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SCDOT
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TESTING OF PILE TO PILE-CAP CONNECTIONS UNDERWAY

The University of South Carolina (USC) is conducting Research Project 672, "Behavior of Pile to Pile-Cap Connections Subjected to Seismic Forces." The research team is led by Dr. Paul Ziehl, Principal Investigator for the study. Lucero Mesa, SCDOT's Seismic Design Support Engineer, is serving as Chairperson of the Steering and Implementation Committee. The Committee provides guidance and direction to the researchers throughout the life of the study and is also responsible for implementation of results.

The use of prestressed concrete piles as columns, also called pile extensions, is standard practice for SCDOT on Flat Slab bridges. This type of bridge is widely used across the state, particularly in the Coastal Plain where geological and soil conditions make seismic hazard considerations more complex.

The primary objectives of the study are: 1) to examine and test, under cyclic tension and compression as well as reverse cyclic lateral loading, the current pile to pile-cap connection used by SCDOT; 2) to improve modeling and to better predict the seismic behavior of the connection and the prestressed pile; and 3) to develop and test potential production details for pile to pile-cap connections to be used on SCDOT bridge projects, if needed as the study progresses. The research will provide SCDOT with specific pile to pile-cap connection details, taking into account seismic behavior, for use in bridge plans and construction.

Several series of tests are planned for the study. The first two tests were on full scale single interior pile to pile-cap connection members. The third test will be on an exterior pile to pile-cap connection. After the designs of the first two specimens were finalized, piles were cast by Florence Concrete Products and the specimens were constructed at the USC Structures Laboratory.

Test Specimens with an Interior Pile on the Left and an Exterior Pile on the Right

The specimens were instrumented with different types of sensors, some embedded in and others attached to the pile and bent cap members. Strain gages, string potentiometers, and displacement transducers were used to measure strain and displacement at critical locations.

Pile and Cap after Testing

After the results are analyzed, a full scale 3-pile bent will be designed and tested in the USC Structures

Setup for Testing the Second Interior Pile Specimen

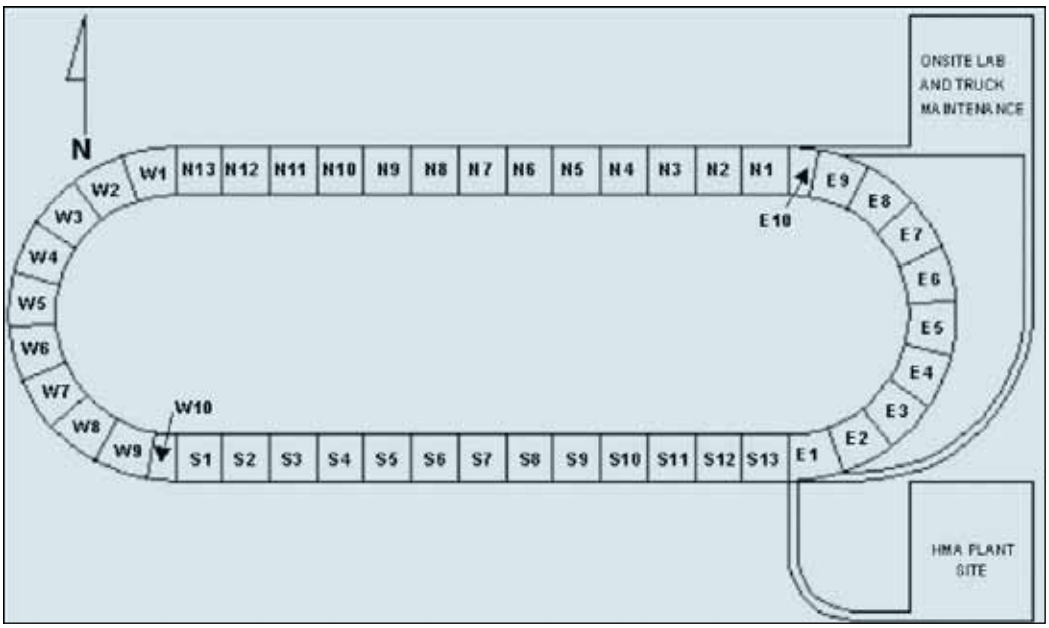
Laboratory. Based on the results of those tests and with input from the Steering and Implementation Committee, a cost efficient connection that provides adequate performance will be designed and utilized in a reduced scale 3-pile bent for shake table testing at the University of Nevada-Reno. Because the shake table provides simulated ground motions, the testing should provide results highly representative of seismic behavior in an actual earthquake.

The second of two tests on an interior pile was conducted in May 2009. The specimen was tested to failure.

SCDOT PARTICIPATING IN TEST TRACK GROUP EXPERIMENT

The National Center for Asphalt Technology (NCAT) Pavement Test Track, a full scale accelerated loading facility, was originally constructed as a result of interest and support from state DOTs who shared a concern for predicting and reducing distresses in their flexible pavements. The track, located in Opelika, Alabama, is an oval containing 46 test sections, each a length of 200 feet. Alabama DOT funded construction of the test track up to the top of the supporting pavement structure. Participating states purchase test sections through a pooled-fund project that covers the cost of test section construction and other operational costs for the track. Each state provides their own materials for construction of the hot mix asphalt (HMA) courses to be tested in their sections.

Loads are applied by trucks, traveling around the track at 40 to 50 miles per hour, at a rate of 5,000,000 equivalent single axle loads (ESALs) per year. An ESAL is a method of characterizing wheel load repetitions by converting wheel loads of various magnitudes and repetitions (mixed traffic) to an equivalent number of standard 18,000 pounds single axle loads. Each cycle of testing lasts two years for a total loading of 10,000,000 ESALs. NCAT monitors performance of the test sections during each cycle in accordance with the test plan developed by an advisory group composed of representatives from the participating states.



Test Track Layout

Trucks with Weighted Trailers apply Load to Track

The inaugural cycle of testing began in the summer of 2000 and was basically a study of surface mix performance. The test sections were rebuilt in 2003 for the second cycle of testing then again in 2006 for the third cycle, both times with a combination of mill/inlay surface mixes and variable thickness structural sections at the discretion of each participating state.

The fourth cycle of the NCAT Pavement Test Track is getting underway. Individualized test sections are still available to states. However in this cycle, a six-section "Group Experiment" is being offered that is intended to encompass multiple timely issues. SCDOT will participate in this option. The sections will include: a control section built with conventional HMA; two sections using different warm mix asphalt (WMA) technologies; two additional WMA sections with high percentages of reclaimed asphalt pavement (RAP), one with high RAP content in the lower lift and low RAP content in the upper lift and the other with high RAP contents in both lower and upper lifts; and the final section will be identical to the control except the conventional surface mix will be replaced with a drainable surface mix. A representative from each state participating in the "Group Experiment" will serve on the advisory panel that will make the decisions on mix design options, WMA technologies to be tested, and other similar matters. Information on both structural and surface performance will be obtained by monitoring response instrumentation that will be installed during construction and by documenting changing surface conditions (rutting, roughness, cracking, etc.) under heavy truck traffic.

SCDOT INITIATES STUDY ON WARM MIX ASPHALT

As the name implies, warm mix asphalt (WMA) is mixed and placed at considerably lower temperatures than conventional hot mix asphalt (HMA). In general, WMA mixing temperatures range from approximately 210°F to 280°F while HMA mixing temperatures range from approximately 300°F to 350°F. The major benefit of decreasing production temperatures is a reduction in fuel consumption. Though not enough data is available to quantify the reduction in fuel requirements, it was estimated during some field trials in this country that a reduction in fuel consumption of 10 to 30% is possible (Astec Inc, 2007; Kristjansdottir, 2006; The Asphalt Pavement Association, Oregon, 2003). Using less fuel should also lower the emissions of hazardous air pollutants.

Warm Mix Demonstration Project by Boggs Paving, Inc. in Rock Hill, South Carolina

Though WMA has been around for some time, recent rising energy prices, concerns with global warming, and more stringent environmental regulations have all intensified interest in the technology in this country. Warm asphalt mixes have been placed in several states, including South Carolina, but most of the field experience has been in Europe where materials and construction practices are very different. In this country, there have been limited studies on many technical issues involved with the technology.

SCDOT recently initiated a research project with Clemson University to investigate selected WMA technologies with materials routinely used in asphalt mixes in the state. The study also includes an investigation of the use of higher percentages of reclaimed asphalt pavement (RAP) in both HMA and WMA. Dr. Serji Amirkhanian is the Principal Investigator (PI). The project will be guided by the Steering and Implementation Committee. Members include:

- **Merrill Zwanka,** *Assistant Materials and Research Engineer (Chairman)*
- **M. O. Fletcher,** *Materials and Research Engineer*
- **Charles Eleazer,** *State Construction Engineer*
- **Cliff Selkinghaus,** *Asphalt Materials Manager*
- **Lee Neighbors,** *District Construction Engineer, District 2*
- **David Law,** *Pavement and Materials Engineer, FHWA*

INDUSTRY ADVISORY REPRESENTATIVE:

- **David Herndon,** *Executive Director, SC Asphalt Pavement Association*

Specifically, the research will investigate: 1) selected WMA technologies and will focus on mix design methods, aged and virgin blending analysis, moisture-susceptibility, plant and construction issues, and binder characteristics of plant produced mixes; 2) changes to the asphalt mixture performance properties with varying RAP contents, asphalt binder grades and additives, and mixture types including both HMA and WMA. Based on the findings, specifications will be developed and implemented for use in SCDOT's work.

SCDOT CURRENT AND COMPLETED PROJECTS

For a complete list of current and/or completed research projects, please visit the Materials and Research web site located at **www.clemson.edu/t3s/scdot**. The current research projects page lists the project name, principal investigator, and the objective of the project.

The completed research project page shows summaries of completed research projects and a number of them have pdf copies of final reports attached. The Research Problem Statement Form is also located on the website for your convenience.