NCAT Research Spurs Use of Highly Modified Asphalt

CAT AP-1000D asphalt paver places HiMA intermediate or binder course on U.S. 231 in Troy, Ala.

ALDOT HiMA Application on Busy Highway Driven by Persistent Rutting, Experience at Close-By Test Track

by Tom Kuennen

The Alabama Department of Transportation (ALDOT) leveraged pavement research from the National Center for Asphalt Technology (NCAT) to validate the use of a new, high-performance, highly modified asphalt pavement mix that it anticipates will stand up to brutal truck traffic.

The highly modified asphalt (HiMA) mix, placed as an intermediate or binder course on U.S. 231 in mid-2012, contains a much higher percentage of polymer modifier than conventional modified mixes. The HiMA binder contained 7.5 percent SBS (styrene-butadiene-styrene) polymer, more than twice that used in conventional polymer-modified binders.

Material transfer vehicle loads HiMA intermediate or binder course into paver

The existing pavement – placed 4 years earlier – had begun rutting under heavy traffic in just 3 months after placement. But in spring 2013, 8 months after placement of the new HiMA intermediate course, the new pavement shows no sign of rutting, cracking or any other distress, according to ALDOT.

The implementation of the Superpave system of asphalt pavement materials selection and mix design has led to widespread modification of asphalt binder to achieve binder performance targets. While modification of liquid asphalt binders with polymers improves resistance to rutting and raveling of asphalt mixes, up until now there has been a practical limit to polymer concentration. Usually, as polymer concentration exceeds three to four percent, the viscosity of the binder increases such that the mix becomes more difficult to produce in the plant and less workable for the paving crew.

However, the polymer used in the Alabama U.S. 231 project in Troy, Alabama, was Kraton D0243, a new SBS product manufactured by Houston-based Kraton Performance Polymers Inc., which maintains mix workability even when used in significantly larger dosages than conventional polymer modifiers.

NCAT a Powerful Resource

In its validation stage, the HiMA modifier was used in trial segments on the NCAT Pavement Test Track, located in southeastern Alabama, and resulting data provided strong support for its use by ALDOT on the U.S. 231 project.

The NCAT Pavement Test Track is a full-scale accelerated performance test facility managed by NCAT at Auburn University. The project is funded and directed by a multi-state research cooperative program in which the construction, trafficking, and performance evaluations are carried out on 46 different 200-foot test sections around a 1.7-mile oval test track.

Kraton D0243 HiMA polymer modifier liquid binder from Ergon Asphalt & Emulsions is loaded into Heatec portable tank at APAC Midsouth drum plant in Troy, Alabama.

Each test section is constructed with the asphalt materials and design methods used by individual sponsors. A fleet of heavy trucks is operated on the track in a highly controlled manner in order to apply a design lifetime of truck traffic (10 million equivalent single axle loads, or ESALs) in 2 years. Test sections are rebuilt every 3 years to provide experimental pavements for the next research cycle, and a new cycle commenced in summer 2012.

At NCAT, the Kraton HiMA modifier was used in track sections during its 2009-2012 research cycle. There, Kraton's Section N7 and Oklahoma DOT's Section N8 – repaired with HiMA – performed so well that the Oklahoma DOT decided to use HiMA on I-10 west of Oklahoma City, where it's intended to resist rutting and reflective cracking.

"The original HiMA test section was built significantly thinner than conventional comparison sections," said Buzz Powell, P.E., Ph.D., Assistant Director of the NCAT. "That came about as the result of an extensive laboratory testing and modeling effort, in which it looked as if the stiffness and fatigue resistance of the highly modified polymer mix would work together to achieve a longer life, with a significantly thinner asphalt pavement structure, on top of similar base materials and subgrade."

"And that's exactly how it worked out," Powell said. "We determined a significantly longer fatigue life expectation for the high-polymer mix because its resistance to bottom-up fatigue cracking – which is brought about through repetitive strains induced by passing truck loads – is so high," he said.

Having such a resource in its backyard proved to be a valuable component in ALDOT's search for a durable pavement. "Alabama had several projects with special circumstances, and the U.S. 231 project was one in which forensic studies confirmed structural cracking in lower layers and significant rutting in upper layers," Powell said. "We felt that due to the cracking and rutting resistance of the HiMA at the track that it might be a possible solution for the DOT on U.S. 231."

"About 1999 we began using stone matrix asphalt (SMA) on projects similar to U.S. 231 and had good luck with it in both the binder and the surface courses," said Jim Adams, Assistant Division Engineer-Construction, ALDOT 7th Division. "But in 2008 we tried it on U.S. 231 and it immediately began rutting. We asked NCAT to do an extensive amount of forensic testing, but the exact problem was never determined. We milled up the rutted SMA at intersections and placed more SMA there, but the project and the intersections continued to rut terribly."

As a result, the 7th Division went on a quest for a better-performing asphalt. "We asked about what we could use and found that the HiMA had been used on the NCAT test track and performed," Adams said. "And here we are."

Jim Adams, P.E., Assistant Director of Engineering for Construction, ALDOT 7th Division

"ALDOT had heard about the success of the Oklahoma section, and they came to us and asked if we could see if the HiMA could solve problems for them," said Powell. "We went in and looked at all the material data the DOT had on U.S. 231 from the cores they had cut, the trenches they had cut, and the falling weight deflectometer (FWD) investigations, and we thought the HiMA mix would be a good fit. We recommended it to the DOT and they acted on it."

Milling, Then HiMA Placement

The summer 2012 project involved milling of rutted SMA 4-inches deep in the right-hand truck lane, and in some especially compromised spots to get into the underlying base course, on both north- and southbound truck lanes from the southern city limit of Troy, north 4.9 miles. A Wirtgen W 2200-12 Cold Mill was used with full-lane, 12.5-foot-wide drum.

For paving, an Astec SB-2500C Material Transfer Vehicle ("Shuttle Buggy") fed a Caterpillar AP-1000D Paver. Compaction was provided by Ingersoll-Rand DD-118 Tandem Rollers.

On the milled surface the HiMA binder course was placed to a compacted depth of 2 ½-inch, a rate of 275 pounds per square yard. A traditional PG surface course without the HiMA modifier was compacted to 1½ inch. "We're milling 4 inches and putting back two layers, for a total of 4 inches," Adams said. Both lifts have a compaction density target of 94.

Left-hand passing lanes also would be milled 1½-inch deep, but resurfaced with the conventional PG mix.

"We're trying to improve our rut resistance and durability by putting down the same thickness of lifts as before, but using a high polymer content binder course," said Chris Huner, P.E., Assistant Division Engineer-Materials and Testing, ALDOT 7th Division. "Based on trenches we cut in 2008, in which we measured the thicknesses of each layer, the binder layer was the one that was rutting heavily. For the most part, the surface mix kept its thickness across the board, so we were confident the problem was with the binder layer. However, we don't know exactly why."

For the HiMA intermediate binder course, a PG 76-22 E liquid binder with 7.5 percent modifier and 1-inch maximum aggregate size was specified. "The aggregate was predominantly limestone, with 35 percent No. 67 size that is ¾- to 1-inch-size rock," Huner said. "We had 20 percent No. 8910 limestone screenings. Fifteen percent was No. 9 limestone, which is ¼-in. size. Shot gravel – a crushed gravel that is ¼-inch in size – was 15 percent. And we had 15 percent sand."

For the surface course, Alabama was using its traditional Superpave PG 76-22 binder mix. "Other than SMA, it was what we put on most of our high-traffic routes, a PG mix with ¾-inch maximum aggregate size," Huner said.

No reclaimed asphalt pavement was used in this initial HiMA placement, Huner said. "We allowed no RAP in the mix, we wanted all-virgin aggregates," he said. "We wanted the highest quality, and the SMA mix that failed contained 25 percent RAP. In this application RAP would have been an unknown factor, as we don't have as good a history on the quality of its aggregates or residual liquid binder. We wanted to eliminate the variable of the RAP in this placement."

Workability of the HiMA mix was not an issue, Huner said. "We' were pleasantly surprised that the mix was as workable as it was. That being said, they were pulling a 12.5-foot lane without radiuses or tapers for turn lanes. It was night work, so the going was slow, but it went smoothly. All the QC/QA checks at the plant were well within the acceptable ranges, the densities were good, and it rides smooth."

For the ALDOT specs for U.S. 231, the higher degree of modification was permitted via a special provision to the contract, prior to award. "We do that for quite a few items as needed," Adams said. "As you get away from our standard spec book, things change, and the list of special provisions gets longer and longer." Contractor for the project was APAC Midsouth and the HiMA liquid binder was supplied by Ergon Asphalt & Emulsions.

Chris Huner, P.E., Assistant Director Engineering Materials for ALDOT 7th Division.

Looking to the Futur

Because Huner drives the HiMA pavement every day, he has a chance to scrutinize its condition week after week.

"The HiMA intermediate course has held up really well," Huner said. "The previous project, done 5 years ago, had rutting within 3 months. We're well past that time frame now, we've just gone through a winter, and have seen no rutting.

"The best indicator is after a rain, you will see water begin to pool in the wheel tracks," he said. "And we're not seeing that. There are no distresses like shoving, bleeding or cracking. We have been pleased to say the least, and so far there have been no problems. There is no indication that this project won't last its anticipated design life."

If the HiMA performs as predicted, ALDOT may use it in additional applications. "Our intention is to get a product that doesn't rut," Adams said. "What we've placed so far is doing great."

The premium paid for the HiMA modifier was no more than the premium the state paid for SMA mix on the project. "It's a costly mix, but we don't have any problems with that if we can get the longer life out of it," Huner said.

In the meantime, ALDOT is proud that NCAT calls the Cotton State home. "We consider NCAT to be invaluable from our central office on down," Adams said. "When sections can hold up at NCAT, the ALDOT has confidence in the results. We have a lot of faith in what NCAT does, says and in its findings."

"ALDOT is benefiting from research done locally," Huner said. "Auburn is just an hour-and-a-half from Troy, where our Division 7 offices are located, and we're excited to have been able to take some of the research from NCAT and apply it to a real-world situation."

IMAGE CREDITS: Kraton Performance Polymers, Inc.