Wakefield

This project recorded and analyzed VDOT's bridge/structure inspection processes as an aid to modernizing and automating them through the use of mobile PC devices such as Palm/PPCs and other wearable computing devices. The research was conducted using an informal conversational interview process coupled with direct observations to match the perceived processes with actual processes. Workflows were mapped and analyzed for operational bottlenecks and process improvement opportunities. The results of the mappings and a comprehensive literature review were used to analyze the existing work processes. New process transformation maps were created and overlaid on current mappings to complete a transformation model. Redundancies were observed in the reporting function, and bottlenecks were identified in the inspection management and inspection functions. The inspection process can be readily transformed from one that relies on personnel marking up paper reports in the field and then returning to the office for semi-manual reporting to one that is electronically assisted in data capture, automated bridge inventory updates, and semi-automated report production. From this analysis, a series of strategies and recommendations were made to assist VDOT in modernizing and transforming their bridge inspection processes to more efficient digitally assisted processes.

Related Publication: VTRC 04-CR: Mills, T.H., and Wakefield, R.R. *Modernizing Bridge Safety Inspection with Process Improvement and Digital Assistance*

Project No. 64452: Stabilization Techniques for Unpaved Roads

Principal Investigators: William H. Bushman, Thomas E. Freeman, and Edward J. Hoppe

This project was designed to evaluate promising soil stabilization products using the relatively new technique of deeply mixing chemical additives into unpaved roadbeds as an alternative to paving low-volume secondary roads. A 1.75-mile-long trial installation was constructed on Old Wheatland Road in Loudoun County, wherein seven commercially available stabilization products were applied to the unpaved road. Results thus far indicate that the introduction of soil stabilizers through deep mixing is promising. The life cycle cost analysis indicates that constructing a standard bituminous surface-treated roadway and maintaining it as such is much more cost-effective than using any of the products in this trial. Further, the analysis indicates the bituminous surface treatment alternative is also much more cost-effective than maintaining an unpaved road.

Related Publication: VTRC 04-R18: Bushman, W.E., Freeman, T.E., and Hoppe, E.J. *Stabilization Techniques for Unpaved Roads*

Project Nos. 64844 and 60711: Risk Assessment and Management of Critical Highway Infrastructure

Principal Investigators: Y.Y. Haimes, and J.H. Lambert

The objective of this effort was to develop methodologies for risk analyses of critical highway infrastructure at both the system and asset levels. The project evaluated and prioritized elements of the infrastructure using a sizeable inventory of assets. Eight detailed case studies of selected VDOT sites were conducted and a prototype computer tool for use by VDOT security analysts was developed.

Related Publications: VTRC 04-CR15: Haimes, Y.Y., Lambert, J.H., Horowitz, B.M., Kaplan, S., Pikus, I.M., Leung, M.F., and Mosenthal, A.D. *Risk Assessment and Management of Critical Highway Infrastructure*; VTRC 04-CR16: Haimes, Y.Y., Lambert, J.H., Horowitz, B.M., Kaplan, S., Pikus, I.M., Leung, M.F., and Mosenthal, A.D. *Risk Assessment and Management of Critical Highway Infrastructure: Executive Summary*

Project No. 70793: Structural Load Testing and Flexure Analysis of the Route 701 Bridge in Louisa County, Virginia

Principal Investigators: H. Jeremy Lucas, Thomas E. Cousins, Michael C. Brown, Stephen R. Sharp, and D. Stephen Lane

This study determined if the current load rating of the continuous slab bridge on Route 701 over the Little River in Louisa County could be raised. The bridge had developed a planar horizontal crack along the length of all three spans. The structure appeared to perform well under load testing. However, the significant cracking of the slab compromised its structural integrity and durability. The structure should be reevaluated after 1 to 2 years of additional service to determine whether cracks continue to propagate because of loading or continued material distress related to the observed alkali-silica reaction.

Related Publication: VTRC 04-R12: Lucas, H.J., Cousins, T.E., Brown, M.C., Sharp, S.R., and Lane, D.S. *Structural Load Testing and Flexure Analysis of the Route 701 Bridge in Louisa County, Virginia*

Project No. 1121002: Forensic Investigation of Pavement Distress: Old Airport Road in Bristol, Virginia

Principal Investigator: Thomas E. Freeman

A few years after Old Airport Road in Bristol, Virginia, was reconstructed, inordinate distortions of remarkable uniformity began to appear in the paved asphalt surface directly above concrete pipe culverts, which were buried beneath and across the road to transport storm runoff. The portion of the road afflicted by the distress is five lanes wide and extends approximately 0.80 mile in length. This forensic investigation, which included visual and video surveys of pavements and culverts, a geotechnical examination of subgrade conditions, a non-destructive pavement deflection analysis, laboratory and microscopic analyses of culvert trench backfill material, and review of a pertinent geotechnical exploration conducted by others, was designed to determine if the distress was the result of (1) settlement between culverts, or (2) heaving of the trenches themselves. The cause of the distortions was expansive heave of the black pyritic shale used to backfill transverse culvert trenches. In addition, significant structural damage to culvert pipes resulting from excessive heave expansion pressures was documented. The laboratory analysis of shale backfill samples indicated that heave, which results from the oxidation of pyrite and the formation of new minerals, is ongoing. Recommendations for remedial action include removing all shale trench backfill in distorted zones, replacing damaged pipes, and properly backfilling with a flowable fill or a suitable, compactable non-shale granular material.

Related Publication: VTRC 04-R6: Freeman, T.E. *Forensic Investigation of Pavement Distress: Old Airport Road in Bristol, Virginia*

IMPROVING MATERIALS, DESIGN & CONSTRUCTION

Project No. 21706: Creep of High-Strength Normal and Lightweight Concrete

Principal Investigators: E.C. Vincent, B.D. Townsend, and R.E. Weyers

This project evaluated the creep and shrinkage of specimens prepared with high-strength normal and high-strength lightweight concrete (LTHSC) with identical materials and similar mixture proportions as those used in the casting of the beams for the Pinner's Point Bridge. The measured creep and shrinkage strains were compared to several prediction models to determine which model was the most accurate. The ACI 209 model modified by Huo was the most accurate in predicting time-dependent strains for the normal mixture. The best overall predictor of LTHSC time-dependent deformations was the GL 2000 model for the standard-cure LTHSC specimens, and the ACI 209 model was the best predictor of the total stains and individual time-dependent deformations for the matched-cure LTHSC mixture. Bridge designers can optimize the design of beams by using the most accurate model and thereby reduce the life cycle cost of

the beam. VDOT spends $50 million per year on precast/prestressed concrete for bridges. The use of optimum beam designs should reduce costs by at least 5% and thereby save VDOT at least $2.5 million per year.

Related Publication: VTRC 04-CR8: Vincent, E.C., Townsend, B.D., and Weyers, R.E. *Creep of High-Strength Normal and Lightweight Concrete*

Project No. 21706: Development of Concrete Shrinkage Performance Specifications

Principal Investigators: David W. Mokarem, R.M. Meyerson, and R.E. Weyers

This project examined the shrinkage of VDOT-approved concrete mixtures. The goal was to develop a concrete shrinkage performance specification and an associated test procedure to measure and place limits on the amount of drying shrinkage in concrete mixtures purchased by VDOT. Based on the results of the study, the limits on the percentage length change should be 0.0300 at 28 days and 0.0400 at 90 days for portland cement concrete mixtures and 0.0400 at 28 days and 0.0500 at 90 days for supplemental cementitious material mixtures. These limits will aid in reducing the probability of cracking due to drying shrinkage, which could lead to increased service life. This would reduce the costs of maintenance, repair, and rehabilitation of concrete structures, and the cost savings to VDOT could be around $12 million per year.

Related Publication: VTRC 04-CR1: Mokarem, D.W., Meyerson, R.M., and Weyers, R.E. *Development of Concrete Shrinkage Performance Specifications*

Project No. 21724 (ongoing): Composite Action in a Steel Girder Span with Precast Deck Panels: The I-81 Bridge Over the New River in Radford, Virginia

Principal Investigators: Michael C. Brown, Jose P. Gomez, T.E. Cousins, and Furman W. Barton

This project comprised a study of the 10-span structure that carries the northbound lane of I-81 over the New River in Radford. In recent years, a number of maintenance issues have been reported, primarily related to cracking of the cast-in-place topping over partial-depth precast deck panels. The influence of the observed deterioration on the structural capacity of the affected bridge spans was investigated, and the analysis indicates that the full potential of the composite slab-girder system is no longer being realized. As a potential mitigation option, replacement of the fiber bolster material between the top flange of the girders and the precast panels with more rigid steel shims and/or concrete is recommended to increase the bearing surface of the panels, reduce vertical displacement of panel edges, and minimize dynamic impact at the joints.

Related Publication: VTRC 04-R4: Brown, M.C., Gomez, J.P., Cousins, T.E., and Barton, F.W. *Composite Action in a Steel Girder Span with Precast Deck Panels: The I-81 Bridge Over the New River in Radford, Virginia*

Project No. 21727: A Traffic Data Plan for Mechanistic-Empirical Pavement Designs (2002 Pavement Design Guide)

Principal Investigators: Benjamin H. Cottrell, Jr., T.O. Schinkel, and Trenton M. Clark

This project developed a traffic data plan for VDOT's new *Pavement Design Guide.* Traffic data comprise an important element for mechanistic-empirical pavement designs. The proposed traffic data program for pavement design takes advantage of the flexibility permitted in the Traffic Monitoring Guide and the availability of weigh-in-motion data from the Department of Motor Vehicles to keep program costs at a minimum. A traffic data plan and a phased approach to implement the plan were proposed. Implementing the program would save VDOT an estimated $50,000 to $250,000 annually over the first 5 years.

Related Publication: VTRC 04-R3: Cottrell, B.H., Jr., Schinkel, T.O., and Clark, T.M. *A Traffic Data Plan for Mechanistic-Empirical Pavement Designs (2002 Pavement Design Guide)*

Project No. 50199: Field Study of a Shredded-Tire Embankment in Virginia

Principal Investigators: Edward J. Hoppe and W. Gregg Mullen

In response to increased environmental concerns, this project investigated the feasibility of using shredded tires for constructing highway embankments. Approximately 1.7 million discarded tires were used on the project constructed near Williamsburg in the summer of 1993, the only shredded-tire highway embankment in Virginia to date. During the 10-year monitoring period, the shredded-tire embankment performed satisfactorily based on environmental and engineering assessments. The researchers recommended that the use of shredded-tire embankments be considered a viable option for disposing of discarded tires in an environmentally responsible way.

Related Publication: VTRC 04-R20: Hoppe, E.J., and Mullen, W.G. *Field Study of a Shredded-Tire Embankment in Virginia*

Project 50808: Petrographic Methods of Examining Hardened Concrete

Principal Investigator: D. Stephen Lane

This project comprised a revision of *Petrographic Methods of Examining Hardened Concrete: A Petrographic Manual.* This manual provides a comprehensive discussion of equipment and techniques that have been found useful in performing petrographic examinations of hardened concrete and its constituent materials. It includes a restructured chapter on alkali-aggregate reactions, a new chapter on the use of the application of the scanning electron microscope and associated equipment to concrete petrography and greatly expanded appendix on aggregates. The references and reading list are updated. The manual is now in an electronic format for posting as a web-based publication and can easily be updated when new information is available.

Project No. 53201: Corrosion Protection Service Life of Epoxy-Coated Reinforcing Steel in Virginia Bridge Decks

Principal Investigators: Michael C. Brown and Richard E. Weyers

This project assessed the corrosion protection service life extension provided by epoxy-coated reinforcement (ECR) as determined by comparing ECR and bare steel bars in concrete cores from 10 Virginia bridge decks built between 1981 and 1995. Laboratory nondestructive monitoring during exposure to chloride-rich solution occurred over 36 months. Time of corrosion initiation and cracking and chloride content of the concrete were used in the analysis. The resulting service life projection procedure predicts that less than 25% of all Virginia bridge decks built under the specifications in place since 1981 will corrode sufficiently to require rehabilitation within 100 years, regardless of bar type. The corrosion service life extension attributable to ECR in bridge decks was found to be approximately 5 years beyond that of bare steel and, therefore, ECR is not a cost-effective method of corrosion prevention for bridge decks. Deleting the requirement for ECR would save Virginia approximately $845,000 per year.

Related Publication: VTRC 04-CR7: Brown, M.C., and Weyers, R.E. *Corrosion Protection Service Life of Epoxy-Coated Reinforcing Steel in Virginia Bridge Decks*

Project No. 54169: Plate and Tube Bridge Deck Evaluation in the Deck Test Bed of the Troutville, Virginia, Weigh Station

Principal Investigators: T.E. Cousins and J.J. Lesko

This project evaluated the laboratory and field performance of multi-cellular fiber-reinforced polymer (FRP) composite bridge deck systems. In the field-testing facility, FRP decks were installed, tested, and monitored to study their in-service field performance. No significant loss of deck capacity was observed. However, the long-term field monitoring and testing results showed that the unsupported edges (or free edges) are undesirable. The systems performed well in the intense service load environment of the Troutville weigh station. FRP decks are viable structures for highway bridge deck applications, particularly in areas where rapid construction is warranted or in the rehabilitation of posted bridges to lighten the dead load.

Related Publication: VTRC 04-CR12: Cousins, T.E., and Lesko, J.J. *Plate and Tube Bridge Deck Evaluation in the Deck Test Bed of the Troutville, Virginia, Weigh Station*

Project No. 54175: Trial Use of a Stainless Steel-Clad Steel Bar in a New Concrete Bridge Deck in Virginia

Principal Investigators: Gerardo G. Clemeña, Dina N. Kukreja, and Claude S. Napier

This project summarized recent research on cost-effective, corrosion-resistant reinforcing bars that VDOT can use in building long-lasting concrete bridges that will be exposed to heavy salting. Funded under the FHWA's Innovative Bridge Research and Construction Program, the project evaluated the performance of a 316L stainless steel-clad bar used in a new bridge deck in Virginia. The research supplemented our recent laboratory evaluation that confirmed the high corrosion resistance of the cost-effective bars. The project revealed no significant problem with the use of bars as a direct substitute for the currently used black steel and epoxy-coated bars. The authors conclude that even though the initial cost of the clad bars is slightly higher than that of the currently used bars, the life cycle cost for the deck is lower than for one built with either of the two other bars. Based on these findings, we conclude that the clad bar is a cost-effective reinforcement for extending the service life of concrete bridges and should be used in the construction of new concrete bridges in Virginia. Use of the clad bars in bridge decks can save VDOT more than $1 million dollars per year based on a life cycle cost analysis.

Related Publication: VTRC 04-R5: Clemeña, G.G., Kukreja, D.N., and Napier, C.S. *Trial Use of a Stainless Steel-Clad Steel Bar in a New Concrete Bridge Deck in Virginia*

Project No. 54176: A Laboratory and Field Study of Composite Piles for Bridge Structures

Principal Investigator: Edward J. Hoppe

This project evaluated the use of bridge foundation piles made of a fiberglass shell filled with concrete. This type of pile was seen as a potential replacement for a conventional prestressed concrete pile since it had no metallic reinforcement and hence would not corrode. The study involved extensive laboratory and field testing, including installation of the piles on one bridge in Hampton Roads. Although the load-bearing capacity of these piles approached that of conventional piles, the fiberglass shells absorbed water, which results in a substantial decrease in strength with time. This condition, combined with a relatively high cost of production, renders composite piles impractical for use at this time.

Project No. 54581: Evaluation of Continuously Reinforced Hydraulic Cement Concrete Pavement at Virginia's Smart Road

Principal Investigator: Celik Ozyildirim

This project evaluated continuously reinforced concrete pavements placed on asphalt-stabilized and cement-stabilized open-graded drainage layers. Because of cold weather, one of the two lanes was covered with plastic and straw in addition to the curing compound, thus enabling the evaluation of different curing methods. Results indicate that the concrete had high early strength and low permeability. Shrinkage values were high, but the average crack spacing was more than 3 feet, indicating satisfactory performance. Crack spacing was more in the lane that was covered with plastic and straw, which was attributed to a better control of moisture loss. In addition, the spacing was more in the concrete over the asphalt-stabilized base compared to the cement-stabilized base. The width of cracks appeared to be greater when the crack spacing was greater. However, the differences in spacing and crack width were variable and small in some cases for different lanes and bases. Therefore, no changes to the specifications are recommended.

Related Publication: VTRC 04-R22: Ozyildirim, C. *Evaluation of Continuously Reinforced Hydraulic Cement Concrete Pavement at Virginia's Smart Road*

Project No. 56757: Procedures for Implementing the VDOT Statewide Geotechnical Database Management System (GDBMS)

Principal Investigator: Edward J. Hoppe

This project expanded the Internet-based geotechnical database from the Hampton Roads Third Crossing to all statewide projects. The tool, an application on VDOT's server, offers both historic and new geotechnical information at a glance and geotechnical profiles in less than 1 minute.

Specifically, the tool provides a quick and effective means of sorting and accessing historic and new geotechnical data. Engineers can use these data to plan future soil explorations, which can cost as much as $10,000 per day. During construction, the data will be used to compute pile lengths, among other applications. The next phase of this project is to extend its implementation to the I-81 widening project. We collaborated with several VDOT divisions, Old Dominion University, and the U.S. Army Corps of Engineers in developing the tool.

Project No. 57911 (ongoing): Investigation of the Resistance of Several New Metallic Reinforcing Bars to Chloride-Induced Corrosion in Concrete

Principal Investigator: Gerardo G. Clemeña

This project evaluates alternative corrosion-resistant reinforcing bars that can be used to build cost-effective concrete bridges that will be exposed to salting. The research is funded under the FHWA's Innovative Bridge Research and Construction Program. The project evaluated stainless steel–clad carbon steel bars, bars made of an MMFX-2 "micro-composite" steel, bars made of a new "lean" duplex stainless steel called 2101 LDX, a carbon steel bar coated with a 2-mil layer of arc-sprayed zinc and then epoxy, two solid stainless steel (304 and 316LN) bars, and an ASTM A 615 carbon steel bar. The bars were embedded in concrete blocks that were then subjected to severe weekly cycles of ponding with a saturated salt solution and drying. Their times-to-corrosion were estimated from weekly monitoring of the macrocell current, open-circuit potential, and polarization resistance. The project provides bridge engineers with timely information on alternative reinforcement, which should be valuable when they select the most economical metallic reinforcing bars that will satisfy their design life goal for concrete bridge components exposed to salting. We recommend using MMFX-2 or clad bars, or even the Zn/EC bars (pending further research), for concrete bridges exposed to heavy salting, such as those on urban highways and heavily traveled primary and interstate routes. We recommend using MMFX-2 bars or the currently used epoxy-coated rebars for concrete bridges on low-volume highways that will not be heavily salted.

Related Publication: VTRC 04-R7: Clemeña, G.G. *Interim Report: Investigation of the Resistance of Several New Metallic Reinforcing Bars to Chloride-Induced Corrosion in Concrete*

Project No. 60808: Influence of the New LRFD Seismic Guidelines on the Design of Bridges in Virginia

Principal Investigators: M.A. Widjaja and C.L. Roberts-Wollmann

This project assessed the effect of the new AASHTO *LRFD Guidelines for the Seismic Design of Highway Bridges*. Two Virginia bridges were analyzed using the methods prescribed in the guidelines. The details of the bridge designs were also checked against the corresponding seismic design requirement. Results indicate that the typical column spiral reinforcement is not adequate to satisfy the requirements of the new guidelines. Other details, such as beam-column joint reinforcing and splice locations, also require modification. The resultant cost increases for the two bridges were 0.1% and 0.3%. An associated parametric study to explore the effects on substructure design of different column heights, superstructure lengths, and soil classifications in different parts of Virginia indicated that for bridges located on good soil (Class B), typical column longitudinal reinforcing ratios (~1.5%) provide adequate strength to resist seismic forces. For bridges on poor soils (Class D) in regions of low to moderate seismic activity, such as the Northern Virginia and Richmond Districts, column longitudinal reinforcing may need to be increased, particularly in bridges with short columns, long spans, and sliding bearings at the abutments. For bridges on poor soils in regions of higher seismic risk, such as VDOT's Bristol and Salem districts, column sizes may need to be increased.

Related Publication: VTRC 04-CR17: Widjaja, M.A., and Roberts-Wollmann, C.L. *Influence of the New LRFD Seismic Guidelines on the Design of Bridges in Virginia*

Project No. 61216: Assessment of the Performance of Several Roadway Mixes Under Rain, Snow, and Winter Maintenance Activities

Principal Investigator: G.W. Flintsch

This project assessed the relative functional performance, including skid resistance and splash and spray, of five hot-mix asphalt surfaces and a tinned portland cement concrete highway surface during controlled wet and wintry weather events. The study focused on the surfaces placed within the all-weather testing area at the Virginia Smart Road. With regard to winter maintenance, under the temperature and precipitation conditions encountered, there were no significant differences in the performance of the different surface mixes tested. However, conditions encountered did not correspond to conditions normally encountered with natural snow. At temperatures at and just below freezing, artificial snow might not be appropriate for evaluating the effectiveness of winter maintenance chemicals. The open-graded friction course appears to have enhanced spray and splash performance; however, a more objective measure of splash and spray characteristics of the surfaces is needed to quantify the beneficial effect of this type of mix. No visual difference in performance was observed among the other mixes.

Related Publication: VTRC 04-CR18: Flintsch, G.W. *Assessment of the Performance of Several Roadway Mixes Under Rain, Snow, and Winter Maintenance Activities*

Project No. 67968: Quantitative Determination of Asphalt Antistripping Additive

Principal Investigator: G.W. Maupin, Jr.

This project determined the accuracy of a device that measures the percentage of antistripping additive in asphalt liquid binders and asphalt concrete mixtures. Approximately two thirds of the binder regressions predicted the additive content within $\pm$0.2%. Although single tests were accurate to within only $\pm$0.2%, it is possible to perform multiple tests quickly, thereby increasing the confidence level of test results. To use the equipment for quality assurance testing, the accuracy should be improved to approximately $\pm$0.1% in order for the test to be considered feasible. Modifications to the equipment and procedures as suggested in the report should help. The manufacturer has agreed to continue our line of testing to determine whether switching asphalt suppliers affects the calibration that must be performed with each mixture. Additional research and development is necessary to determine whether the device can be useful for quality assurance testing. The development of a successful device would preclude the necessity of performing the lengthier tensile strength ratio stripping test during hot-mix production.

Related Publication: VTRC 05-R3: Maupin, G.W., Jr. *Quantitative Determination of Asphalt Antistripping Additive*

Project No. 1121002: A Review and Assessment of Virginia's License Plate Sheeting Specifications

Principal Investigator: Stephen C. Brich

At the request of Virginia's Secretary of Transportation, this project comprised a review and assessment of Virginia's license plate sheeting specifications. As a result, the new specifications allow for more open competition from prospective bidders in the marketplace. The review was focused on the five test methods or specifications called into question, i.e., cold temperature resistance, solvent resistance, gasoline resistance, ISO 9002 registration, and directional warranty mark. As a result of our review, a number of changes to the Commonwealth's license plate sheeting contract specifications were recommended to bring them up to date. All recommendations were implemented, making Virginia's specifications for license plate sheeting performance-based rather than product-specific.

Related Publication: VTRC 04-R2: Brich, S.C. *A Review and Assessment of Virginia's License Plate Sheeting Specifications*

INCREASING MOBILITY & REDUCING CONGESTION

Project No. 60597: Development of Left-turn Lane Guidelines for Signalized and Unsignalized Intersections

Principal Investigators: Vijayendra R. Lakkundi, Brian Park, Nicholas J. Garber, and Michael D. Fontaine

This project developed new guidelines for installing left-turn lanes at signalized and unsignalized intersections that will enhance operational efficiency and safety on Virginia's roadways. An event-based simulation model was developed that VDOT engineers can use to determine the need for a left-turn lane. This model was validated using data collected from a number of signalized and unsignalized intersections around Virginia and thus reflected real-world traffic flow more accurately than previous guidelines. The simulation was used to update existing guidelines for left-turn installation at unsignalized intersections and to create new guidelines for signalized intersections. The proposed guidelines corrected many of the flawed assumptions of earlier models and provide more guidance to the engineer as to when a turn lane should be installed.

Related Publication: VTRC 04-R11: Lakkundi, V.R., Park, B., Garber, N.J., and Fontaine, M.D. *Development of Left-turn Lane Guidelines for Signalized and Unsignalized Intersections*

Project No. 60984: Research Needs for Developing a Commodity-Driven Freight Modeling Approach

Principal Investigators: Kathryn L. Peacock and Michael J. Demetsky

This project investigated merging supply chain logistics and the conventional approach to statewide freight traffic forecasting. It provides a direction and procedure for state and metropolitan transportation planners to develop a complete set of freight forecasting tools. The recommended planning strategy provides techniques to identify and plan for improvements to the infrastructure system to allow for more efficient freight flow throughout Virginia. The findings provide for the following guidelines regarding freight forecasting:

- Freight transportation planning studies should consider representative commodity supply chains as the basic level of behavioral analysis for freight transport decisions and use that reference as the basis for developing forecasting methods.
- A methodology for freight planning derived in the study provides for integrating existing trip generation and distribution methods with supply chain data to account for the shortcomings surrounding the conventional four-step methods.
- Surveys should be designed and implemented to obtain the information required to define trip destination and mode choice characteristics of the selected commodity flows.

Related Publication: VTRC 04-CR13: Peacock, K.L., and Demetsky, M.J. *Research Needs for Developing a Commodity-Driven Freight Modeling Approach*

Project No. 63832: ITS Data Quality: Assessment Procedure for Freeway Point Detectors

Principal Investigator: Brian L. Smith

VDOT has made significant investments in the traffic monitoring infrastructure that supports ITS. The project developed a data quality assessment procedure based on theory, practice, and an empirical investigation. The procedure has the following features:

- benchmark data collection using temporary installation of non-intrusive detectors; this provided the best approach to collecting large quantities of validated data without disrupting traffic flow
- data quality assessed at the lane level to pinpoint problem detectors
- data quality assessed at the 1-minute interval (or minimum practical measurement interval) to provide sufficient quantities of data in reasonable period of time
- analysis techniques including measures and plots, providing quantitative and visual indications of data quality.

The investigators recommend that VDOT begin to use the procedure on an ad-hoc basis and in a statewide program as means of protecting its significant investment in ITS data collection.

Related Publication: VTRC 04-CR10: Smith, B.L., Venkatanarayana, R., and Smith, C.D. *ITS Data Quality: Assessment Procedure for Freeway Point Detectors*

Project No. 68493: A Study of the Proposed Virginia Rail Transportation Development Authority

Principal Investigators: Roger W. Howe, James S. Gillespie, and Joseph A. Matteo

This project examined issues surrounding the proposed Virginia Rail Transportation Development Authority called for in Virginia Senate Bill 1279. Authorities in other states and in Virginia were investigated in hopes of finding a model for the new rail authority. Three options for satisfying the needs to be fulfilled by creating the new authority were examined: (1) create an independent rail authority, (2) create a new rail agency within the government, or (3) provide the powers needed (such as bonding) to a rail agency that already exists: the Department of Rail and Public Transportation.

Related Publication: VTRC 04-R16: Howe, R.W., Gillespie, J.S., and Matteo, J.A. *A Study of the Proposed Virginia Rail Transportation Development Authority*

MANAGING THE ENVIRONMENT & HISTORICAL RESOURCES

Project No. 58867: Strategies for Impediment Rehabilitation to Create Fish Passage Opportunities in the Rappahannock River Basin

Principal Investigators: Stephen P. McIninch and Greg C. Garman

This project assessed different fish passage systems as they related to impediments created by road culverts. Although the researchers experienced significant difficulty in installing and monitoring passage structures in Virginia, a number of similar structures were monitored in Maryland. The researchers concluded that site selections can be prioritized by the use of existing databases that describe anadromous fish use in the appropriate watershed. Unfortunately, there are insufficient data to state conclusively whether one structure is better than another for fish passage in Virginia. Because of the delays in structure installation and data collection, Virginia Commonwealth University has informally agreed to monitor the Virginia sites for an additional year to determine better the advantages and disadvantages of each type of structure.

Related Publication: VTRC 04-CR2: McIninch, S.P., and Garman, G.C. *Strategies for Impediment Rehabilitation to Create Fish Passage Opportunities in the Rappahannock River Basin*

Project No. 59083: Mitigating Contaminant Transportation in Utility Installations

Principal Investigators: Wu-Seng Lung and Alex J. Nice

This project developed an operations manual to classify the contamination problems potentially encountered by VDOT when it participates in utility installation. The manual also outlines mitigating measures to prevent or minimize contamination related to this practice. The investigators recommend general materials and engineering practices to be used depending on existing hydrogeology and contaminants of concern. The manual is intended to be used as the first step in the mitigation process by field operatives and designers and presents general information and concepts while also providing gateways to more detailed information.

Related Publication: VTRC 04-CR14: Lung, W.-S., and Nice A.J. *Mitigating Contaminant Transportation in Utility Installations*

Project No. 60440: Development of a Stormwater Best Management Practice Placement Strategy for the Virginia Department of Transportation

Principal Investigator: Shaw L. Yu

This project determined the effects of different placement and configuration scenarios for stormwater best management practices (BMPs). Construction, operational, and maintenance

costs and pollutant removal efficiencies were modeled for BMPs at three scales: on-site, sub-regional, and regional. The investigators determined that cost savings could be realized if BMPs were placed at the regional level rather than in a linear fashion, which is typically the current practice. The investigators recommend that VDOT's Location & Design Division consider a proactive approach in planning stormwater BMP placement by strategizing with other stakeholders such as regulators, pollutant dischargers, citizen groups, localities, etc., to develop optimal placement schemes for highway projects impacting a given watershed. This and other recommendations offered in the report provide VDOT with opportunities for reducing BMP construction and maintenance costs while also achieving the water quality goals for the watershed.

Related Publication: VTRC 04-CR9: Yu, S.L., Xiaoyue, J.Z., and Yanyun, S.Z. *Development of a Stormwater Best Management Practice Placement Strategy for the Virginia Department of Transportation*

Project No. 66906: Field Validation of Speed Estimation Techniques for Air Quality Conformity Analysis

Principal Investigators: John S. Miller and G. Michael Fitch

This project validated the post processors VDOT uses to estimate speeds for the purpose of air quality conformity analyses. Data collected at 15 sites in Richmond and Charlottesville helped determine the accuracy of three post-processing techniques (methods for estimating vehicle speeds once long-range planning models have forecast future traffic volumes). On average, the mean absolute errors for the post processors were relatively similar and can be reduced to 5 mph by judiciously adjusting some of the assumptions in the model. This work, in conjunction with other VDOT initiatives, could lead to cost savings for VDOT of $1.3 million by the end of FY05.

Related Publication: VTRC 04-R19: Miller, J.S., Fitch, G.M., Dougald, L.E., Kreissler, S.R., and Hill, D.H. *Field Validation of Speed Estimation Techniques for Air Quality Conformity Analysis*

Project No. 68883: Archiving History Publications

Principal Investigator: Ann B. Miller

In this project, 19 pre-2001 volumes of our Historic Roads of Virginia Series were put into an electronic format. These publications, some dating back to the 1970s, are now on our website and will be available in CD format soon. The volumes include the road orders (18th century Virginia records pertaining to transportation) and our published road histories, which are highly regarded resources in constant demand by historical and cultural resource researchers. As some of these volumes are lengthy (several exceed 300 pages), their electronic availability will save VDOT the cost of reprinting and binding literally tens of thousands of pages each year.

Project No. 71119: Highway Runoff in Areas of Karst Topography

Principal Investigator: Bridget M. Donaldson

This project comprised a literature review designed to summarize the effects of and the federal and state regulations pertaining to highway runoff in karst areas. Recent activity at the state level has focused on the impacts of stormwater runoff on underground sources of drinking water and habitats of sensitive aquatic species. In the event that new requirements regarding karst area runoff are passed that would affect VDOT's construction and maintenance activities, this report summarizes the research and regulations to assist VDOT in determining its position on these issues. This review can also serve as grounds for future decisions concerning whether a full-scale research project on this topic is needed. Findings suggest that highways are not major contributors of non-point source pollution of karst aquifers compared to other land uses. Although more studies of karst groundwater contamination are needed, the literature does not currently support the need for more stringent regulatory controls than are already in place.

Related Publication: VTRC 04-R13: Donaldson, B.M. *Highway Runoff in Areas of Karst Topography*

Project No. 1121019: New Kent County and Hanover County Road Orders 1706-1743
Principal Investigator: Ann B. Miller

This project identified and provided a comprehensive transcription and cross-index of the surviving early transportation-related records of western New Kent (later Hanover) County, Virginia, during the first half of the eighteenth century. During this period, the territory of these counties covered a large portion of the central Virginia Piedmont. These records are the principal extant evidence concerning the early development of transportation routes in that region. The locations of early roads and bridges provide a key to many of those historic resources that are now becoming increasingly important during the environmental review process required prior to highway and bridge construction. Recognition of early road locations is an important element in identifying potentially historic properties that must be considered during the environmental review process. These road orders are also useful for such things as the preparation of cultural resource surveys; the surveying and recording of historical bridges, archaeological surveys, and excavations; the identification of historic roads and scenic byways; and the placement of historic markers.

Related Publication: VTRC 04-R17: Miller, A.B. *New Kent County and Hanover County Road Orders 1706-1743*

IMPROVING PLANNING & FINANCIAL & ADMINISTRATIVE MANAGEMENT

Project No. 68102: Options for Improving the Coordination of Transportation and Land Use Planning in Virginia
Principal Investigators: John S. Miller and Roger W. Howe

This project investigated options for improving the coordination of transportation and land use planning and documented legislative and technical assistance practices VDOT staff could use to assist localities with quantifying transportation impacts of different land development strategies. The investigators found that there is no single best practice that coordinates transportation and land use planning. Instead, a best practice occurs when the state legislature clearly articulates a policy goal that transportation and land use planning are expected to achieve. Requested by the 2003 Virginia General Assembly, the resulting report identified steps VDOT could take to meet particular policy goals selected by the General Assembly or the locale. VDOT is now actively pursuing one of the practices on a pilot basis: helping counties quantify the transportation impacts of proposed land development alternatives. A second product of the report—a description of alternative sources of transportation funding—was distributed to various planning district commission staff and VDOT district planners and was well received.

Related Publication: VTRC 04-R14: Miller, J.S., Howe, R.W., Hartman, R.P., and Goswami, A.K. *Options for Improving the Coordination of Transportation and Land Use Planning in Virginia*

Technical Assistance Project: Tort Liability: A Handbook for Employees of the Virginia Department of Transportation and Virginia Municipal Corporations, Third Edition
Principal Investigator: Patrick Wachendorf

VTRC has published a tort liability handbook since 1995 to provide the employees of VDOT and of Virginia's municipal corporations with sufficient information to allow them to make informed decisions concerning events that could lead to tort claims against their employers or themselves. This handbook presents a broad outline of what constitutes a tort and identifies specific instances that may lead to legal liability. Risk management can help reduce tort liability that employees and employers confront. If readers have questions concerning tort liability, there is a frequently asked questions section that may answer their inquiries. This handbook is not a substitute for legal advice.

Related Publication: VTRC 04-R30: Wachendorf, P. *Tort Liability: A Handbook for Employees of the Virginia Department of Transportation and Virginia Municipal Corporations, Third Edition*

Technical Assistance Project: Feasibility of Protecting Corridors Through the National Environmental Policy Act

Principal Investigator: John S. Miller

This project illustrates how VDOT can use the NEPA process and subsequent agreements to protect select arterial facilities from having too many signals and unsignalized driveways. Although the techniques described in the report do not guarantee effective access management, they can make it easier for VDOT and local governments to avoid adding access points, thereby helping to protect the mobility and safety of select corridors. Specifically, NEPA can be used to help protect a corridor through four administrative mechanisms: (1) including the limited access requirement as a condition in the record of decision; (2) effecting a contract between VDOT and the FHWA, known as the Federal-Aid Project Agreement, that stipulates limiting access as a requirement; (3) implementing a supplemental agreement between VDOT and interested parties that indicates how the character of the corridor shall be maintained; and (4) documenting the corridor-preservation conditions that remove the requirement that a project have an Environmental Impact Statement.

Related Publication: VTRC 04-R29: Kamprath, M.T., and Miller, J.S. *Feasibility of Protecting Corridors Through the National Environmental Policy Act*

Special Project: The VTRC FY03 Annual Report

Principal Investigator: Linda D. Evans

The *FY03 Annual Report* describes the innovations and cost-savings our research program afforded VDOT in FY03. The report also describes the projects completed, provides a staff listing, and provides a roster of our research advisory committees.

Related Publication: VTRC 04-R24: *FY03 Annual Report*

STAFF LISTING

ADMINISTRATION TEAM

Gary R. Allen, B.A., Ph.D., Economics—Chief of Technology, Research & Innovation
Areas of Expertise:
- Program and staff management
- Economics
- Highway finance
- Administration
- Transportation policy
- Information technology

Memberships:
- AASHTO National Research Advisory Committee
- AASHTO Region II Research Advisory Committee
- AASHTO Standing Committee on Research
- Construction Dashboard Council
- National ITS Implementation Research Center Advisory Board
- SASHTO 2004 Steering Committee
- Secretary of Transportation's IT Oversight Committee
- Transportation Research Board State Representative
- Virginia Tech Transportation Institute Review Committee
- Virginia Transportation Research Council's Advisory Board
- Visiting Professor, Department of Systems and Information Engineering, University of Virginia School of Engineering and Applied Science

William E. Kelsh, B.A., Mathematics; Master of Urban and Environmental Planning; Master of Computer Science—Associate Director for Administration
Areas of Expertise:
- Program and staff management
- Research administration
- Information technology

Administrative, Technical & Media Support Staff
Steve R. Blackwell—Information Technology Specialist, IT desktop support
Ivy M. Carlton—Administrative Assistant to Chief of Technology, Research & Innovation
Chiara Canzi—Administrative & Office Specialist, reception, administrative support
Donna P. Cognata—Financial Services Specialist, accounting, contracts and grants administration
F. Randolph Combs—Media Specialist, technical illustrations and graphs
Edward J. Deasy, Jr.—Media Specialist, webmaster
Patricia R. DeSalvo—Library Specialist, library technical services
Linda D. Evans—Public Relations & Marketing Practitioner, technical editing and writing, *2003 Employee of the Year Award*
Teresa S. Evans—Administrative & Office Specialist, fiscal, human resources, and facilities support
Arlene M. Fewell—Administrative & Office Specialist, administrative support
Jerry M. Garrison—Printing Technician, reproduction and distribution
Bruce E. Johnsen—Information Technology Specialist, IT network and server support
Kristen D. Knight— Historian & Preservationist, receptionist, research assistant
Peter J. Massarelli—Research Scientist, web design and support

Brian L. Paul—Information Technology Specialist, IT network and server support
Cynthia S. Perfater—Administrative & Office Specialist, administrative support
Michael W. Powell—Utilities Trades Worker, facilities maintenance
Kerri A. Runnett—Administrative & Office Specialist, reception, administrative support
Gale K. Smith—Library Specialist, library technical services
Jennifer M. Ward—Information Technology Specialist, administrative support
Kenneth A. Winter—Library Specialist, library technical services, *2003 Employee of the Year Award*

FINANCIAL & ORGANIZATIONAL STUDIES TEAM

Amy A. O'Leary, B.A., M.A., Ph.D., Sociology—Associate Director for Financial & Organizational Studies

Areas of Expertise:

- Organizational and legislative studies
- Program and staff management
- Public involvement
- Right of way
- Social and economic impacts
- Survey research

Memberships:

- Chair, Transportation Research Board Committee ADD20, Social and Economic Factors
- Chair, Research Subcommittee of TRB Committee ADA60, Public Involvement
- Public Member, Board of Directors, Accreditation Board for Engineering and Technology (ABET)

James S. Gillespie, B.A., Chemistry; M.A., Economics—Senior Research Scientist

Areas of Expertise:

- Transportation finance
- Life cycle cost analysis
- Economic impact analysis

Memberships:

- American Economics Association
- Secretary, Transportation Research Board Committee ADD10, Transportation and Economic Development
- TRB Committee ABE20, Transportation Economics
- TRB Committee APO25, Public Transportation Planning and Development
- NCHRP Project Panel 02-23, Development of an Update to the 1977 AASHTO Red Book

Ilona O. Kastenhofer, M.S., Transportation Systems Planning; M.E., Civil Engineering—Senior Research Scientist

Areas of Expertise:

- Policy analysis
- Organizational development
- Land use and transportation

Memberships:

- Institute of Transportation Engineers, Associate Member
- ITE Public Agency Council, Executive Member
- ITE Pedestrian and Bicycle Committee

Cheryl A. Kyte, B.A., M.A., Economics—Senior Research Scientist
Areas of Expertise:
- Economics
- Finance
- Cost-benefit analysis

Memberships:
- American Economics Association

Administrative & Technical Support Staff
Adam S. Hyde—Research Associate, economics
Audrey K. Moruza—Policy & Program Specialist, economics, finance
Penny Y. Sloope—Administrative & Office Specialist, administrative support, data compilation

KNOWLEDGE MANAGEMENT & TECHNOLOGY TRANSFER TEAM

Maureen L. Hammer, B.A., Political Science; M.L.S.—Director, Knowledge Management & Technology Transfer
Areas of Expertise:
- Program and staff management
- Knowledge management
- Library science
- Organizational development
- Adult education and training

Memberships:
- Chair, KMPro, Marketing Committee, Richmond Chapter
- American Library Association, Library and Information Technology Division, Education Committee
- Global Knowledge Economics Council, American National Standards Institute, Standards Committee, Metrics Subcommittee
- National Honor Society (Beta Phi Mu), Library Science

Russell A. Neyman, B.A., History; M.B.A.—Training and Instruction Manager
Areas of Expertise:
- Program and staff management

Administrative Support Staff
Darleen E. Miller—Engineering Technician, administrative support
S. Noelle On—Policy & Planning Specialist, publications
Carmen A. Rea—Administrative & Office Specialist, administrative support
W. Rhudy Renfro—Program Associate, newsletter editor
Barbara A. Turner—Administrative & Office Specialist, program coordination

MATERIALS TEAM

Michael M. Sprinkel, B.S., M.S., Civil Engineering; P.E.—Associate Director for Materials
Areas of Expertise:
- Program and staff management
- Asphalt
- Hydraulic cement concrete
- Corrosion and nondestructive evaluation
- Polymer concrete

- Hydraulic cement concrete
- Protection, repair, and rehabilitation of concrete structures

Memberships:

- Fellow, American Concrete Institute
- Chair, ACI Committee 503, Adhesives
- Past Chair, ACI Committee 345, Bridge Construction, Maintenance, and Repair
- ACI Repair Technical Activities Committee
- ACI Committee 546, Repair of Concrete
- ACI Committee 548, Polymers in Concrete
- ACI Committee 548A, Polymer Modified Concrete
- American Segmental Bridge Institute, Grout Committee
- American Society of Civil Engineers
- American Society for Testing and Materials
- Highway Innovative Technology Evaluation Center, Standards and Specifications Task Force
- International Concrete Repair Institute
- Post-tensioning Institute, Grout Committee
- Prestressed Concrete Institute
- Chair, Transportation Research Board Committee AFN00, Concrete
- Member Emeritus, TRB Committee AFN20, Mechanical Properties of Concrete
- TRB Group 2 Council Committee AFO00, Design and Construction of Transportation Facilities
- TRB Committee AHD40, Adhesives, Bonding Agents and Their Use
- VDOT/Virginia Road and Transportation Builders Association Joint Highway Cooperative Committee

Gerardo G. Clemeña, B.S., M.S., Analytical Chemistry; Ph.D., Physical Chemistry—Principal Research Scientist

Areas of Expertise:

- Corrosion and nondestructive evaluation
- Alternative reinforcement
- Chloride analysis
- Electrochemical chloride extraction
- Cathodic protection
- Ground penetrating radar
- Impact echo

Memberships:

- Transportation Research Board
- National Association of Corrosion Engineers
- American Concrete Institute
- Philippines-American Society for Scientists and Engineers

Awards:

- 2003 Shelburne Award for Outstanding Scientific Achievement, Publication Record, and National Leadership

Charles S. Hughes, B.S.C.E., M.S.C.E., Civil Engineering, P.E.—Senior Research Scientist

Areas of Expertise:

- Asphalt
- Quality assurance
- Specifications

Memberships:

- Honorary Member, Association of Asphalt Paving Technologists
- Member Emeritus, Transportation Research Board Committee A2F03, Management of Quality Assurance

Awards:

- Induction into the Virginia Tech Academy of Distinguished Alumni for the Charles Edward Via, Jr. Department of Civil and Environmental Engineering

D. Stephen Lane, B.A., M.S., Geology—Senior Research Scientist

Areas of Expertise:

- Aggregates
- Hydraulic cements
- Hydraulic cement concrete
- Petrography

Memberships:

- American Concrete Institute Committee 221, Aggregates
- American Society for Testing and Materials Committee C09, Concrete and Aggregates
- ASTM Committee C09 Subcommittees:
  - — Executive Subcommittee, Member-at-Large
  - — Chair, Chemical Reactions Subcommittee
  - — Petrography Subcommittee
  - — Resistance to Fluid Penetration Subcommittee
  - — Chair, Papers & Symposia Subcommittee (Joint with C01)
- ASTM Committee C01, Cement
- ASTM Committee C01 Subcommittees:
  - — Chair, Alkali Subcommittee
  - — Chair, Volume Change Subcommittee
  - — Secretary, Executive Subcommittee
  - — Air Content Subcommittee
  - — Hydraulic Cements Subcommittee
  - — Research Subcommittee
  - — Strength Subcommittee
  - — Sulfate Content Subcommittee
- Chair, National Cooperative Highway Research Program Panel D4-30, Aggregate Shape Characterization
- NCHRP Panel D18-11, Processing Additions in Portland Cement
- Chair, Transportation Research Board Committee AFP70, Mineral Aggregates
- TRB Committee AFN30, Durability of Concrete

G. William Maupin, Jr., B.S., M.S., Civil Engineering; P.E.—Principal Research Scientist

Areas of Expertise:

- Asphalt
- Superpave
- Permeability
- Durability
- Stripping
- Mixture characterization

Memberships:

- American Society of Civil Engineers
- Chair, American Society for Testing and Materials Subcommittee D04.23, Plant-Mixed Bituminous Surfaces and Bases
- ASTM Committee D-4, Road and Paving Materials
- Association of Asphalt Paving Technologists
- Transportation Research Board, Expert Task Group on Analysis of Long Term Pavement Performance Data
- TRB Committee AFK20, Characteristics of Bituminous Materials
- TRB Committee AFK40, Characteristics of Bituminous-Aggregate Combinations to Meet Surface Requirements

- National Cooperative Highway Research Program, Panel 9-38, Fatigue Characterization of Asphalt Mixtures for Long-Life Pavements

Kevin K. McGhee, B.S., M.S., Civil Engineering; P.E.—Senior Research Scientist
Areas of Expertise:
- Hot-mix asphalt construction
- Pavement surface characteristics
- Flexible pavement evaluation
- Pavement forensic studies

Memberships:
- Association of Asphalt Pavement Technologists (AAPT)
- Vice-Chair, American Society for Testing and Materials International Committee E-17, Vehicle/Pavement Systems
- Federal Highway Administration Expert Task Group, Pavement Smoothness
- National Cooperative Highway Research Program Panel 1-43, Guide for Pavement Friction
- NCHRP Panel 10-58(02), Using Contractor-Performed Tests in Quality Assurance
- NCHRP Panel 9-41, Cold-Weather Performance of Open-Graded Friction Courses
- National Society of Professional Engineers
- Road Profiler User Group
- Transportation Research Board Committee AFH20, Management of Quality Assurance
- TRB Committee AFD90, Surface Properties/Vehicle Interaction

Awards:
- 2003 Dillard Award for Best Paper: *Using High-Speed Texture Measurements to Improve the Uniformity of Hot-Mix Asphalt*

David W. Mokarem, B.B.A., Business Management; B.S., M.S., Ph.D., Civil Engineering—Research Scientist
Areas of Expertise:
- Pavements
- Transportation systems analysis
- Materials testing and evaluation
- Durability of construction materials

Memberships:
- American Society of Civil Engineers
- American Society for Testing and Materials
- Transportation Research Board

H. Celik Ozyildirim, B.S., M.S., Ph.D., Civil Engineering; P.E.—Principal Research Scientist
Areas of Expertise:
- Concrete
- High performance concrete
- Concrete pavements
- Permeability
- Admixtures
- Workability
- Specifications

Memberships:
- American Concrete Institute Committee 211, Proportioning Concrete Mixtures
- ACI Committee 233, Ground Slag in Concrete
- ACI Committee 234, Silica Fume in Concrete
- ACI Committee 308, Curing Concrete
- ACI Committee 506, Shotcreting

- American Society for Testing and Materials Committee C-9, Concrete and Concrete Aggregates
- Transportation Research Board, Section A2E06, Basic Research and Emerging Technologies Related to Concrete

Stephen R. Sharp, B.S., Materials Engineering; M.S., Engineering, Specialization in Materials Engineering—Research Scientist
Areas of Expertise:
- Corrosion and nondestructive evaluation
- Materials science
- Smart materials
- Chloride extraction

Memberships:
- ASM International, The Materials Information Society
- The Minerals, Metals & Materials Society
- National Association of Corrosion Engineers Technical Committee Member
  - — NACE Specific Technology Group 01, Reinforced Concrete
  - — NACE STG 64, Corrosion Science and Technology Transformation Roadmap—The Next 20 Years
  - — NACE Technology Exchange Group 043X, Reinforced Concrete: Cathodic Protection
  - — NACE TEG 053X, Reinforced Concrete: Design, Evaluation, and Remediation
  - — NACE TEG 100X, Corrosion and Corrosiveness Sensor Development
  - — NACE Task Group 047, Reinforced Concrete: Sacrificial Cathodic Protection
  - — NACE TG 054, Electrochemical Chloride Removal and Realkalization

Administrative & Technical Support Staff
Eileen F. Aiken—Administrative & Office Specialist, administrative support, corrosion
Cesar M. Apusen—Engineering Technician, manages NDE/corrosion lab
William S. Bane—Research Associate, concrete
Michael W. Burton— Engineering Technician, manages concrete lab
Troy H. Deeds—Engineering Technician, manages asphalt mixture lab
Carolyn D. Desmond—Research Assistant, concrete
Donald W. Dodds—Engineering Technician, manages asphalt binder lab
John W. Dorman—Lab and Research Technician, asphalt
Benjamin G. Earl—Research Assistant, asphalt
Kenneth B. Elliton—Engineering Technician, asphalt
Jung H. Lee—Research Assistant, electronics
Bobby F. Marshall—Engineering Technician, petrography
Andrew J. Mills, Jr.—Engineering Technician, concrete
Godwin R. Nestor—Research Assistant, asphalt
William Ordel III—Engineering Technician, concrete
Christopher R. Standridge—Research Assistant, corrosion
David L. White—Research Assistant, asphalt
L.E. Wood—Engineering Technician, asphalt

MOBILITY MANAGEMENT & ENVIRONMENT

Michael A. Perfater, B.A., Sociology; M.Ed.—Associate Director for Mobility Management & Environment
Areas of Expertise:
- Program and staff management
- Public involvement
- Right-of-way issues

- Motorist services
- Environmental and human factors

Memberships:

- International Right of Way Association, Virginia Chapter 52, Executive Board Member and Newsletter Editor
- Chair, VDOT Project Cost Estimation Task Force

Eugene D. Arnold, Jr., B.C.E., M.S.C.E.; P.E.—Senior Research Scientist

Areas of Expertise:

- Traffic operations
- Transportation planning

Memberships:

- Fellow, Institute of Transportation Engineers
- Honorary Member, ITE, Virginia Section
- ITE, Southern District
- Transportation Research Board

Stephen C. Brich, B.S., Civil Engineering; M.S., Civil Engineering—Senior Research Scientist

Areas of Expertise:

- Transportation systems
- Operations
- Safety
- Visibility

Memberships:

- American Society of Testing and Materials
- Institute of Transportation Engineers, Virginia Section
- Transportation Research Board

Benjamin H. Cottrell, Jr., B.S., M.S., Civil Engineering; P.E.—Senior Research Scientist

Areas of Expertise:

- Traffic operations

Memberships:

- Institute of Transportation Engineers, Virginia Section
- Transportation Research Board Committee AHB50, Traffic Control Devices Committee

Michael J. Demetsky, B.S., M.S., Ph.D., Civil Engineering; P.E.—Faculty Research Scientist; Professor, Civil Engineering, University of Virginia

Areas of Expertise:

- Transportation planning
- Traffic operations analysis
- Intelligent transportation systems
- Transportation models

Memberships:

- American Road and Transportation Builders Association, Education Division
- American Society of Civil Engineers Urban Transportation Division: Publications Committee
- ASCE Intermodal Transportation Committee
- Council on Intelligent Vehicle Highway Systems
- Council of University Transportation Centers
- Institute of Transportation Engineers
- ITE, Virginia Section
- ITS America
- ITS Virginia
- Transportation Education Council

- Transportation Planners Council
- Transportation Research Board Committee, Artificial Intelligence
- TRB Committee, Freight Transportation Planning and Logistics

Bridget M. Donaldson, B.A., Biology; M.S., Ecology and Evolutionary Biology—Research Scientist

Areas of Expertise:

- Ecology
- Wildlife
- Threatened and endangered species
- Geographic information systems

Memberships:

- Transportation Research Board Committee ADC30T, Task Force on Ecology and Transportation

G. Michael Fitch, B.S., Biology; M.S., Environmental Science—Senior Research Scientist

Areas of Expertise:

- Water quality
- Waste management
- Geographic information systems
- Wetlands
- Natural resources

Memberships:

- National Association of Environmental Professionals
- Transportation Research Board Committee ADC60, Waste Management in Transportation

Awards:

- 2003 Dillard Award for Best Paper: *Minimizing the Impact on Water Quality of Placing Grout Underwater to Repair Bridge Scour Damage*

Kenneth E. Lantz, Jr., B.S., M.S., Civil Engineering; P.E.—Senior Research Scientist

Areas of Expertise:

- Transportation operations
- HOV systems
- Performance measures and value pricing

Memberships:

- Institute of Transportation Engineers
- ITE, Virginia Section
- Transportation Research Board Committee AHB35, High-Occupancy Vehicle Systems

Catherine C. McGhee, B.S., M.S., Civil Engineering; P.E.—Senior Research Scientist, Co-Director, Virginia Smart Travel Laboratory

Areas of Expertise:

- Transportation operations
- Intelligent transportation systems

Memberships:

- ITS America
- ITS Virginia
- AASHTO Subcommittee on System Operations and Management, Task Force on Operations Deployment and Performance
- NGSIM Stakeholders Group (FHWA)

Ann B. Miller, B., Architectural History; M., Architectural History; Certificate in Historic Preservation—Senior Research Scientist

Areas of Expertise:

- History
- Architectural history
- History of technology
- Historic preservation
- Transportation history

Memberships:

- Association for the Preservation of Virginia Antiquities
- Madison County Historical Society
- Memorial Foundation of the Germanna Colonies
- Orange County Historical Society
- Board of Directors, Preservation Piedmont
- Transportation Research Board Committee A1F05, Historic and Archeological Preservation in Transportation
- TRB Subcommittee, Canals, Bridges, and Roadways
- Vernacular Architecture Forum
- Chair, Virginia Historic Structures Task Group
- Virginia Historical Society
- Winchester Regional Office of the Virginia Department of Historic Resources Advisory Committee

Brian Park, B.S., M.S., Urban Engineering, Ph.D., Civil Engineering—Faculty Research Scientist

Areas of Expertise:

- Traffic operations
- Intelligent transportation systems
- Traffic simulation modeling
- Signal optimization

Memberships:

- American Society of Civil Engineers
- Institute of Transportation Engineers
- ITS America
- Korean Transportation Association in America
- TRB Committee, Traffic Signal Systems
- Transportation Management Center Committee

Brian L. Smith, B.S., Mechanical Engineering; M.S., Systems Engineering; Ph.D., Civil Engineering—Faculty Research Scientist

Areas of Expertise:

- Intelligent transportation systems
- Transportation operations
- Information technology

Memberships:

- American Society of Civil Engineers Committee, Computing in Transportation
- Institute of Electronics and Electrical Engineers, Intelligent Transportation Systems Council Representative 2003
- Intelligent Transportation Society of America, Advanced Transportation Management Systems Committee
- Transportation Research Board Committee A5003, Information Technology
- TRB Committee A5008, Artificial Intelligence

Administrative & Technical Support Staff
Lance E. Dougald—Transportation Engineer, transportation systems, environmental engineering
Janice M. Kennedy—Engineering Technician, data analysis and compilation
Penny Y. Sloope—Administrative & Office Specialist, administrative support, data compilation

Graduate Student
John A. Pegues

SAFETY, PLANNING & LEGAL TEAM

Wayne S. Ferguson, B.S., Master of Commerce—Associate Director for Safety, Planning & Legal
Areas of Expertise:
- Program and staff management
- Evaluation of highway traffic safety programs
- Development of curriculum material for workshops
- Multidisciplinary approaches to traffic safety problems
- Transportation safety research
- Multimodal planning
- Legal issues in transportation

Memberships:
- Virginia Safety Management System, Executive Steering Committee
- Seaboard Incident Management Committee
- Chair, Seaboard Incident Management Committee, Task Force on Research
- VDOT Security and Preparedness Panel
- Virginia Safety Association

Michael D. Fontaine, B.S., M.S., Civil Engineering; P.E.—Research Scientist
Areas of Expertise:
- Traffic operations
- Traffic safety
- Work zone traffic control

Memberships:
- Institute of Transportation Engineers

Awards:
- 2003 Horizon Award for Outstanding Productivity and Achievement
- Transportation Research Board Committee A3C04, Work Zone Traffic Control, Best Paper Award: *Guidelines for the Application of Portable Work Zone Intelligent Transportation Systems*

Nicholas J. Garber, B.S., M.S., Ph.D., Civil Engineering, P.E.—Faculty Research Engineer; Professor, Department of Civil Engineering, University of Virginia
Areas of Expertise:
- Traffic operations
- Safety
- Intelligent transportation systems

Memberships:
- American Society of Civil Engineers Traffic Operations Committee
- Transportation Research Board Committee AHB55, Work Zone Traffic Control
- TRB Committee AHB65, Operational Effects on Geometrics
- Institute of Transportation Engineers

Matthew C. Grimes, B.S., M.S., Civil Engineering—Research Scientist
Areas of Expertise:
- Land development,
- Transportation planning
- Access management

Memberships:
- Institute of Transportation Engineers

Lester A. Hoel, B.C.E., M.C.E., D. Eng., Civil Engineering; P.E.—Faculty Research Scientist; L.A. Lacy Distinguished Professor of Civil Engineering, University of Virginia
Areas of Expertise:
- Transportation planning
- Operations
- Safety

Memberships:
- American Society of Civil Engineers
- Institute of Transportation Engineers
- American Society for Engineering Education
- National Academy of Engineering

Cheryl W. Lynn, B.A., Psychology; M.A., Educational Psychology—Senior Research Scientist
Areas of Expertise:
- Safety
- Human factors

John S. Miller, B.S., Electrical Engineering; Ph.D., Civil Engineering; P.E.—Senior Research Scientist
Areas of Expertise:
- Transportation planning
- Safety
- Operations

Memberships:
- Transportation Research Board Committee AVO50, Airport and Landside Access
- TRB Committee ANB20, Safety Data and Evaluation

Administrative & Technical Support Staff
Thomas L. Bane—Research Assistant, safety
Roger W. Cooper—Engineering Technician, safety
Brian S. Cox—Engineering Technician, safety
Wanda T. Floyd—Engineering Technician, safety
Jonathan D. Goodman—Engineering Technician, safety
Ryan P. Hartman—Graduate Legal Assistant
Steven M. Henn—Research Assistant, Safety
Roger W. Howe—Public Relations & Marketing Specialist, planning
Joan M. Johnson—Engineering Technician, safety
Michael T. Kamprath—Graduate Legal Assistant
Jami L. Kennedy—Engineering Technician, safety
Marc F. Kirkland—Graduate Legal Assistant
Joseph A. Matteo—Graduate Legal Assistant
Kimberly M. Mattingly—Graduate Legal Assistant
M. Ann McDaniel—Administrative & Office Specialist, administrative and technical program support, *2003 Employee of the Year Award*
Benjamin J. Oxley—Graduate Legal Assistant
Katherine J. Peters—Graduate Legal Assistant
Darrell J. Ratcliffe—Research Assistant, safety

Kristin M. Sprinkle—Graduate Legal Assistant
Daryl E. Thomas—Research Assistant, safety
Patrick L. Wachendorf—Graduate Legal Assistant
Matthew G. Webber—Research Assistant
Lewis L. Woodson—Engineering Technician, traffic safety

Graduate Students
Changseok Baek
Andrew G. Beacher
David B. Ellington
Arkopal K. Goswami
R. Khandelwal
Vijayendra R. Lakkundi

STRUCTURES, PAVEMENTS & ASSET MANAGEMENT TEAM

Jose P. Gomez, B.S., M.C.E., Ph.D., Civil Engineering; P.E.—Associate Director for Structures, Pavements & Asset Management
Areas of Expertise:
- Program and staff management
- Analysis and design of bridges
- Computer modeling of bridges
- Field testing of bridges
- Use of innovative materials in bridge structures

Memberships:
- American Society of Civil Engineers
- Transportation Research Board, Committee AFF40, Dynamics and Field Testing of Bridges

Furman W. Barton, B.C.E., M.S., Ph.D., Civil Engineering; P.E.—Senior Research Scientist
Areas of Expertise:
- Static and dynamic response of bridge structures
- Field testing of bridges
- Computer modeling of bridge components

Memberships:
- American Society of Civil Engineers

Michael C. Brown, B.S., M.S., Ph.D., Civil Engineering; P.E.—Research Scientist
Areas of Expertise:
- Innovative applications for structural design and materials
- Maintenance and rehabilitation of highway transportation structures
- Asset management of bridges and other transportation structures
- Condition assessment of structures and structural elements
- Service life prediction of structural elements
- Corrosion assessment, mitigation, and prevention for reinforced concrete structures

Memberships:
- American Concrete Institute Committee 345, Concrete Bridge Construction, Maintenance & Repair
- American Society of Civil Engineers
- National Cooperative Highway Research Program Panel, Project 12-67, Multiple-Objective Optimization for Bridge Management Systems
- Member and Web Moderator, Transportation Research Board Committee AHD45, Corrosion

Awards:
- 2003 Horizon Award for Outstanding Productivity and Achievement

James W. Bryant, Jr., B.S., M.S. Ph. D., Civil Engineering; P.E.—Research Scientist
Areas of Expertise:
- Asset management
- Highway maintenance and operations management
- Preventive maintenance
- Pavement preservation

Memberships:
- American Society of Civil Engineers
- Transportation Research Board Committee ABC40, Transportation Asset Management

William H. Bushman, B.S., Civil Engineering; P.E.—Research Scientist
Areas of Expertise:
- Maintenance and construction operations
- Lead-based paint removal methods
- Chemical stabilization of unpaved roads

Memberships:
- Secretary, Transportation Research Board Committee AHD15, Maintenance Operations-Personnel

Rodney T. Davis, B.S.C.E., M.S.E., Ph.D., P.E.—Research Scientist
Areas of Expertise:
- Design and behavior of prestressed concrete bridges
- Bridge instrumentations and testing
- Investigations and inspections of structures

Memberships:
- Precast/Prestressed Concrete Institute Subcommittee on Full-Depth Precast Deck Panels

Brian K. Diefenderfer, B.S., M.S., Ph.D., Civil Engineering—Research Scientist
Areas of Expertise:
- Civil engineering materials
- Nondestructive evaluation
- Pavement maintenance and rehabilitation
- Pavement management
- Infrastructure condition assessment

Memberships:
- American Society of Civil Engineers
- Transportation Research Board

Thomas E. Freeman, B.S., M.S., Civil Engineering; P.E.—Senior Research Scientist
Areas of Expertise:
- Pavement design, construction, and management
- Forensic investigations
- Life-cycle cost analysis
- Truck weight limit studies

Memberships:
- American Society for Testing and Materials Committee E 17, Vehicle Pavement Systems
- Transportation Research Board Committee, Pavement Monitoring, Evaluation and Data Storage
- TRB Committee, Sealants and Fillers for Joints and Cracks

Edward J. Hoppe, B.S., M.S., Ph.D., Civil Engineering; P.E.—Senior Research Scientist
Areas of Expertise:
- Geotechnical engineering

Memberships:
- U.S./American Association of State Highway and Transportation Officials Representative and Secretary of World Road Association-PIARC Committee on Earthworks, Drainage, and Subgrade
- American Society of Civil Engineers
- ASCE Committee, Engineering Management and Business Practices
- National Cooperative Highway Research Program Panel, Flowable Fill
- Transportation Research Board Committee AFS20, Soil and Rock Instrumentation

Awards:
- 2003 Commissioner's Award for Excellence

Wallace T. McKeel, Jr., B.S., M.C.E., P.E.—Senior Research Scientist
Areas of Expertise:
- Bridge design
- Bridge maintenance
- Bridge management

Memberships:
- Member Emeritus, Transportation Research Board Committee A3C06, Structures Maintenance
- TRB Committee A3C17, Bridge Management Systems

Daniel S. Roosevelt, B.S., Civil Engineering; P.E.—Research Scientist
Areas of Expertise:
- Highway maintenance and operations
- Construction management
- Winter maintenance practices

Technical & Administrative Support Staff
T.M. Bagnall—Research Assistant, data reduction and analysis
Richard T. Childs—Engineering Technician, data reduction and analysis
Linda L. DeGrasse—Engineering Technician, geotechnical materials, pavements
Jonathan D. Evers—Lab and Research Technician, data reduction and analysis
James W. French—Engineering Technician, bridges
Phillip R. Haas—VDOT Summer Intern, data reduction and analysis
Wesley J. Keller—Research Associate, data reduction and analysis
Justin M. Morris—Research Assistant, data reduction and analysis
Lauren T. Nunnally—Research Assistant, data reduction and analysis
Vishal T. Patil—Engineering Technician, data reduction and analysis
David C. Simons—Research Assistant, data reduction and analysis
Penny Y. Sloope—Administrative & Office Specialist, administrative support, data compilation
Arthur J. Wagner—Engineering Technician, geotechnical materials
Megan C. Wheeler—Research Assistant, data Reduction and analysis
James T. Woodward—Research Assistant, concrete

Graduate Student
Matthew R. Tilley

APPENDIX:
RESEARCH ADVISORY COMMITTEES & THEIR MEMBERS

ASPHALT RESEARCH ADVISORY COMMITTEE

D. T. Lee, Chairman, District Materials Engineer, Salem, VDOT
G. W. Maupin, Jr., Executive Secretary, Principal Research Scientist, VTRC
I. L. Al-Qadi, Professor, Department of Civil & Environmental Engineering, VPI&SU
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M. K. Brittle, District Construction Engineer, Bristol, VDOT
L. Casanova, Program & Technology Engineer, FHWA
W. B. Coburn, Jr., Division Administrator, Scheduling & Contract Development, VDOT
R. W. Crandol, Resident Engineer, Ashland, VDOT
D. H. Grigg, Jr., District Construction Engineer, Lynchburg, VDOT
G. A. McMillan, District Maintenance Engineer, Fredericksburg, VDOT
A. Mergenmeier, Division Administrator, Materials, VDOT
D. C. Morris, District Materials Engineer, Staunton, VDOT
H. I. Shami, District Materials Engineer, Culpeper, VDOT
D. P. Shields, District Materials Engineer, Northern Virginia, VDOT

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W. F. Dotson, Assistant Division Administrator, Structure & Bridge, VDOT
H. D. French, Architect/Engineer Manager, Lynchburg, VDOT
P. D. Gribok, Resident Engineer, Chesapeake, VDOT
M. T. Kerley, Jr., Chief Engineer for Program Development, VDOT
D. F. Komara, Resident Engineer, Harrisonburg, VDOT
G. J. Lovins, District Structure & Bridge Engineer, Bristol, VDOT
C. S. Napier, Division Structural Engineer, FHWA
C. D. Riffe, District Materials Engineer, Fredericksburg, VDOT
D. B. Sprinkel, District Structure & Bridge Engineer, Culpeper, VDOT
J. F. Volgyi, Jr., Assistant Division Administrator, Structure & Bridge, VDOT
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N. D. Widgen, District Structure & Bridge Engineer, Salem, VDOT

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D. W. Nester, Quality Control Engineer, Scheduling & Contract Division, VDOT

M. B. Pritchett, Structural Engineer Supervisor, Structure & Bridge Division, VDOT
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F. R. Giles, Assistant Division Administrator, Management Services, VDOT
H. E. Gregori, Assistant to the Director, Department of Environmental Quality
M. Holma, Architectural Historian, Department of Historic Resources
E. E. Hull, Deputy District Administrator, Northern Virginia, VDOT
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B. Moyer, Wildlife Biologist, Department of Game & Inland Fisheries
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A. F. Opperman, Preservation Program Manager, Environmental Division, VDOT
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E. Sundra, Environmental/Air Quality Engineer, FHWA
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Q. D. Elliott, Division Administrator, Asset Management, VDOT
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L. Casanova, Program & Technology Engineer, FHWA
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TRAFFIC RESEARCH ADVISORY COMMITTEE

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W. D. Ealding, Scientist Manager, Materials Division, VDOT
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T. Jennings, Transportation Systems Management Engineer, FHWA
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