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HIGHLY MODIFIED ASPHALT KEEPS RUTS AT BAY

by Tom Kuennen

A highly modified asphalt mix on a two-mile, four-lane section of Oklahoma I-40 in Caddo County is standing up to punishing cross country semi traffic and oil patch drill rigs alike, keeping ruts at bay over the seven years since it was installed in 2012.

For seven years, highly modified asphalt pavement structure of Oklahoma I-40 has resisted chronic rutting and delivered exceptionally high IRI and PQI numbers.

The pavement – incorporating highly modified asphalt (HiMA) made using Kraton polymers in three different asphalt mixes and lifts – features enhanced durability with a thinner cross section of pavement than is typical for Oklahoma interstates. A special low viscosity polymer allows the use of 7.5 percent SBS (styrene-butadiene-styrene) polymer, more than twice as much as used in conventional polymer-modified binders without the workability problems that characterize heavily modified mixes.

The HiMA sections are located from mile marker 102.2 to 104.2 just west of Oklahoma City.

These sections endured an average annual daily traffic (AADT) of 25,300 vehicles, of which 7 percent were single-unit trucks and 29 percent combo trucks in 2017, the most recent year for which data are available. These data indicate over 17 million equivalent single axle loads (ESAL) have been applied on the design lanes since 2012.

In late 2019, the result was pavement sections that featured an International Roughness Index (IRI) averages of 50 and 53 inches/mile, which is smooth enough to result in ride quality bonuses for new construction in some states. IRI is combined with a Pavement Condition Rating to develop Pavement Quality Indices (PQI) of the sections. Oklahoma DOT determined the sections had PQI of 96 and 94 out of 100.

"Since 2012, when the mix was put down, we've had no patching there," says Brent Almquist, P.E., Division 5 Engineer, Oklahoma DOT. "The product has performed very well. We've had a historical problem with rutting in that area and we just wanted to get rid of the rutting and not have it come back. So it definitely has done a good job."

FIXES FOR RUTTING

Previously, rutting on I-40 was dealt with in different ways. At one point, money was so tight that only the wheelpaths were filled with an "armor coat" placed by state maintenance forces. "CRS2S asphalt emulsion goes down, and then we put rock on top of that," Almquist says. "That's all we could afford at that time. Back in the early 1990s,

'Popcorn' thin open-graded friction course performs on I-40 HiMA pavement.

Later, a hot in-place surface recycling took place, topped by an ultra-thin bonded overlay (UBTO). But the rutting continued until 2011, when the HiMA rehabilitation project was bid and awarded.

"The product has held up well, especially considering the history of rutting and other issues we've had with that section," said Matt Romero, P.E., Materials Division Engineer, Oklahoma DOT. "The HiMA modifier helped us come in with a thinner design to fix the ruts while saving on material costs.

"Things are changing across the Materials Department," Romero adds. "We've been trying different things. We're looking at the balanced mix designs for enhanced performance, so HiMA is coming into play."

Transverse crack halts at interface with 8-in. HiMA-modified pavement structure.

PERPETUAL PAVEMENT DESIGN

The I-40 HiMA design reflects a "perpetual pavement" design that's a deep section in which base and intermediate courses are developed to resist bottom-up fatigue cracking.

As a pavement bends under loads, the maximum tensile stress will occur in the bottom lifts, and resulting cracks at the bottom can migrate upward to become fatigue cracking at the top. If more polymer modified asphalt can enhance the lower layers, it provides an opportunity to 'heal' that bottom lift and not propagate or initiate a crack there.

The I-40 HiMA concept was based on experience from the Oklahoma test sections in the 2009-2012 cycle of the National Center for Asphalt Technology (NCAT) test track in Alabama, in which HiMA was recommended as a good repair option for failed test sections. "NCAT's assistant director Buzz Powell suggested we try HiMA to repair our section that had failed," says Jeff Dean, P.E., then-Oklahoma DOT Pavement Engineer, and now with Terracon Consultants, Inc. "It's performed very well since."

The I-40 project used some 1,500 tons of liquid asphalt, equivalent to 30,000 tons of mix, for about three months of paving.

Original HiMA pavement placed in 2012 by Haskell Lemon Construction Co.

For this project, back in 2012, 5 in. of existing asphalt was milled from I-40. On the milled, cleaned and tacked surface, a single 1.5-in. HiMA-rich bottom layer of 3/8-in NMAS was placed. It was followed by two 2.5-in. lifts of Oklahoma S3 base course, a HiMA-modified lift with 3/4-in.-NMAS gradation with 100 percent passing the 1-in. screen.

These were topped with one 1.5-in. lift of Oklahoma S5, a HiMA mix with 3/8-in.-NMAS gradation with 100 percent passing the half-inch screen. All of these HiMA lifts were topped with a 0.75-in. open-graded friction course (OGFC) – which is dubbed a "popcorn" mix in Oklahoma – containing PG 76-28 OK asphalt binder, but no HiMA.

SBS polymer modifiers benefit asphalt mixes by adding a "rubbery" component that enhances resiliency and resists rutting, but there is a practical limit to SBS polymer concentration. Typically, when conventional polymer concentration exceeds 3 percent, the binder viscosity increases such that the mix becomes more difficult to produce in the plant and less workable for the paving crew.

However, the unique polymer used in the Oklahoma I-40 PG 76-28 E binder was Kraton™ D0243, an SBS product manufactured by Houston-based Kraton Corporation. The product can be used in significantly larger amounts than conventional polymer modifiers – up to 7.5 to 8 percent while retaining workability. The result is a significantly more durable pavement, standing up to truck traffic while permitting thinner sections.

Florida bid on some 160,000 tons of HiMA modified asphalt pavement in 2019, and Oklahoma nearly that much.

Today, Oklahoma is not using the full dosage of HiMA modifier in its mixes. "They're using what could be called HiMA-light, not the full complete rubbery material. However, that's still more highly modified than typical materials with Superpave specs, and still used for durability," says Bob Kluttz, senior scientist, Research and Development, at Kraton.

A typical, conventional SBS-modified mix would contain 2.7 to 4 percent SBS modifier. A full implementation of HiMA modifier would be in the 7.5 to 8 percent range. "Oklahoma's PG 76-28 OK binder has 5 to 5.5 percent HiMA, so it's an intermediate application," Kluttz says. "But they are still improving the binder well beyond Superpave specs for that region – and improving performance."

In 2012, material transfer vehicle ensures high quality placement of HiMA modified asphalt lifts.

DESIGNING WITH HIMA

"Oklahoma I-40 has turned out to be an exceptionally durable pavement," Kraton's Kluttz says. "It is very much both rut-resistant and crack-resistant, and that's unique.

"It's very easy to design a pavement that won't rut, and it's very easy to design a pavement that won't crack, but it's very difficult to do both," Kluttz adds. "That's what HiMA is. It's an extremely tough, rubbery binder that resists both permanent deformation and is tough enough to resist cracking."

Essentially, by using HiMA, Oklahoma built a durable, long-term, rut-free pavement using just 8 in., compared to 12 to 14 in. of conventional design, Kluttz says. "You can build a thinner pavement using HiMA and get as good or better performance, or fix a problem that you simply can't solve another way," he says. "And it still will be a thick, perpetual pavement. It'll be a more expensive pavement because it's incorporating a more expensive binder, but it will last substantially longer, and life cycle costs can be very much improved."

With these applications, HiMA is finding more and more approbation in the Sooner State. "With a good seven years here on I-40, and the fresh project going in the northeast, I will start singing its praises," says Kevin Suitor, Asphalt Branch Manager for Oklahoma DOT. "I can't tell you that it's going to take off or go further. But now we've got some long term experience. At the demo in the northeast we can start saying, 'Okay guys, look at this. Here's an alternative to what you're doing.' I go out and they said, Kevin, we've got a problem. I tell them 'Go ahead and look what we've done, and this is how HiMA performed for seven years."

Oklahoma DOT team from left to right:
Matt Romero, P.E., Materials Division Engineer; Brent Almquist, P.E., Division 5 Engineer; Will Snipes, Construction Division Engineer; and Kevin Suitor, Asphalt Branch Manager.