NCAT Makes Pavements Fail to Produce Better Designs

Newest test track sections at National Center for Asphalt Technology include one group that researchers hope will fail by cracking

By Paul Fournier

Researchers at the National Center for Asphalt Technology hope that one group of experimental pavement sections just built at their Pavement Test Track in Opelika, Alabama will crack.

"We want them to fail," said Dr. Raymond "Buzz" Powell, NCAT Assistant Director and Track Manager. NCAT personnel operate and manage the Pavement Test Track under Dr. Powell with key staff including Jason Nelson and Dr. Nam Tran. The track utilizes accelerated performance testing that simulates the effect on pavements from up to 15 years of interstate truck traffic. NCAT Director Dr. Randy West has overall responsibility for the research facility, which is headquartered at Auburn University.

NCAT personnel launched its sixth research cycle at the track in August 2015, with the construction of new test sections by East Alabama Paving of Opelika. Hot mix asphalt for the experimental pavements is provided by the contractor's Astec Double-Barrel plant located nearby. This latest research cycle includes a special focus group on pavement cracking.

East Alabama Paving rollers compact S-5 Cracking Group section for sixth research cycle at test track of National Center for Asphalt Technology.

Cracking Indicates Fatigue Failure

Cracking in asphalt pavements is generally recognized by researchers as a principal indicator of pavement failure due to fatigue from repeated loading, and is often manifested as alligator type cracking in the wheelpaths. One type of fatigue cracking initiates at or near the pavement surface and propagates downward, in contrast with reflective type cracking, which commonly occurs in rehabilitated pavements near the junction with an underlying asphalt layer or stabilized base that is already cracked, and propagates upward to the surface of the overlay.

"Cracking is our biggest concern with asphalt pavement at present," said Dr. Powell. "Rutting used to be, but that problem was mostly solved with the development of SUPERPAVE. Now we need to have healthy asphalt binder in the mix to ward off cracking," he said.

But with fewer new roads being built today, and more calls for reusing the asphalt already installed on existing roads, there is growing concern among researchers about the "health" of the aged, oxidized reclaimed asphalt binder and whether its use detracts from a pavement's ability to resist failure by cracking.

"Everybody wants to use more RAP and more RAS in the mix, but we need to balance that demand against the need for a long service life," said Dr. Powell. "Dr. West and I have discussed the lack of information on the effects of high RAP and high RAS content on mix performance in resisting cracking," he said.

"We decided to address this by proposing the formation of a Cracking Group for our sixth research cycle to the 17 current state department of transportation sponsors of test track sections, and nine of them decided to take part, together with the Federal Highway Administration and the Alabama Department of Environmental Management," he said. The state sponsors of CG test sections include the departments of transportation of Alabama, Florida, Illinois, Michigan, Minnesota, North Carolina, New York, Oklahoma, and Wisconsin.

Controlling Variables

Recent studies show that principal factors influencing the occurrence of load-related fatigue cracks in asphalt pavements are environmental conditions, tire-pavement interaction, mixture characteristics, pavement structure, and construction practices.

Lab technician Tina Ferguson conducts a test on a core sample from an experimental section of track.

Extreme Loads and Sophisticated Equipment

NCAT's 1.7-mile oval Pavement Test Track, built in 2000, was designed for accelerated pavement testing of 200-foot-long sections of track in two-year trafficking cycles with loading that simulates 10- to 15 years of heavy Interstate truck traffic. Test sections are available to sponsors, offering the opportunity to measure, record and analyze pavement responses to heavy loading, with the aim of developing more economical and efficient pavement designs.

Truck trafficking subjects pavement test sections to 10 million equivalent single axles (ESALs) of 18,000 pounds each, with two shifts of drivers operating eight-axle, 155,000-pound tractor-trailers continuously between 5 AM and 11 PM six days a week, with each of five trucks travelling about 680 miles a day.

Pavement changes are measured and recorded by many instruments, some embedded in the pavement such as temperature sensors, strain gauges and pressure plates. Other equipment and instruments periodically measure pavement smoothness, rutting and cracking. A wireless mesh network installed along the entire length of track provides high speed transfer of data to a central computer.

Samples taken from the hot plant are used to make specimens for many different types of laboratory performance tests. For instance, a base course mixture undergoes beam fatigue and push-pull testing while a wearing course is subjected to dynamic modulus, flow number, Asphalt Pavement Analyzer (APA) and Hamburg wheel track testing for calculating resistance to permanent deformation. Surface mixes are also subjected to overlay testing, semi-circular bending, indirect tension, creep/strength testing and energy ratio testing in order to ascertain mix cracking susceptibility.

A Roadtec material transfer vehicle in service lane conveys hot mix asphalt to a Roadtec paver on track's travel lane.

Shown at test track are key NCAT personnel, from left: Dr. Nam Tran, Jason Nelson, Dr. Buzz Powell and Dr. Randy West.

For the NCAT Cracking Group seven different experimental sections were designed and constructed, keeping all but one influencing factor the same for all sections. The sections are all on the same track, subject to the same environmental characteristics, experience the same loading from truck tires, have the same pavement structure (aggregate sizes, layer thicknesses, etc.), and are created with the same construction practices (one contractor builds all of them).

Only the surface mix characteristics differ. And this factor provides the focus of the group's research, i.e., identifying laboratory tests that predict cracking differences observed on the NCAT Pavement Test Track in mixes with varying recycled asphalt product contents.

In order to preclude the introduction of other variables that might skew test results, NCAT designed the CG sections with essentially the same dense graded, structural composition with a thin surface mix inlay. There are four layers of materials on top of the stiff track subgrade: a 6-inch-thick dense crushed granite base; a 2-1/4-inch-thick asphalt base with a 19mm (3/4-inch) maximum sized aggregate; a 2-1/4-inch asphalt intermediate course mimicking the previous aggregate size; and a 1-1/2-inch asphalt surface course with a 9.5mm (3/8-inch) maximum aggregate. One section employed a wearing course containing 12.5mm (1/2-inch) aggregate mixed with Arizona rubber (crumb rubber from tires).

RAP, RAS and Binder Type

The CG test section mixes contain varying combinations of RAP and RAS. For example, three have 20 percent RAP but range in density from low to medium to high. High density means the mix is over compacted, yielding few voids, while low density means it's under compacted, and contains excess voids. Another section has 20 percent RAP plus 5 percent RAS, while one section has 35 percent RAP.

The liquid asphalt binder used to manufacture the hot mix in five of the seven sections was a PG 67-22, one section was made using highly modified asphalt (HiMA) binder, and one section was made using a softer, PG 58-22. These performance grade numbers indicate a range of temperatures over which the binder meets certain requirements. For example, a PG 58-22 performance grade indicates that the binder meets high temperature physical properties up to 58 degrees Celsius (136 degrees Fahrenheit) and low temperature physical properties down to -22 degrees Celsius (-8 degrees Fahrenheit).

Why Failure Can Be Good

Dr. Buzz explained why researchers want the test sections to fail.

"The NCAT Pavement Test Track is a large outdoor laboratory that allows us to test a diversity of cracking situations," he said. "As each section is constructed, we take large samples of that particular mix right from the plant and then run a number of lab tests on them. When a field section fails, we can compare its failure with that of the lab failure for the same mix to establish field-to-lab correlation."Accumulating such data enables researchers to develop models of behavior for different mixes, which can be used for predicting crack initiation and propagation.

"This will allow us to validate tests that can be used by DOTs, contractors and consultants to predict how different types of mixes will perform in the field and at what point pavements with different combinations of RAP and RAS would likely fail," he said.

"And this will open the door to the entire industry for higher permissible RAP and RAS content in asphalt pavement mixes in a manner that does not compromise life cycle pavement performance."

Five 155,000-pound tractor-trailers subject pavement test sections to 10 million equivalent single axles (ESALs), simulating 15 years of Interstate truck traffic.

Helpful Data From Non-CG Test Section

There is an eighth test section not included in the Cracking Group but which is nevertheless playing an important role in this research, according to Dr. Buzz.

"We found the research being done by Collaborative Aggregates on asphalt rejuvenators to be interesting and timely," he said, referring to section N-7, which is sponsored by Collaborative Aggregates LLC, an affiliate of Wilmington, Mass.-based Warner Babcock Institute for Green Chemistry. The company is using the section, a dense-graded, high-recycled asphalt content, thin surface mix inlay, to document the performance of its newly commercialized Delta S asphalt rejuvenator product. Delta S is designed to minimize asphalt pavement rutting and cracking.

"We're going to compare the performance of their stand-alone section, N-7, which contains the asphalt rejuvenator, with our section N-8, which is similar in design and construction but doesn't contain a rejuvenator," he noted.

NCAT researches pavement to make sure it is up to the task of being driven on by large trucks, such as the one pictured.

While NCAT added an anti-stripping agent to the seven CG sections, it was decided not to add the anti-strip chemistry to the Collaborative Aggregates section since tests concluded that there was no measurable difference with or without the anti-strip when Delta S was present.

"The results of the comparison of N-7 and N-8 will give us more data points to examine as we look for ways to accurately predict the crack resistance performance of pavements containing large amounts of recycled asphalt products," Dr. Buzz concluded.

Truck traffic for the sixth research cycle was scheduled to begin October 2015. Results of the research will be presented at a Pavement Test Track Conference tentatively scheduled for March 2018 at The Hotel at Auburn University and Dixon Conference Center.

NCAT's asphalt pavement research covers such areas as design, construction methods, materials and testing, performance measurement and prediction, and pavement preservation.