



Spring 2010

RESEARCH Showcase



**Reducing Nitrogen Load
BRIDGE Application
Vibrations Specifications**



Spring 2010

The Florida Department of Transportation (FDOT) Research Showcase is published to inform transportation professionals and friends of FDOT about the benefits of FDOT-funded research.

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Back Cover: Bayard Conservation Area on the St. Johns River, St. Johns River Water Management District

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FDOT Research Showcase

From the Manager...

One of the challenges that faces a dynamic transportation research program is how, within its limited resources, to meet and balance the diverse needs of the organization. FDOT's Research Center has, since its inception, regarded its mission as facilitating research to improve and protect Florida's transportation system. The Research Center is uniquely positioned to assist FDOT to meet new challenges and fulfill its mission to provide a safe transportation system that ensures the mobility of people and goods, enhances economic prosperity, and preserves the quality of our environment and communities. Each issue of Research Showcase includes examples of projects that cover a broad array of transportation subject areas, each of which is designed to advance FDOT's mission.

The cover story demonstrates how research performed by the Stormwater Management Academy provided both environmental and economic benefits by presenting a rational basis for eliminating the use of fertilizer in select areas of right of way. Two other articles address research that explored ways to improve planning processes through evaluating opportunities for enhancing key tools: these projects developed solutions that have increased efficiencies, saving time and money. The final article in this issue presents research that resulted in the development of a specification that reduces construction delays on certain types of projects, which saves time and money.

Included in each issue of Research Showcase is a profile of a project manager, a principal investigator, and a research partner. It is through relationships with these people and institutions that the research program is able to achieve the successes that it does. Please take time to read these articles to see the valuable work that they contribute within and the benefits that they provide to, and often beyond, the transportation community.

Darryll Dockstader

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District 2 Reduces Nitrogen Load, Saves up to \$1 Million Annually

Many surface water bodies in Florida are polluted with excessive nitrogen and phosphorus. Applied as fertilizer to turf and landscape plants, excess nutrients are deposited into rivers, lakes, and other surface water bodies through stormwater runoff.

These nutrients cause algal blooms and deplete oxygen levels in surface waters, which, consequently, do not meet water quality requirements for recreational use or for the propagation and maintenance of a healthy and well-balanced fish and wildlife population.

The Florida Department of Environmental Protection (FDEP) has established a program to implement Basin Management Action Plans (BMAPs) that address the reduction of pollutants in surface waters. BMAPs are designed to achieve compliance with pollutant loading limits established by the federal Total Maximum Daily Load (TMDL) regulation. BMAPs are blueprints developed by local stakeholders for restoring impaired waters. They represent a comprehensive set of strategies (e.g., permit limits on wastewater facilities, urban and agricultural best management practices, conservation programs, financial assistance, and revenue generating activities) designed to implement the pollutant reduction targets established by the TMDL.

The Lower St. Johns River (LSJR) BMAP was adopted in September 2008 in partnership with FDOT, the St. Johns River Water Management District, local industry, cities, counties, environmental groups, and other stakeholders. Located in FDOT District 2, the basin encompasses 2,750-square miles.

The LSJR BMAP identifies sources of nutrients that discharge both directly and indirectly (e.g., through



Freshwater algal blooms are the result of an excess of nutrients, such as nitrogen and phosphorus. Algae grows quickly under high nutrient availability. Each algal bloom is short-lived, and the result is a high concentration of dead organic matter. The dead organic matter consumes dissolved oxygen in the water. Without sufficient dissolved oxygen, animals and plants may die off in large quantities. Pictured here is an algal bloom in the Caloosahatchee River, Fla., in June 2008.

soil) into the Lower St. Johns River. It also identifies management strategies necessary to achieve the nutrient TMDLs for the main stem of the river from the confluence of the Ocklawaha River north to the mouth of the river.



The Lower St. Johns River Basin located within the St. Johns River Water Management District

The LSJR BMAP recommends various project opportunities for reducing nutrient loading, such as upgrading wastewater treatment plants, redirecting wastewater discharges to beneficial reuse (e.g., non-potable applications such as irrigation), and retrofitting stormwater facilities.

The LSJR BMAP assigns nitrogen reduction responsibility to FDOT District 2 for nutrient loads associated with state roads and FDOT-managed stormwater treatment facilities. It directs FDOT to remove 18,472 pounds of nitrogen per year from stormwater runoff to meet its proportional share of the nitrogen reduction identified for the Lower St. Johns River.

If FDOT is unable to develop projects to reduce nitrogen by this amount, the plan requires FDOT to purchase TMDL credits to meet its pollutant load allocation. The cost of the credits could range from \$500,000 to \$1,000,000 per year for 20 years, at which point a new plan cycle would begin.

In District 2, the standard practice was to apply a 12-3-6 fertilizer mix, at an annual rate of 500 pounds per acre, to the 15 feet adjacent to pavement edges of all FDOT-maintained roads. The purpose of this practice was to ensure a healthy roadside turf and prevent erosion. FDOT needed to know how much of the nitrogen in the fertilizer being applied was finding its way to surface water bodies through runoff.

FDOT contracted with the University of Central Florida's Stormwater Management Academy to study this phenomenon, known as nutrient washout. The Stormwater Management Academy is a leading source for stormwater management research, developing and delivering some of the most innovative subject matter education and training programs in the nation. Since its inception in 2002, the academy has been working with local, state, and federal agencies to study and deliver better methods of pollution control.

Dr. Manoj Chopra led a team of researchers at the academy in an effort to estimate the quantity of nitrogen that enters water bodies through runoff containing nitrogen from roadside fertilization.



The outdoor rainfall simulator at the Stormwater Management Academy, University of Central Florida in Orlando is the largest in the world and part of the UCF Stormwater Management Academy lab. It consists of an 8-foot-wide by 30-foot-long arrangement of pipes that are connected to a 1,500-gallon water tank. The simulator sprays water onto a bed of sod or soil that can be set at different slopes to study runoff.



The UCF Stormwater Management Academy rainfall simulator can release up to the equivalent of 20 inches of rain an hour and produce the drop size and intensity of rainfall common to semitropical areas and also northern rainfall. It allows researchers to study how water falls on different surfaces, and how it runs off and dislodges particles that can become sediment, clogging drains and polluting surface and ground waters.

The researchers examined soil composition, slope, moisture level, and vegetation cover, and assumed an annual rainfall of 50 inches to ascertain pollution levels due to fertilizer application. Using the results of the research, District 2 determined that of the 112,020 pounds of nitrogen applied annually to roadsides, 18,477 pounds wash into surface waters. This amount is slightly more than the load reduction target of 18,472 pounds identified in the LSJR BMAP. Consequently, FDOT determined that it could meet its TMDL target simply by ceasing to apply fertilizer to roadside vegetation.

In addition to the substantial savings resulting from not having to purchase TMDL reduction credits, utilizing this approach to comply with the LSJR BMAP requirement would result in FDOT saving approximately \$150,000 per year in fertilizer and application costs.

Additional research at the academy is focusing on the evaluation of best management practices for

maintaining healthy roadside turf. The researchers hypothesize that the natural content of nitrogen in north Florida soils and the nitrogen deposition in rainfall are sufficient to accommodate discontinuation of fertilization without adversely affecting turf health. FDOT anticipates that other districts will apply the results of the academy's research to meet nutrient reduction requirements. The result will be increased environmental benefits and cost-effectiveness of maintenance practices.

For more information contact Rick Renna, P.E., State Hydraulics Engineer, Office of Roadway Design, FDOT, phone (850) 414-4351, e-mail rick.renna@dot.state.fl.us. ●



FDOT Research Project Develops New Straight-Line Diagram Application

When it comes to reviewing large amounts of technical data about a highway, a picture is worth a thousand words. For more than 60 years, Florida Department of Transportation planners, engineers, and technicians have relied on the straight-line diagram (SLD) to help analyze roadway data. The SLD applies technical information about a selected segment of a road and displays the features and characteristics in a straight line.

To keep pace with improvements in technology, FDOT contracted researchers from the University of South Florida to develop a new SLD application, reducing the amount of time needed for post-production while providing an enhanced product.

“Historically, straight-line diagrams have been extremely tedious and time-consuming to produce,” said Rodney Floyd, FDOT project manager for the research. “Until 1988, they were drawn by hand, taking a week or more to make one diagram. With this new software, you can complete a diagram within a few minutes to a few hours depending on the complexity. Most people find the diagrams easier to read than traditional construction plans.”

SLDs are generated using data from the Roadway Characteristics Inventory (RCI). With more than two million records, the RCI is FDOT’s largest database. It tracks a range of highway assets, including lane information, roadway signs, signals, lighting, guardrails, barriers, pavement, shoulders, intersecting roads, and medians. Data is recorded on 75 asset features, which are described by 271 characteristics. Each roadway is indexed by a unique ID number with beginning and ending mile points.

“The most important factor of the new SLD application is that it provides a flexible procedure for

customizing the SLD,” said John Lu, professor of civil and environmental engineering at the University of South Florida (USF) and principal investigator for the project. “In the older SLD application, the operator had few options to specify SLD output attributes.”

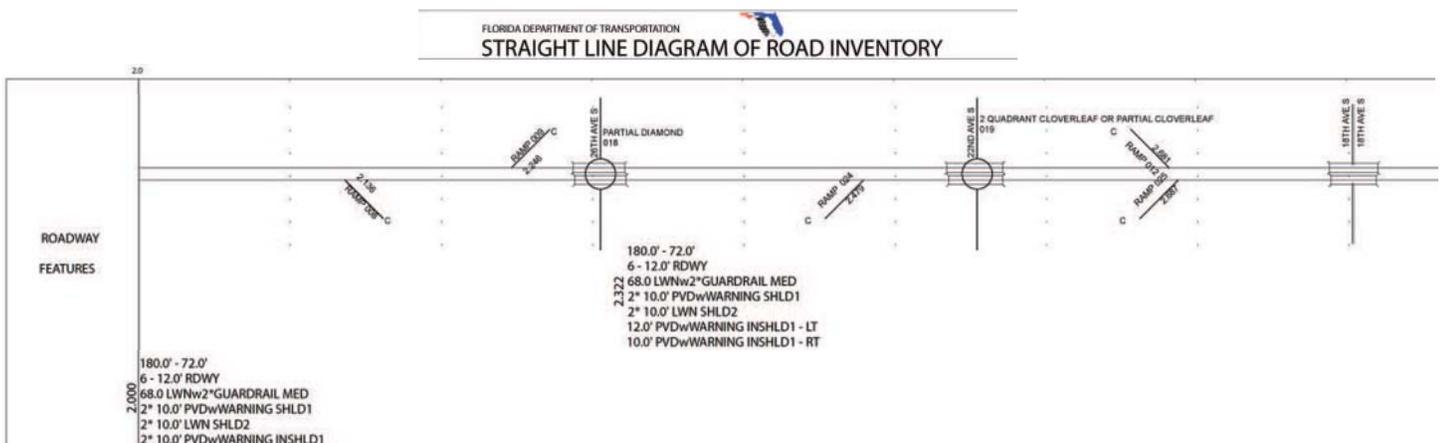
Zhenyu Wang, a USF research assistant professor of civil and environmental engineering and developer of the software, said that having the ability to customize the output was the single most requested improvement by SLD producers.

Wang said other features of the new software include a user-friendly Web interface, a wizard to allow operators to follow pre-defined steps, and a direct connection to the RCI database to avoid downloading new data manually each time the database is updated. Future enhancements to the software may incorporate additional data sources and improved customizing functions.

Each FDOT district office generates SLDs for the counties within its district. By this summer, employees who produce SLDs will be able to access the new application, called Straight-Line Diagrammer, via the FDOT Intranet. Customers outside of FDOT, including local governments, developers, law enforcement agencies, and emergency medical service providers to name a few, may obtain SLDs by contacting the statistics administrator in their district.

“Although the new application is designed for the SLD producer,” said Floyd, “the benefit to FDOT customers is a better looking, more informative document.”

For more information contact Rodney Floyd, Manager, Highway Data Collection/Quality Control, Transportation Statistics Office, FDOT, phone (850) 414-4702, e-mail rodney.floyd@dot.state.fl.us. ●



BRIDGE Bridges the Gap

New Method Links SIS-EST and ESIS Databases

In 2003, the Florida Legislature created the Strategic Intermodal System (SIS), a high-priority network of transportation facilities vital to Florida's economic competitiveness and quality of life. The SIS comprises the state's largest and most critical transportation facilities, including major airports, space centers, ports, railways, and highways. The SIS facilities are the primary means for moving people and freight between Florida's diverse regions, and between Florida and other states and nations.

The framework for SIS designation reflects five key principles:

1. Emphasize interregional, interstate, and international travel and transport.
2. Use objective measures of transportation activity that reflect national and industry standards.
3. Consider the economic requirements of key Florida industries.
4. Identify transportation facilities emerging in importance.
5. Screen for responsible environmental stewardship.

FDOT's Environmental Management Office plays a key role in addressing the fifth principle and has processes in place to ensure that screening methods properly assess how a proposed facility will impact community livability, land use, air quality, natural resources, cultural and historic sites, and agricultural uses.

One tool developed to this end is the SIS Environmental Screening Tool (SIS-EST). Planners and environmental staff use this tool to evaluate proposed changes to designated SIS facilities and assess the potential impacts of the changes on natural, physical, cultural, and community resources.

The SIS-EST is a web-based GIS application that provides access to several hundred databases that contain maps, reports, analytic tools, and methods to capture agency comments and evaluate recommendations. The SIS-EST provides a set of tools to input and update information about transportation projects, perform standardized analyses, gather and report comments about potential project effects, and provide information to the public.



Log-in screen to the SIS-EST application

Proposals to change SIS facilities often require staff to evaluate several alternatives. For example, for a given planned improvement, several routes may be analyzed for potential impacts to determine the best option.

Each alternative could consist of multiple facility types, such as roads, railroads, bridges, bus stops, and airports. Planners evaluate each alternative and facility type against various features in the standard enterprise SIS (ESIS) database. These evaluation processes are followed to achieve the optimal transportation system enhancement.

FDOT recently contracted the University of Florida (UF) to study methods to link the SIS-EST and the ESIS databases. Alexis Thomas, Director of Operations at the GeoPlan Center at UF investigated opportunities to expand upon existing SIS-EST toolsets and develop interoperability among the different databases used to perform project evaluations. The result is BRIDGE.

The BRIDGE application was designed to enhance the ESIS database, analyze the facilities contained within it, and provide recommended actions back to ESIS to aid FDOT decision-making. This functionality was accomplished without requiring additional modifications to either ESIS or SIS-EST. The BRIDGE schema also links to another GIS application, the Efficient Transportation Decision Making (ETDM)/Environmental Screening Tool (EST), which is used by review

agencies and the public to provide comments to FDOT regarding potential impacts of proposed major transportation improvement projects.

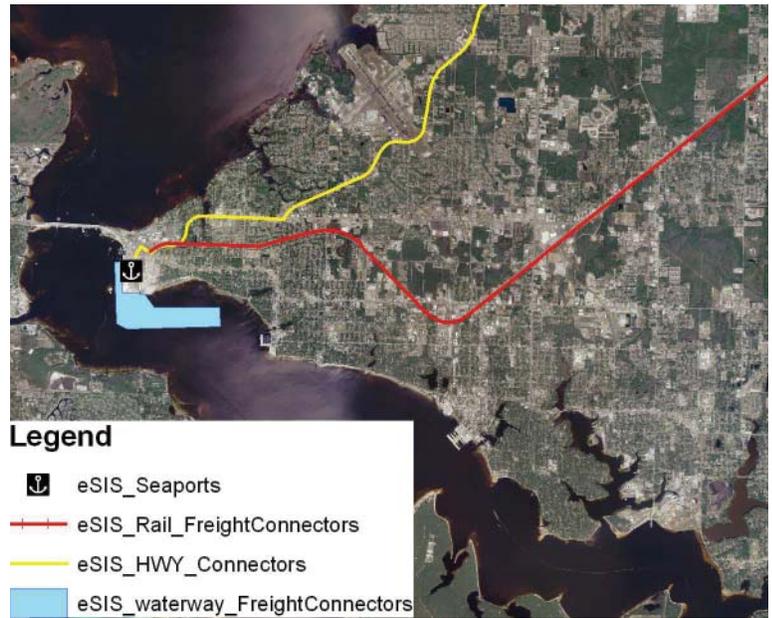
BRIDGE contains the bare bones database infrastructure necessary to perform GIS analysis and provides for specific SIS-EST needs. BRIDGE has the ability to integrate and combine disparate geographic features (e.g., bridges, roads, ports) into a collection of related features and then to analyze them as a single entity. Before BRIDGE was available, each collection of features was analyzed independently and then combined.

In many cases, this combining process would result in double counting potential impacts if and when different feature types that were combined overlapped: for example, a port and the road leading into the port might have impacts on a given area, such that their impacts overlap and could be counted twice, which would adversely affect evaluations. BRIDGE automatically prevents unintended double counting.

BRIDGE also allows users to evaluate individual components of a project, rather than being constrained to evaluating the project as a whole. Users can immediately pinpoint problem areas and remedy the problems by identifying alternative routes and facilities. Users also can customize BRIDGE to define analysis parameters, criteria, input data, and buffer distance, which expedites project application development and provides flexibility. Users can customize analyses simply by changing values on a form, which updates the database tables to reflect varying buffer distances, or selecting alternatively desired spatial layers needed for analysis.

By enabling ESIS, SIS-EST, and ETDM/EST to communicate electronically, BRIDGE has significantly increased process efficiencies. Reviews of proposed changes to SIS facilities that previously took planners a week to complete can now be completed in a day.

For more information, contact Peter McGilvray, Technology Resource Manager, FDOT, phone (850) 414-5330, e-mail peter.mcgilvray@dot.state.fl.us.



The above screen shot depicts a roadway and a railroad connector that potentially could require improvements based on proposed changes submitted by the Port of Panama City. Prior to the creation of the BRIDGE database application, each facility had to be analyzed individually, often resulting in the miscalculation of effects to the facilities due to overlapping impacts at the point where the port, the roadway, and the railroad converge.



The above screen shot depicts each type of facility (waterway connector, roadway, and railroad) being combined into a single project (pulling lines and polygons into a single layer), which is then analyzed as a whole, resulting in a more accurate estimate of potential impacts at the point where the port, the roadway, and the railroad converge.

Our Research Partner: Bridge Software Institute

In the early 1990s, the FDOT Research Center began funding research at the University of Florida (UF) Department of Civil and Coastal Engineering to develop new bridge analysis and design software that would dramatically increase the accuracy of bridge analysis and design. At the time, the prevailing practice called for engineers to use eight pieces of software to design and analyze bridge substructures. For a typical, fairly complicated substructure design, just one configuration could take up to two weeks to design and determine accurate loads. The ambitious goal of the research was to develop a way to collapse these applications into one.

The software, known as FLPIER, a DOS-based, three-dimensional soil structure interaction analysis program, was a huge success. It could create and evaluate three to ten models per day and perform accurate analysis of design loads. This software gave engineers the ability to design bridges with a much higher degree of confidence and obtain more accurate assessments of design loading conditions, resulting in both time and materials savings. One of the first bridges designed using FLPIER resulted in an estimated savings of \$2 million in construction costs.

In January 2000, FDOT collaborated with UF to develop a strategy to maintain and further enhance the capabilities of FLPIER. The result was the creation of the non-profit Bridge Software Institute (BSI). The goal of BSI is to transform the understanding of modern bridge engineering technology through advanced research and software development, to pave the way for innovation in bridge design.

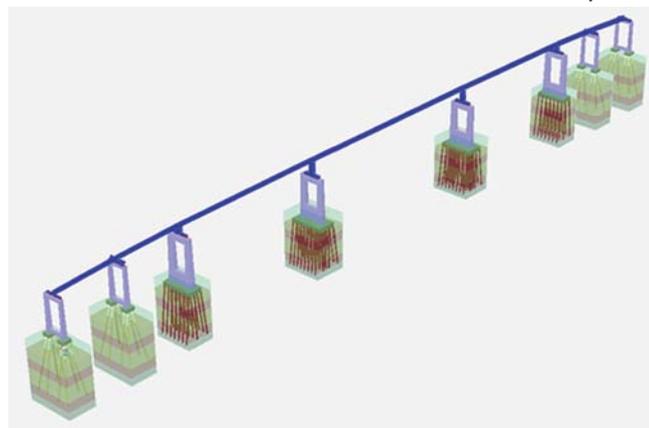
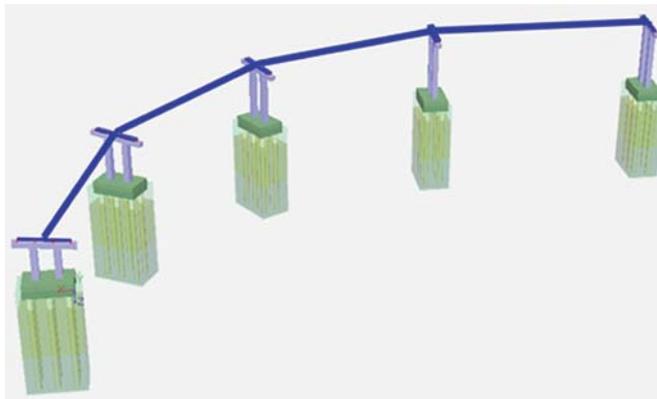
Soon after its establishment, BSI converted FLPIER into a Windows-based program



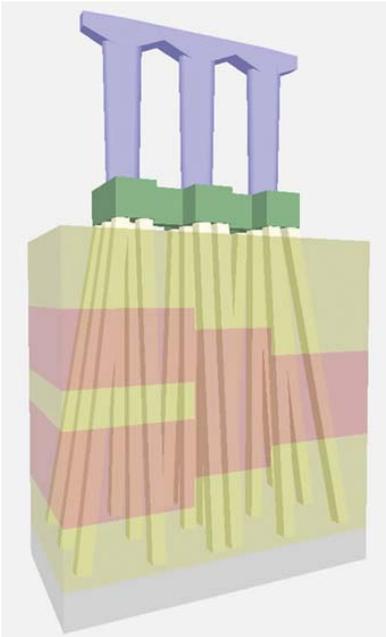
and renamed it FB-Pier. Beyond analyzing bridge pier structures, FB-Pier could analyze features outside of the realm of standard bridge design. For example, FB-Pier could analyze mast arm applications, high mast lighting and signing foundations, sound wall foundations, retaining wall applications, different pile cross sections, and pile bent modeling.

Since its establishment, BSI has developed other bridge-related software programs, including an upgrade to FB-Pier that allowed it to generate multiple piers in an automated process and subsequently to analyze an entire bridge simply by changing pile layout, materials, and geometric configurations of the pier structures. Dubbed FB-MultiPier, this program can also analyze second order effects, such as impact forces from collisions, buoyancy, wind, and other load types, to solve large-scale extreme event bridge engineering problems.

BSI also maintains two other products developed through FDOT-sponsored research conducted at UF: FB-Deep and the FDOT Geotechnical Database. FB-Deep is a geotechnical engineering design program that analyzes and estimates deep foundation axial capacity for driven piles and drilled shafts using boring data accumulated from standard penetration tests (SPT), cone penetration tests (CPT), and rock core strengths conducted at project locations.



Top: 3D Model of a curved bridge model using FB-MultiPier
Bottom: 3D Model of a complete bridge structure using FB-MultiPier



3D view of general pier model using FB-Pier

FB-Deep has been adopted by many DOT agencies in the nation.

In 2007, UF concluded a study (BD545-43) that evaluated pile design methodologies, with the goal of expanding the data sources that could be used to determine pile and drilled shaft capacities. The principal investigator for the study, Dr. Michael McVay, serves as a co-director of BSI and was able to leverage the research results to provide the

additional benefit of improving the FB-Deep program. This compounding of the benefits of research results is not unique. Dr. Gary Consolazio, a colleague of Dr. McVay and also a co-director of BSI, has performed several FDOT-sponsored studies that have translated into opportunities for advancing BSI products. More notable among these are the barge-bridge impact studies performed on and subsequent to the decommissioning of the St. George Island Causeway Bridge, the results of which were used to enhance the FB-Pier software.

The FDOT Geotechnical Database is a valuable resource that contains geotechnical and construction data for piles and drilled shafts. The value of the database increases with the input of additional data, which can be used for various engineering purposes. Because the structure of the database requires application software to be compatible with its specific hierarchy of data, other programs such as FB-MultiPier are not capable of utilizing the data. Currently, BSI is working with FDOT to improve the FDOT database system to be more robust and easier for users to search data. Within a year, BSI expects to make the FDOT Geotechnical Database available to the public. Within two to three years, BSI expects to expand the capability of FB-MultiPier to be compatible with the database.

BSI has assisted in the development and enhancement of other software programs developed through UF research:

- Pile Technician: a program developed for use by inspectors in the field to provide a fast and efficient

manner of entering pile data to calculate payment for work preformed.

- ATLAS: an analysis/design program used to analyze and design signal lights and signs supported by the dual cable system.
- BRUFEM: a program used to perform automated finite element modeling, analysis, and load rating of highway bridges using a complete 3-D model.

BSI's director, Dr. Jae Chung, describes BSI's success as a perfect example of collaboration among academia, industry, and state government. "Without FDOT's sponsorship and feedback from the transportation industry, BSI's success would not be possible," he said. "BSI links leading-edge knowledge gained through research and development at the university with technology used in practice. BSI is a catalyst in the transfer of technology to the bridge engineering community, where bridge engineers can actually use the research findings. Thus, the public will be the ultimate beneficiary of cost savings through leading-edge technology." Dr. Chung hopes that within ten years, BSI's suite of products will be in widespread use throughout the bridge design industry.

Currently, BSI is self-sustaining and leads the bridge engineering community in software development. Its products have saved tens of millions of dollars in construction costs through more efficient bridge designs. BSI's products are used by engineers in state transportation agencies and leading consulting firms across the nation, and also by engineers in over a dozen countries around the world. BSI has also provided its products free of charge for teaching and research purposes to universities, both nationally and internationally.

For more information about BSI, contact Jae Chung, Ph.D., Bridge Software Institute, at jchun@ce.ufl.edu, or visit <http://bsi-web.ce.ufl.edu>.



Dr. Jae Chung, Director, Bridge Software Institute

Meet the Project Manager

Rick Renna, State Hydraulics Engineer
Office of Roadway Design

"If it's water, it's us." That's how Rick Renna summarizes the function of FDOT's Central Office Hydraulics Section. As FDOT's State Hydraulics Engineer since 2001, Renna works to better understand the forces of water that affect Florida's highway infrastructure.

Renna began his career with FDOT in District 4's Construction Office in 1974. He earned an engineering degree from Florida International University and became a registered professional engineer in 1987. He has worked in hydraulics design ever since.

Renna has been a very active research project manager. Over the last 10 years, he has managed over two dozen research projects related to bridge scour, stormwater management, pipe performance, hurricane hydraulics, and other subjects. Following the 2004 hurricane season and devastation of the I-10/Escambia Bay Bridge, Renna collaborated with Dr. Max Sheppard (University of Florida) to investigate the effects of storm-generated vertical and horizontal forces on bridges and developed predictive equations to design bridges able to resist storm forces. In 2008, the American Association of State Highway and Transportation Officials (AASHTO) adopted the wave forces equations, which were incorporated into the document, "Guide Specifications for Bridges Vulnerable to Coastal Storms."

Renna has championed a better approach to predicting scour in clay and rock. Florida's bridge foundations had been designed based on the known rapid rate that sand scours. Renna managed research to better define scour rates for clayey and rock soils and developed testing mechanisms to measure the actual rate of scour for site specific soils. He managed subsequent research that developed scour-depth prediction equations for the most common bridge foundations constructed in Florida. These research efforts on bridge scour are estimated to have saved tens of millions of dollars on bridge substructure costs.

Renna recalls working with local governments and citizens on two memorable and successful projects



to solve drainage problems. The first involved recurring flooding of a school, businesses, and an interstate highway during heavy rains in the cities of Hollywood, Pembroke Pines, and Hallandale. Renna designed a project to eliminate the flooding, whereby FDOT installed a \$10 million pumping station and related infrastructure, and tunneled an 84" pipe under the highway. Renna successfully negotiated an agreement with the local governments to maintain the system.

The other project involved the flooding of SR 70 in St. Lucie County, which would often become

impassable during heavy rains. Renna worked with regional cattle ranchers and the county to design a regional canal; FDOT raised the road, installed cross culverts, and connected it to the ranchers' existing canal systems. The fill excavated to construct the canal was used to raise the roadway to mitigate flooding in the rainy season. The water retained in the canal was used by farmers for livestock and crops during the dry season. In addition to these improvements, FDOT saved approximately \$5 million by reusing excavation material to raise the road.

Renna has also managed several research projects conducted by the Stormwater Management Academy (SMA), located at the University of Central Florida (UCF). These studies have produced significant environmental and economic benefits, most recently in helping FDOT comply with the Florida Department of Environmental Protection's (FDEP) new stormwater treatment rule to reduce nutrient loading. Renna worked closely with the Research Center, FDEP, and UCF to establish the SMA in 2002, and he currently serves on its board of directors.

Renna chairs FDOT's stormwater management coalition with FDOT's Design and Environmental Management offices and AASHTO's Technical Committee on Hydrology and Hydraulics. In 2010, Renna was awarded FDOT's Bridge Engineering Award. ●

Meet the Principal Investigator

Mubarak Shah, Professor in Electrical Engineering and Computer Science, University of Central Florida

Mubarak Shah is a man with a special vision. His research focuses on giving computers the ability to see.

Shah is founding director of the Computer Vision Lab at the University of Central Florida (UCF) and Agere Chair Professor of Computer Science. The lab is world-renowned for its research in computer vision systems, human activity recognition, object and scene detection, and crowd analysis.

Current projects include unmanned aerial vehicle video analysis for the U.S. Department of Defense, biomedical image analysis for the National Institutes of Health, and visual analysis of crowds for the Army Research Office.

"We want to find real applications for our research and work with companies and industry who are also interested in applying technology," Shah said.

For FDOT, Shah's research team built a visual surveillance system to automatically monitor the motion of pedestrians, bicyclists, and vehicles entering a railroad crossing. The computer vision system tracks objects and analyzes activity in an effort to reduce the likelihood of a crossing accident. The system can sound an alarm to warn a detected party and transmit the warning message to appropriate authorities, such as law enforcement.

"Dr. Shah always took the time to make sure details were understood by FDOT staff and questions were answered appropriately," said Clipper Tefft, FDOT project manager for the study.

In an ongoing FDOT project, Shah's team has developed a computer vision and pattern recognition system to assess railroad track compliance with federal safety standards.

"Dr. Shah is very responsive to our needs and can assemble the right team to do the project," said Michael Dowell, FDOT project manager for the study. "Our staff works closely with his staff to fully understand the project needs, resulting in a complete product for FDOT utilization."

Shah's researchers installed a computer with sensors and lasers on a vehicle used for rail inspections. The lasers check the distance between two rails for



standard gauge – a width of 56.5 inches. The system sounds an alarm if it finds a problem.

Wide gauge is a leading cause of derailments. Since wide gauge can be difficult to detect with the human eye, which is subject to fatigue, an automated system aids the work of rail inspectors by providing an electronic eye, thus enhancing detection and increasing the length of track that can be inspected. Researchers are currently developing a camera system capable of visually inspecting for additional defects such as missing bolts and cracks.

"These projects are good examples of how computer vision technology can be applied in transportation," Shah said. "The researchers, visiting scholars, and students who work in the lab not only publish high-quality journal articles but excel in applied research."

Shah also helps to train the next generation of research scientists. He participates in two National Science Foundation (NSF) programs to attract talented undergraduates and high school students.

NSF has designated the Computer Vision Lab as a site for its Research Experiences for Undergraduates (REU) program. The lab has administered REU since the program's inception in 1987. Close to 200 undergraduate students from more than 25 different U.S. schools have participated and co-authored more than 70 research papers with Shah, Professor Niels Lobo from UCF, and colleagues from other universities.

"The REU program helps strengthen recruitment in science and engineering fields, which often experience difficulties in attracting students," Shah said. "The students take initiative and realize having a published paper is great."

Shah is also involved in the NSF Pictures Represent Opportunities for Inspiration in Technology (PROFIT) program at UCF led by Professor Lobo. The program introduces computer vision and imaging into high school mathematics curriculums.

"I like what I do, especially because I work with smart, young students on many different projects," Shah said. "When they are finished, they are leaders, and I can be proud of them." ●

Vibrations Specifications for Freshly Poured Concrete Save Time and Money

Installation of deep foundations typically occurs in two ways in Florida. Precast concrete piles can be driven into the ground, or casings can be driven into the ground, the soil within the casing excavated, a reinforcing cage placed, and the hole filled with fresh concrete to form a drilled shaft. Both techniques induce ground vibrations with varying intensities. Other construction activities, such as the use of compactors during the placement of base material and asphalt, also induce ground vibrations.

Prior to 1999, FDOT specifications restricted pile driving within 200 feet of freshly poured concrete in drilled shafts less than two days old because of concerns that vibrations could compromise the hardening and strength properties of fresh concrete. However, because no empirical evidence was available to support the time and distance restrictions, they were perceived as unsubstantiated and costly. The restrictions were removed pending further study.

In 2000, researchers at Florida Atlantic University (FAU) examined the effects of vibrations on freshly poured concrete within 24 hours of placement to determine how vibrations affect concrete strength. The research consisted of laboratory testing, field testing, and data analysis. The tests revealed that vibrations up to 2.5 in/sec do not damage fresh concrete at a distance of two times the shaft diameter and beyond. Researchers concluded that construction vibrations should be avoided within a distance of three times the shaft's diameter.

Having established distance recommendations, FDOT's State Materials and State Construction offices worked with Florida Agricultural and Mechanical University-Florida State University (FAMU-FSU) College of Engineering researchers in 2003 to conduct additional laboratory tests. The purpose of the supplemental research was to determine acceptable vibration velocity at the distance recommended by FAU before the final set of fresh concrete occurs. Researchers determined that, during the length of time necessary for fresh concrete to obtain its final set, no vibrations exceeding 2.0 in/sec should occur within a distance of three times the diameter of the shaft from the location of fresh concrete.

With sufficient research data available, in 2007, FDOT adopted Specification 455-1.4, Standard Specifications



A series of drilled shafts reinforced with steel casings at the Bridge of Lions rehabilitation project, St. Augustine, Fla., 2008

for Road and Bridge Construction, establishing a maximum vibration velocity and the distance necessary between the source of vibrations and the fresh concrete to protect it from damage.

This specification directed that the distance between ground vibrations and fresh concrete should be three shaft diameters or 30 feet, whichever is greater. Compared to the previous specification of 200 feet, the 2007 specification reduces the distance restriction by 170 feet or 85 percent.

Both research studies found that vibration levels of 2.5 in/sec and 2.0 in/sec, respectively, would not adversely affect the properties of fresh concrete at the identified distance. The specification has been revised to include a conservative vibration level of 1.5 in/sec.

The specification provides that these distance and vibration limits are applicable until the fresh

concrete has attained its final set as defined by the American Society of Testing and Materials (ASTM C-403), typically between 12 and 15 hours depending on the mix design, from the time of placement. Compared to the previous specification that required construction activities to wait two days while concrete attained the final set, the current specification reduces the delay time by 33 to 36 hours, or approximately 75 percent.

The new specification has resulted in improved processes that reduce construction costs by reducing the time needed to construct bridges with drilled shafts, chiefly for projects that include parallel or adjacent structures in confined spaces.

For more information, contact Sastry Putcha, Ph.D., P.E., Geotechnical Engineer, State Construction Office, FDOT, phone (850) 414-4148, e-mail sastry.putcha@dot.state.fl.us. ●



Close-up view of a drilled shaft pier surrounded by a cofferdam that protects the area from water intrusion during construction, Bridge of Lions rehabilitation project, St. Augustine, Fla., 2008

For More Information

Nitrogen Load Reduction

BDK78 977-04, Evaluation of Pollution Levels Due to the Use of Consumer Fertilizers under Florida Conditions

Manoj Chopra, Ph.D., P.E., Principal Investigator
Rick Renna, P.E., Project Manager

BD521-04, Florida Manuals for Erosion and Sediment Control and the Creation of the Stormwater Management Academy Research and Testing Laboratory

Marty Wanielista, Ph.D., P.E., Principal Investigator
Rick Renna, P.E., Project Manager

Straight-Line Diagrammer

BD544-41, Roadway Data Representation and Application Development

John Lu, Ph.D., P.E., Principal Investigator
Rodney Floyd, Project Manager

BRIDGE Bridges the Gap

BD545-63, Environmental Digital Data Repositories Project

Alexis Thomas, Principal Investigator
Peter McGilvray, Project Manager

Bridge Software Institute

BD545-17, Evaluation of Existing Deep Foundation Performance Using the FDOT Database to Improve Current Design Methodologies

Michael McVay, Principal Investigator
Peter Lai, P.E., Project Manager

BD545-43, Updating FDOT's Pile/Shaft Design Procedures Based on CPT & DTP Data

Michael McVay, Principal Investigator
David Horhota, Ph.D., P.E., Project Manager

Vibrations Specifications for Freshly Poured Concrete

BC352-14, Effect of Vibration on Concrete Strength during Foundation Construction

Kamal Tawfiq, Ph.D., P.E., Principal Investigator
Sastry Putcha, Ph.D., P.E., Project Manager

WPI0510794, Effects of Vibration and Sound during the Installation of Deep Foundations

D. V. Reddy, Ph.D., P.E., Principal Investigator
Sastry Putcha, Ph.D., P.E., Project Manager

