Premier Issue
Spring 2007

RESEARCH Showcase

Disappearing Cargo

Electronic reporting helps recovery of stolen goods

also

Bridge-barge collision research,

Stormwater Management Academy

...and more

RESEARCH Showcase

Spring 2007

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

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In This Issue...

The Florida Department of Transportation's Research Center is one of the most exciting places to work in state government. The research program has developed many of the new and innovative transportation practices, processes, and technologies now implemented by the department. On occasion, we get home runs like FBPier, the bridge design software that was developed over several years and many research projects. That research has transformed the way bridges are designed in Florida, and it has resulted in multi-million dollar savings in the process. FBPier continues to be improved and will, in fact, benefit from the barge-bridge impact tests described in this publication.

In 2006, the Research Center closed out 50 projects affecting most of FDOT's functional areas. The projects are advancing the state of transportation practice in Florida in subjects ranging from public involvement processes to crack resistance in concrete. Some, like the *Computer Based Examiner Training and Certification Program* (BD550-04), which will advance the state of the art in motor carrier compliance officer training, and the *Guidebook for Start-up Transit Agencies* (BD549-14) are attracting national interest. The overall goal of the research program is to achieve a safer, more effective, and more efficient transportation system by advancing the processes, procedures, and products used to deliver and maintain it.

The Research Center is proud of the benefits that research provides to the mission of the FDOT, to the citizens of Florida, and to the larger transportation research community. *Research Showcase*, an FDOT Research Center publication, is being produced to better communicate some of FDOT recent research program successes.

This issue offers articles on research addressing freight theft management, low-profile barriers, automated pavement analysis, scour, and wave force analysis. There is also an article on one of FDOT's most exciting research projects: A full-scale barge-bridge impact experiment on a recently decommissioned bridge.

Other articles highlight the people and institutions involved in FDOT's research program. One features the Stormwater Management Academy, a center of excellence dealing with the problems and opportunities posed by stormwater. Years ago, the Research Center identified the need for such an academy. It convened a meeting of subject experts from FDOT, the Department of Environmental Protection, and the University of Central Florida (UCF), who agreed to partner in developing the academy, which was established at UCF and is acquiring a national reputation for excellence.

Please take time to read these articles to learn some of the things the department is doing to advance the state of the art in transportation.

Richard Long, Director

Florida Fights Cargo Losses with Electronic Reporting System

The Background

Around 6 a.m. one morning in 2002, two trucks sped along US 301 south of the Florida/Georgia line, pursued by a lone FDOT Motor Carrier Compliance officer. The truck drivers first tried to run the officer off the road. When the trucks finally stopped, the drivers fled into the woods.

Both trucks and their load of computers had been stolen the previous evening. The thefts had been reported promptly to the Florida Highway Patrol (FHP) through the cargo theft FaxAlert system. However, the FDOT officer believed he was just chasing speeders because the dispatcher was waiting until 7 a.m. to broadcast the alerts to the entire morning shift of FDOT officers and FHP troopers at the same time.

With that incident, Lt. Col. David Binder, deputy director of the FDOT Office of Motor Carrier Compliance, decided it was time to find a way to immediately send theft alerts to officers via their laptop computers.

The Solution

Cargo thefts alerts in Florida can now quickly reach law enforcement agencies statewide through the electronic freight theft management system (EFTMS). The goal is to improve the recovery of goods lost to cargo theft, which nationwide is a multi-billion dollar epidemic.

Thefts are reported through a secure interface on the FHP web site (https://reportcargotheft.fhp.state.fl.us). Information about the vehicle license plate number and description, the value of the cargo and equipment, the ID of the vehicle driver, and the case control number goes into an online database.

The immediate notification about theft information enables law enforcement officers to know in advance of a traffic stop that the vehicle is stolen. Additional officers can be brought in to assist, making each stop safer and more likely to result in the recovery of goods.

David Binder has been working with Lt. William Shiver of the FHP and engineering research associate Patrick Kerr at the University of Central Florida to develop and refine the EFTMS since 2003. The next version will feature Geographic Information System (GIS) tools that will allow the reports to be mapped individually or grouped into areas, which means that several thefts can be compared for details in common.

“The EFTMS is one of the latest and most progressive tools in the law enforcement arsenal and is a true public-private partnership,” Binder says, noting that 25% of the theft notices are sent by trucking companies or insurance companies. “The EFTMS will reduce costs for freight operators and ultimately for consumers.”

Thieves usually target consumer electronics, especially computers and cell phones. Cigarettes and food products such as frozen beef and seafood are also popular. Pharmaceuticals are the highest ticket items targeted, with loads valued over $4 million being stolen.

Since the introduction of the EFTMS, reported cargo thefts in Florida have declined 67%.

Binder explains that often thieves choose trailers that are parked over a weekend and not hooked up to a power unit. They bring their own power unit to steal the trailer.

"In other cases," Binder says, "the thieves know what they want to steal and stake out a distribution center for the product of choice and follow the truck to the first truck stop and steal the entire unit while the driver is in the truck stop."

Binder reports that the EFTMS has been very effective. He cites a trend in the number of dump truck thefts, almost 300 in one year, that was revealed by EFTMS reports. Using the EFTMS, a multi-agency task force was able to target where and when the thefts typically took place. During one weekend, the task force recovered five stolen trucks and trailers.

The ability to generate intelligence concerning trends makes it possible for law enforcement to aggressively pursue cargo thieves, so much so that since the introduction of the EFTMS, reported cargo thefts in Florida have declined 67%. The EFTMS is serving as a model outside Florida, too. The US Department of Justice's Regional Information Sharing System is interested in the potential of national applications for the EFTMS.

The Research

The safe transport of cargo is vital to Florida's economy. Cargo theft, on the other hand, threatens economic vitality and is a persistent thorn in the sides of manufacturers, insurers, and law enforcement.

In 1992, a FaxAlert system was developed in Florida to facilitate the distribution of theft reports to appropriate law enforcement agencies. These reports were passed from one agency to the next via fax. To be effective, each receiving agency needed to have an employee available to ensure that the fax machine was on, functioning, and supplied with paper; to monitor it for receipt of reports; and to decipher the often illegible handwriting on the reports.

FaxAlert was producing positive results, but the steps involved, the massive amounts of paper required, and the constant monitoring, which often was not available, slowed its operation. A more sophisticated and effective means of reporting thefts that would lead to the rapid recovery of stolen goods was needed.

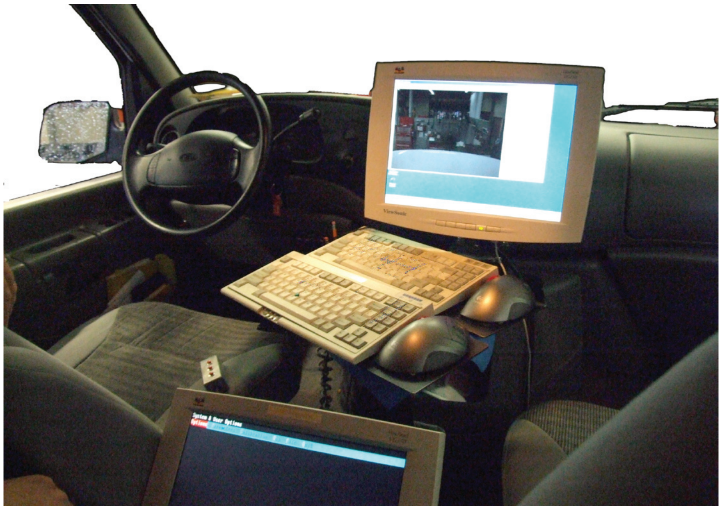
FDOT, in cooperation with the FHP, assembled a task force to develop a better system for quick, efficient statewide theft alerts. FDOT funded development of the EFTMS, which began in 2002 and was carried out by the Center for Advanced Transportation Systems Simulation (CATSS) at the University of Central Florida. In 2003, an enhanced FaxAlert system was implemented.

Follow-on research resulted in the creation of an FHP web page for on-line reporting of theft information directly to a Java-platform database where it can be accessed, updated, and referenced 24/7 by any law enforcement agency.

FDOT's Motor Carrier Compliance Office and the FHP then contracted CATSS to refine the system with a GIS application that uses GIS data from the Florida Geographic Data Library at the University of Florida. Map displays will be able to show individual theft locations within counties as well as aggregates of thefts over time in related locations. Querying tools will allow the data to be assessed for common factors. These enhanced features of the system are expected to be operational soon.

The EFTMS is already proving valuable to the law enforcement and freight transportation communities. It is a tool that has evolved significantly since its inception, and FDOT is continuing to support research to increase the sophistication of the database. Current research is being performed to enhance the search function, allow multiple thefts to be reported at one time, and improve the ability of the system administrator to manage the database. This research is expected to be completed later this year. ⬣

High-Tech Survey Van is Fast, Safe, and Thorough



Work station for the MPSV driver.

A Multi-Purpose Survey Vehicle (MPSV) developed through Florida Department of Transportation (FDOT) research is using lasers and cameras to quickly and inexpensively scan roadways for conditions that affect safety and ride quality.

The MPSV, a modified 10-passenger van, is getting an almost daily workout from FDOT districts that need to evaluate roadways for rehabilitation. While moving at highway speeds, usually about 60 mph, the van's lasers and cameras capture rut, roughness, pavement, and roadway images simultaneously. Exterior mounted lights even allow the van to work at night.

A position and orientation system records the cross-slope of the road, while lasers and accelerometers measure the smoothness of the ride by tracking the motion of the vehicle up, down, and sideways. An on-board computer records the data from the lasers, cameras, and positioning sensors for analysis.

Mobile surveying is a radical departure from the traditional methods of gathering data about roadway conditions. Traditional surveys are slow, expensive, and potentially dangerous to the crews.

As a case in point, one traditional survey job on I-75 in Florida cost $29,000/lane-mile to gather 444 data points. Lanes had to be closed, and traffic was impacted for several days.

In a comparison test, the van surveyed the same stretch of highway and gathered more than 1000 data points at a cost of $35/lane-mile. Processing the data from the van required only one or two days. It should be noted that the MPSV is most accurate on roads in good to relatively good condition. A recent study by the University of South Florida determined the average cross-slope accuracy - including new and old pavements - at speeds ranging from 45 to 65 miles per hour to be 94.24%.

Mobile surveying also eliminates the risk to road crews. In a separate incident, when a traditional survey crew was taking measurements to verify the van's data, one member of the roadside team was hit by a vehicle. While he was not badly hurt, the incident underscored the risk of exposure to roadside crews and validated the safety benefits provided by the survey van.

User feedback to date has been positive. The system is providing engineers with important data needed to optimize pavement design. The MPSV provides additional data and saves time and money, especially in applications for which it can replace the traditional method.

Front end laser array.

The use of automated survey vans is a growing trend around the country. A number of states are using data from their survey systems to enhance pavement management software, as well.

In a similar effort, and to expand the van's capabilities, FDOT research is exploring methods of accurately measuring pavement cracks by analyzing images taken by the van's systems. This is a difficult problem that requires advanced pattern recognition algorithms. Future advances to the van's capabilities are planned, and it is expected that in the future the MPSV will provide increasingly valuable contributions to managing Florida's roadways. ⬣

The MPSV on-board computer system. Automation allows data collection (and driving) to be handled by just one person.

A massive light array allows data collection at night.

Low-Profile Barriers for Roadside Work Zones

Florida is the fourth most populous state in the US and is growing rapidly. New developments and heavy tourist traffic require that new roads be built and old ones maintained regularly.

However, Florida's dense traffic can make roadway work zones dangerous. The National Work Zone Safety Information Clearinghouse ranked Florida in 2005 as second highest nationally in the number of construction and work zone fatalities, with a total of 162.

Safety barriers are commonly used to separate traffic from work zones. However, on low speed urban roads with side entries from cross streets and driveways, work zones need lower barriers that allow wide visibility. The FDOT initiated a project to develop low profile roadside barriers that would meet Federal Highway Administration (FHWA) safety standards.

The FHWA requires that all roadside barriers must pass a set of crash criteria established by the National Cooperative Highway Research Program. Therefore, the project had to create a barrier that would prevent a standard pickup truck of 2000 kgs (about 4500 lbs), or a small car of 820 kgs (1700 lbs), from penetrating the work zone during a crash, and do so without impact injuries to the vehicle's occupants.

Sloping ends will soon replace blunt barrier ends.

The barriers can be curved in any configuration needed.

The crash test criteria focus on issues of structural adequacy, occupant risk, and vehicle trajectory. The barrier system should smoothly redirect the vehicle so that it neither overturns nor intrudes into the work zone. FDOT further required that the barriers consist of segments that could be easily deployed in different configurations.

UF Civil & Coastal Engineering faculty Gary Consolazio, Kurt Gurley, and Ralph Ellis began the project and created several simulations that were computer tested before selecting one for actual crash testing. Full-scale crash testing confirmed the simulation results and the barriers were approved for use. The final version of the barrier became an FDOT design standard in 2005 and is now routinely used by the FDOT. Between January 1, 2005 and December 31, 2006, there were 22 FDOT road contracts that included this barrier as a bid item.

The final design has several advantages: At 18 inches high, it allows clear visibility for workers, pedestrians, and vehicle drivers. The 12-foot-long, 28-inch-wide concrete sections are linked with steel rods rather than bolted to the pavement, so that the force of a vehicle impact is distributed along the barriers. And the segments can be linked in straight or curved lines, as needed.

The links between the segments are somewhat flexible. When struck by a vehicle, the joints between the segments open a bit but stay in alignment so that the vehicle does not collide with the end of a segment. To reduce deceleration forces inside the vehicle, the barrier is allowed to slide about nine inches into the work zone upon impact.

Although the low-profile barriers are well designed, FDOT has requested a refinement of the barrier ends, which are vertical. Currently, the barrier has to be curved away from the roadway at the ends to prevent head-on collisions with the barrier ends. The research team is developing a tapered end treatment that will deflect a vehicle instead of bringing it to an abrupt stop that could injure passengers. The modified design has been tested through simulation and the prototype is being reviewed by FDOT. Once it has been crash tested and approved, the new barrier designs will be deployed. It is anticipated that the tapered end design will further reduce work zone injuries. ⬣

The linkage between barrier segments.

Barge Impact Tests for Better Bridges

The St. George Island Bridge; the old bridge is on the right.

Bridges across navigable waterways are at risk for collisions from vessels such as barges. A barge can strike bridge supports with more force than a hurricane. The impact can even bring down a bridge's superstructure, sometimes with fatal results.

Since 1991, bridges in the United States have been designed to resist vessel collisions according to standards developed by the American Association of State Highway and Transportation Officials (AASHTO). However, these standards are based on analysis procedures that were developed about 20 years ago.

By 2000, the Florida Department of Transportation (FDOT) felt it was time to develop updated analysis and design methodologies, especially as computer hardware and software advances had made it possible to do multiple dynamic structural analyses quickly and cost effectively. Data from full-scale collisions would be needed to calibrate dynamic simulations, but none were available. FDOT decided to arrange the first-ever, full-scale dynamic tests of a bridge/vessel impact.

A perfect testing site was available. The St. George Island causeway bridge near Apalachicola, Florida had been replaced and was due for demolition in 2004. A team led by Gary Consolazio of UF's Civil & Coastal Engineering faculty was chosen to conduct the test.

The team first created numerical models of the probable collision forces on the bridge. Then impact tests were conducted: A tugboat pushed a loaded barge into the bridge's piers 15 times.

Above and left: The barge approaches the bridge piling.

Sensors and high-speed data acquisition systems placed on the piers and the bow of the barge recorded the impact data. When analyzed, the data revealed something that was not entirely expected.

A comparison of the preliminary numerical model with the test data showed that current bridge design practice did not adequately account for inertia and the mass of the deck structure, which combine to generate additional resistance loads.

The initial model had focused on the stiffness and mass of the bridge piers. Including the effect of superstructure mass in the analysis of the impact data revealed that the pier column between the water line and the bridge deck level flexed more under impact than previously thought. In contrast, the test indicated that current design procedures for the embedded bridge foundations are reasonably accurate.

The research team is now using the test data to develop new software tools for analyzing piers under vessel impact. The new tools incorporate the effects of inertia and mass, and offer two approaches to bridge analysis. One approach represents the behavior of a bridge using modes of vibration. The other is a time/history analysis which adds a simplified model of barge behavior to a numerical model of a bridge's pier and soil conditions.

The tools will be added to the FB-Multipier design and analysis software, which was created by UF's Bridge Software Institute with FDOT sponsorship. FB-Multipier is a 3-D, non-linear, soil/structure interaction program used by engineers throughout the country.

Bridge designs nationwide will benefit from the dynamic approach to structural analysis these tools will provide. Correctly analyzing and capturing impact forces will help engineers create bridges that better resist collision forces, providing a more uniform level of safety. ⬣

After the bridge/barge testing was completed, the bridge served as the site for another FDOT research project. See story on the next page.

Bridge Pile Corrosion Testing

Bridges that cross coastal waters are at constant risk from salt water.

Salt water can permeate concrete bridge pilings as the bridge ages. If salt reaches the pilings' embedded steel reinforcement, it can cause severe corrosion, which can lead to spalling (flaking off) of the overlying concrete. Spalling weakens the pilings so that they cannot reliably support traffic loads or resist storm winds.

Visual inspection has been the primary means of rating the carrying capacity of bridge pilings. Assessing the effect of corrosion on piling strength is typically based on engineering judgment and experience. Cathodic protection (protecting reinforcement from corroding by applying an electrical current) is sometimes applied to pilings. This has proven effective in slowing or stopping corrosion of steel reinforcement. No known full scale tests, however, have been conducted on bridge components in service with cathodic protection.

The cost of monitoring, repairing, and replacing corrosion damaged bridge piles is significant. In 2004, FDOT initiated research to better understand how corrosion as well as cathodic protection affects the load capacity of piles. The information will help FDOT make more informed decisions on the repair and replacement of pilings.

The 40-year-old St. George Island Bridge which had been the scene of barge impact testing (see previous story) also proved ideal for recovering and testing corroded bridge piles and piles that had been corroded and subsequently cathodically protected. A research team led by H.R. Hamilton III of UF's Civil & Coastal Engineering faculty selected 12 pilings that would demonstrate a wide range of corrosion damage. After the bridge superstructure was removed, Boh Brothers Construction Company recovered the piles from the bay and shipped them to the FDOT Structures Research Center in Tallahassee for testing.

The research team had visually rated the condition of the piles before they were removed from the bay. Structural testing in the lab revealed that their flexural capacity ranged from 31% to 100% of the original capacity. The loss of flexural capacity was in most cases due to concrete cracking and steel loss due to corrosion.

Two of the 12 piles had received cathodic protection during bridge repairs in 1994. The flexural capacity of these two piles was measured at 53% and 79% of the original. Corrosion was evident in the piles, but, based on visual observation, most of the corrosion had occurred prior to installing cathodic protection.

Corrosion on interior steel strands.

All the piles were opened to examine the steel prestressing strands. Several showed severe corrosion adjacent to the embedded strand pieces provided as handles for heavy equipment to lift the piles. Using protruding metal strands as lift points to put the pilings in place was found to provide an entry point for salt that could lead to corrosion and loss of pile strength. Corrosion potentials of the piles were also measured and were used to develop a relationship between corrosion potential and reduced flexural capacity. Testing for corrosion potentials looks promising as an additional tool for determining piling strength.

The visual ratings and test results were compared to determine if visual inspection results correlated with remaining pile capacity. In seven of the 12 piles, the visual rating was within 10% of the tested capacity. Visual rating overestimated piling capacity for one pile and underestimated capacity in the remaining four piles, which included the two with cathodic protection. Implementing the knowledge gained through this research should improve the management of piles in a marine environment. ⬣

Corroded pilings at the St. George Island Bridge.

FDOT Research on the National Scene

The hurricanes in 2004 and 2005 did enormous damage to major Gulf Coast bridges. The Escambia Bay I-10 bridge in Pensacola was knocked out by Hurricane Ivan. The US 90 bridges in Biloxi and Bay St. Louis, Mississippi were knocked out by Katrina, as was the I-10 Lake Pontchartrain bridge in Louisiana. The cost of replacing the bridges and the impact on state, regional, and national economies ran to billions of dollars.

The Florida Department of Transportation (FDOT) is sponsoring research to study the effect of storm-generated vertical and horizontal forces on bridges. The aim is to develop predictive equations that designers can use to create bridges able to resist dynamic storm forces.

Max Sheppard of UF's Civil & Coastal Engineering faculty (see pages 14, 20) is extending existing theory to include bridge-like structures and conducting wave tank tests with model bridge decks at the UF Coastal Engineering laboratory. The heavily instrumented model decks are being subjected to a wide range of wave heights, wave lengths, and water depths. The objective of the research is to produce methods for predicting wave and storm surge forces and moments on bridges under the maximum storm conditions anticipated for a bridge.

In a related project co-sponsored by FDOT, the American Association of State Highway and Transportation Offials (AASHTO), and the Federal Highway Administration, researchers are developing a screening process to determine which coastal bridges are vulnerable to the type of damage experienced by the I-10 Escambia Bay bridge. The screening procedure uses the importance of a bridge (e.g., location on an evacuation route) and existing design storm wind, surge, and wave information to compute a vulnerability index for that bridge. The bridges most likely to suffer damage can be further analyzed to determine how they would respond if they were hit with a 1-in-100-years storm event like Hurricane Katrina.

The screening procedure has been tested on several of the failed bridges in Florida and Mississippi. A pilot study of the program is under way near Tampa-St. Petersburg, Fla., where there are many low-lying bridges. When the work is complete, FDOT will have a list of the bridge spans in the study area with a ranking of their vulnerability to storm loads. FDOT will know the predicted responses of the spans to these loads and will receive a list of design options for retrofitting the spans.

The benefit of this screening procedure will be in providing FDOT with information that it can use to make informed decisions on where to apply state resources.

A similar national study has the same objectives and will begin once the results of Florida's pilot study are in. Implementing this procedure on a national scale will be somewhat more difficult because most of the affected states do not have the quantity or quality of coastal/ocean data/information that exists for Florida. ⬣

The wave flume at the University of Florida Coastal Engineering Lab.

RETA and the Flume: Inventions for Safer Bridge Designs

The foundation piers of the I-10 Chipola River bridge are sited in limerock. Core rock samples from the bridge site were used for the first test of the Rotating Erosion Test Apparatus (RETA).

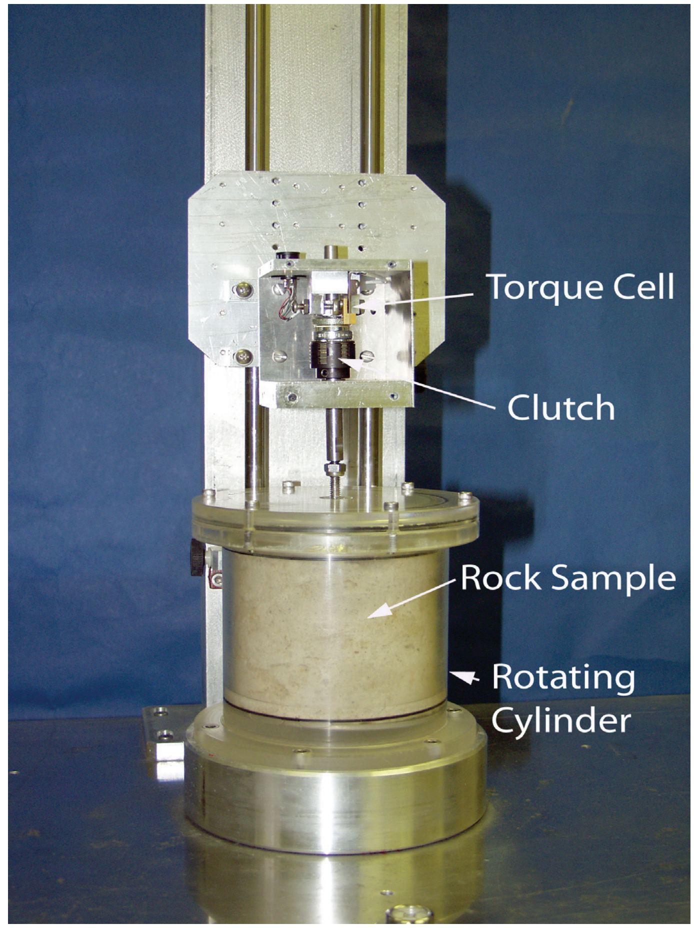
Bridges in Florida are often built on loose, sandy soils, especially along the coast. Currents and wave action around the bridge pilings can undermine the sand, a process called sediment scour. Significant storms, such as hurricanes, intensify this process and must be considered in bridge design. As a result, all Florida bridge pilings are built to a depth determined by equations that predict how deep the scour hole will extend during a design storm event.

Other Florida bridges, especially those over rivers, are built on a mixture of sand and clays, or on limerock. Until now, no equations have existed to predict scour depths in soils other than sand. In the absence of context-appropriate equations, the existing equations had to be used and often resulted in overly conservative design. To remedy this situation, two different testing devices for measuring the erosion rate for these soils were created at UF by Civil & Coastal Engineering faculty members Max Sheppard, who developed the original scour equations, and David Bloomquist. Data gathered from these devices are being used to predict design scour depths in a wide variety of sediments.

The first device, the Rotating Erosion Test Apparatus (RETA), is designed to test erodable rock core samples taken from a bridge site. The samples, which are cylindrical, are placed in a slightly larger Plexiglas® cylinder and the annulus is filled with water. Rotating the outer cylinder exerts a force on the surface of the sample. The shear stress (force per unit area) of the sample surface can be computed from the measurement of the torque exerted on the sample by the water. The material that erodes from the core surface during a set period of time is measured, and the rate of erosion as a function of applied shear stress is computed and plotted. That information plus the history of water flow at the bridge site is used to predict how much material would erode over the life of the bridge.

The first practical application of the RETA was in 2001 for the I-10 Chipola River Bridge west of Tallahassee, Florida. The bridge was determined to be scour critical using current FHWA analysis procedures which require that soil be treated as sand in the scour calculations. A thick layer of limerock is present throughout the area of the bridge and core samples were available for testing in the RETA. The consultant recommended excavating the limerock and replacing it with rip-rap (more dense stone) according to the FHWA procedures. This operation would have been expensive and environmentally sensitive.

The RETA test results and associated scour analyses showed that the bridge was safe well beyond its remaining life. FDOT decided to take no action other than to periodically monitor the scour at the site, resulting in substantial cost savings. The department's State Materials Laboratory has since acquired several RETAs and tested samples from many bridges.



The Rotating Erosion Test Apparatus (RETA).

The second device, the Sediment Erosion Recirculating Flume (SERF) - only 2 x 8 inches in cross section - is designed to test the erosion rate of clays, silts, and soil/sand mixtures. A core sample is placed in a tube attached to the bottom of the flume. The top of the sample is raised to the level of the bottom edge of the flume. Pumps force water through the flume and over the top of the sample. Acoustic beams measure the distance from the top of the flume to the surface of the sample. As the sample surface erodes, a signal goes to a stepper motor that advances a piston under the sample to maintain the sample surface at the level of the flume bottom. The shear stress applied to the sample surface is a function of the speed of the water flowing through the channel. By running a range of speeds and monitoring the rates at which the sample is advanced, the rate of erosion as a function of applied shear stress can be obtained.

These technologies have the potential to save millions of dollars by providing more accurate design scour depth predictions and reducing overdesign of bridge foundations.⬣

The Sediment Erosion Recirculating Flume (SERF) at the University of Florida.

Our Research Partner: The Stormwater Management Academy

It rains in Florida, as much as 40 to 60 inches a year, not counting hurricane rainfall. When that rainwater hits the ground and runs off into drains and ditches as stormwater, it gets dirty and dangerous.

"Stormwater is polluted because of what comes off the streets from cars, the fertilizer used on yards and gardens," said Stormwater Management Academy director Martin Wanielista, "and because of people who don't care about what they are doing and dump paint, or landscape clippings, or grease and oil down a manhole."

Stormwater ends up in Florida's rivers and lakes, and eventually the ground water and aquifer. Without proper controls, so does its load of biological and chemical pollutants.

Making Florida's water resources safer by reducing runoff pollutants is the mission of the Stormwater Management Academy, which is part of the College of Engineering and Computer Science at the University of Central Florida (UCF) in Orlando. Since its inception in 2002, the academy has been working with state, local, and federal agencies to find better methods of pollution control.

FDOT provided the spark and $2 million in seed money to start the academy. Four years later, the academy's research funding from the FDOT, the Florida Department of Environmental Protection, and other sources has totaled more than $6 million.

The academy's research projects are focused on results that have practical applications. A typical example is a water-filtering material the academy developed called Black & Gold Nuggets™, made from ground-up tires, which can be used to filter contaminated drainage water from roadsides and retention ponds.

On a broader scale, the academy is establishing stormwater best management practices to protect important watersheds statewide. In fact, academy researchers literally wrote the book on keeping the Wekiva River clean. In 2005, after a three-year study, the academy published the *Wekiva River Stormwater Management Manual of Practice*, and is helping the South Florida Water Management District rewrite stormwater management rules and regulations that will directly affect the Everglades. The academy is also developing manuals for erosion and sediment control.

The academy is working with the fertilizer industry to minimize the amount of phosphorus and nitrogen in their products. The nitrogen and phosphorus carried by runoff into surface and ground water causes algae bloom that leads to oxygen depletion, fish kills, and, ultimately, dead lakes.

The academy is also working with Federal Emergency Management Agency (FEMA), the Florida water management districts, and FDOT to produce a rainfall depth map for the entire state. The map would show the average volume of rainfall in inches per hour. The data will help FEMA establish a consistent flood zone map.

Left: The Wekiva River rises in Central Florida from springs that tap the Floridan Aquifer and is fed by the Little Wekiva River and Blackwater Creek. The Wekiva and its watershed are home to many Florida native plant and animal species that have become hard to find. These species can thrive near the Wekiva because the river is nearly pristine. For the river to stay that way, the watershed needs protection, especially from pollutants carried by stormwater runoff.

Many activities have grown out of academy research. Some are highlighted on these pages.

Pervious Concrete

The academy is studying pervious concrete as a cost-effective means of managing stormwater runoff. Pervious concrete is a mixture of Portland cement, coarse aggregates, water, and other admixtures. It is more porous than regular concrete, with 15-20% air voids, so it is able to retain stormwater and allow it to drain gradually into the ground. It is about 25% more expensive than regular concrete and has been used for many years in areas where traffic is less heavy, such as parking lots. The academy is also exploring the use of pervious concrete in conjunction with rooftop gardens.

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Green Business Programs

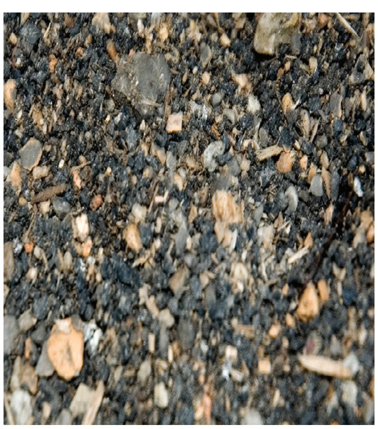
Refuse dumped into drainage systems and surface waters can mix with stormwater and be carried deep into ground waters. It is a major source of pollution. The academy is testing a pollution education program for lawn maintenance businesses in Melbourne and Orlando. Workers who complete the program are awarded a sticker that identifies them as environmentally responsible. The academy also wants to bring painting contractors into the program, as well as food service workers, who sometimes dump kitchen grease directly into sewers.

Stormwater Retention Ponds

The stormwater retention pond (above) at the Dubsdred Golf Course in Winter Park, Fla. collects runoff from nearby I-4. The academy helps local agencies develop ponds that can also be used as revenue sources by selling stormwater for irrigation purposes. Currently, about 50% of Florida's potable water is used for irrigation. Reusing stormwater preserves potable water. The ponds also remove pollutants through evaporation, absorption by plants, and filtration through soil. The academy currently is testing the use of Black & Gold Nuggets™ to line a retention pond in Ocala, Fla.

Black & Gold Nuggets™

Black & Gold Nuggets™ were developed by the academy and patented by UCF. "Black" refers to the old tires that are ground down to crumb size to make the nuggets. "Gold" suggests the outstanding pollution-removing qualities of the activated carbon in the old tires. The nuggets can be used along pavement edges, under pervious concrete in parking lots, and to line retention ponds on the discharge side. The academy is also testing the use of Black & Gold Nuggets™ in a new soil mix for roof-top gardens.



The roof-top garden at the University of Central Florida student union.

Green Roofs

Try a roof-top garden to save money on heating and cooling, and to recycle rain water for irrigation. A model garden installed by the academy atop the UCF student union features durable Florida native plants growing in 8-inch deep soil. The rooms below the garden need less air conditioning because the roof temperature under the soil is 40 to 60 degrees F cooler than elsewhere. The garden base is lined against leaks and the soil soaks up moderate rainfall. A drainage system under the soil carries heavy runoff away to cisterns for reuse in irrigating the garden during dry spells. Green roofs are catching on. The Ford Motor Company has one, the mayor of Chicago wants to make them mandatory for civic buildings, and the Florida Turnpike Enterprise is considering their use on Turnpike buildings. ⬢

Cross section of roof-top soil.

Meet the Researcher

D. Max Sheppard, Professor Emeritus

Civil & Coastal Engineering, University of Florida

Coastal and ocean engineer Max Sheppard is known nationally for his bridge scour research and work on wave loading on bridge decks. His interest in water-related problems dates to his boyhood in Port Arthur, Tex.

"I ran from hurricanes every year," he said, "just like on the coast of Florida."

That interest grew into the study of mechanical engineering and fluid mechanics, which, Sheppard says, is good background for coastal and ocean engineering. He received degrees from Lamar State University (B.S. 1960), Texas A&M (M.S. 1962), and Arizona State University (Ph.D. 1969).

After Sheppard joined the Engineering Science & Mechanics department (now Mechanical & Aerospace Engineering) at the University of Florida (UF) in 1969, he began a joint project with UF's Coastal & Oceanographic Engineering department on ocean internal waves. These subsurface waves occur at the interface between two layers of water with different densities caused by a change of temperature or salinity. Subsurface waves mix ocean water and are of great interest to the US Navy for their effect on submarines.

The project led to Sheppard's joining Coastal Engineering, where he conducted research for the Office of Naval Research, National Science Foundation, Corps of Engineers, and US Environmental Protection Agency. He became department chair in 1978, then took a leave of absence in 1981-84 to head up Mobil Oil's physical oceanography R&D program. This group was responsible for providing meteorological and oceanographic design parameters (e.g., wind speeds, wave heights, current velocities) for all of Mobil's affiliates' offshore operations around the world. The opportunity was too good to miss, but he was happy to return to UF.

Since 1989, Sheppard has worked on FDOT-sponsored research studying sediment scour around bridge piers. Scour occurs when water flow erodes soil around the base of support piers. If scour undermines the piers, it weakens the structure and can cause it to collapse. Under-prediction of these depths can result in expensive damage to the structures and possible loss of life. Over-prediction can cost millions of dollars in overly conservative design.

The research resulted in equations for predicting scour depths. To test the equations, Sheppard conducted experiments at some of the premiere hydraulics research laboratories in the world, such as the US Geological Survey lab in Turner's Falls, Mass., where he studied sediment scour on large piers. This lab features a flume with a large flow channel, 20 feet wide, 21 feet deep, and 126 feet in length.

"Some tests would last 20 days on 3-foot diameter piers," Sheppard said. "We also needed to test the equations at very high velocities, like you get with hurricane storm surge. We did this in a flume designed for this purpose in the Hydraulics Laboratory at the University of Auckland in New Zealand."

The tests verified the equations, and they are now used for all Florida bridge designs.

Currently, Sheppard is busy with significant new wave and scour research for the FDOT (see stories on pages 18-21). He also has his own consulting firm in Gainesville, Fla., Ocean Engineering Associates, Inc.

Someday he would like to take his sailboat again to the Bahamas and the Yucatan with his wife, Alicia, who works with him in his consulting firm. He enjoys hiking, too, and with his son, Colin, has backpacked in the Grand Canyon and climbed Mt. Rainier (without guides). In the meantime, he jogs the steps at the university's stadium to keep in shape. Sheppard also has a daughter, Alyson, and four grandchildren, ages 16 to 4. ⬣

Meet the Project Manager

Stefanie Maxwell, Specialty Engineer
FDOT Construction Office

Stefanie Maxwell does not recall when she was not interested in math and science.

"Ever since I was little, I liked math and was good at it. I always knew I'd end up in a math-related field like accounting, physics, or engineering," Maxwell said.

She did, tackling not one but two of the three. As a dual-enrolled student of North Georgia College and the Georgia Institute of Technology, she received degrees in physics and civil engineering.

After graduating in 1993, Maxwell entered the Florida Department of Transportation (FDOT) Professional Engineering Training Program. As the daughter of Vernon Dixon, a former State Final Estimates Engineer who retired from FDOT in 1989, Maxwell's entry into the department must have felt both new and familiar.

In 2003, Maxwell became a Specialty Engineer in the Office of Construction, where she has worked primarily on Maintenance of Traffic (MOT) and Consultant Construction Engineering and Inspection (CCEI), and, to a lesser extent, utility issues and construction-related Americans with Disabilities Act (ADA) compliancy. Recently, Maxwell has spent much time and effort implementing the Motorist Awareness System (MAS). The MAS consists of a standard lane closure setup plus a portable changeable message sign, two portable regulatory signs, and two radar speed display units. In 2003, a review of Florida's fatalities revealed that approximately 45% were attributed to excessive speed in the work zone. Therefore, FDOT implemented the MAS on high-speed state roadways to reduce vehicle speeds when workers are present, with the expectation of reducing work zone fatalities.

Retroreflectivity of pavement markings, signs, and traffic control devices is now a high priority for Maxwell. A survey of the traveling public revealed that the retroreflectivity of pavement markings was poor. As a result, Maxwell has been involved with modifying the standard specifications to require a higher retroreflectivity, and establishing standards for more durable and longer lasting pavement markings, a need caused by the growing number of elderly drivers in Florida. The new standards are expected to provide substantial cost savings.

On a daily basis, Maxwell provides information to FDOT employees and MOT contractors on issues related to work zone striping, signs, guardrails, barrier walls, attenuators, traffic control devices, and the related procedures and specifications that govern the use of these and other MOT devices and processes.

One MOT feature, taper length, is the subject of ongoing research. In a work zone, various taper configurations are used to divert traffic from a work area. Cones or other traffic control devices used to merge traffic from two lanes into one constitute a merging taper. The length of roadway used for this purpose is the taper length.

The Manual on Uniform Traffic Control Devices (MUTCD) defines the minimum taper length, to which FDOT contractors must adhere. Some contractors, however, feel that the minimum taper length is longer than necessary. If so, then the MOT contractor employees setting up the taper are exposed to traffic for longer periods than necessary; however, if the taper is inappropriately shortened, driver safety could be compromised.

Maxwell is investigating this issue in her first assignment as a research project manager, *A Human Factors Examination of Driver Response to a Specific Workzone Design (Design Standard #613, Duration Note 2) and Key Moderating Factor(s)* (BD548-18). The principal investigator is Dr. Aaron Duley, of the University of Central Florida Minds in Technology/Machines in Thought Laboratory. The goal is to determine whether further discussion of taper length is warranted based on driver behavior related to various features of the work zone - i.e., could taper length safely be reduced.

"This research," Maxwell comments, "will hopefully either put this issue to rest or let us know that we should elevate it to the next level." ⬣

More information on featured projects

Detailed information on all the research in this publication can be found on the Florida Department of Transportation Research Center web site.

www.dot.state.fl.us/research-center

Electronic Freight Theft Management

BD548-12 Development of an Electronic Freight Theft Management System to Minimize Capture Time, Aid in Cargo Theft Recovery, and Improve State Economic Development

BD548-21 The Enhancement and Upgrade of the Electronic Freight Theft Management System

Patrick Kerr, Principal Investigator
David Binder, Project Manager
www.dot.state.fl.us/research-center/Completed_MCC.htm

Low Profile Barriers

BC976 Temporary Low Profile Barrier for Roadside Safety

BD545-33 Development of Low Profile Barrier Features for Space Restrictive Applications

Gary Consolazio, Principal Investigator
John Shriner, Project ManagerAndrew Keel, Project manager

BD545-06 Temporary Low Profile Barrier: Width Reduction

Ralph Ellis, Principal Investigator
Jim Mills, Roadway Design Research Coordinator
www.dot.state.fl.us/research-center/Completed_RD.htm

Multi-Purpose Survey Vehicle

BC965 Feasibility of Video Logging with Pavement Condition Evaluation

BD544-11 Evaluation and Validation of a High-Speed Multifunction System for an Automated Pavement Condition Survey

Manjriker Gunaratne, Principal Investigator
Abdenour Nazef, Project Manager
www.dot.state.fl.us/research-center/Completed_StateMaterials.htm

St. George Island Barge Impact

BC354-23 Barge Impact Testing of the St. George Island Causeway Bridge, Phase I

BC354-56 Barge Impact Testing of the St. George Island Causeway Bridge, Phase II: Design of Instrumentation Systems

BC354-76 Barge Impact Testing of the St. George Island Causeway Bridge, Phase III: Physical Testing and Data Interpretation

BC545-29 Development of Improved Bridge Design Provisions for Bridge Impact Loading

Gary Consolazio, Principal Investigator
Henry Bollmann, Project Manager
Marcus Ansley, Project Manager
www.dot.state.fl.us/research-center/Completed_Structures.htm

Bridge Pile Testing

BD545-27 St. George Island Bridge Pile Testing

H.R. Hamilton, Principal Investigator
Marcus Ansley, Project Manager
www.dot.state.fl.us/research-center/Completed_Structures.htm

Rotating Erosion Test Apparatus and Sediment Erosion Recirculating Flume

BC354-12 Water Erosion of Florida Rock Materials

David Bloomquist and Max Sheppard, Principal Investigators
David Horhota, Project Manager
www.dot.state.fl.us/research-center/Completed_RD.htm

Stormwater Management Academy

BD521-01 Wekiva River Stormwater Management Manual of Practice

BD521-02 Performance Assessment of Portland Cement Pervious Pavements

BD521-03 Regional Stormwater Irrigation Facilities

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

Martin Wanielista, Principal Investigator
Rick Renna, Project Manager
www.dot.state.fl.us/research-center/Completed_RD.htm

Back cover: The blue heron is one of many native Florida species living near Wekiva Springs, the headwaters of the Wekiva River.