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HALFWAY HOME FOR HARBOR HiMA

by Tom Kuennen

Port of Napier is New Zealand's fourth busiest, with intensive container movements
Initial HiMA lift at Port of Napier was placed in 2010

Halfway through its 20-year design life, a placement of highly modified asphalt (HiMA) pavement at one of New Zealand's busiest ports is still standing up to intensive forklift and shipping container movements without rutting or other pavement damage.

Placed in 2010 and re-evaluated in 2019, this trial section shows no signs of structural distress. "Deformation is estimated at less than 5 mm (0.2 in) and no cracking has been observed," says Sean Bearsley, Technical Innovation and Implementation Manager for New Zealand based road infrastructure contractor Higgins, Palmerston North, N.Z.

The pavement is one of the most heavily loaded sections (H8/K1) at Napier Port. It has a 20-year design life and so far carried an estimated 700,000 20-ft. equivalent unit (TEU) vehicle movements, with high forklift axle loads up to 100 tonnes (110 short tons) and high pressure tires, with no appreciable rutting.

"We design for a 20-year life because if you're going to spend the money, you want to get a reasonable return on it. For us, 20 years works quite nicely," said Clarke Curtis, Infrastructure Maintenance Manager, Port of Napier Ltd., Napier, N.Z.

Looking back in 2010, the initial 420 m² (500 yd²) HiMA trial section replaced an old pavement in a congested part of the port facility that began to fail after 10 years. The last two years showed accelerated deterioration and had 100 mm (4 in) ruts by the time it was replaced. Additional HiMA installations at the port followed, with a 2,700 m² (3200 yd²) section placed in December 2010, and an 800 m² (960 yd²) section in 2015.

Following its experience at the port, Higgins constructed additional HiMA pavements in New Zealand, including state highways, municipal streets and port facilities elsewhere in the country.

WHAT IS HiMA?

Highly modified asphalt, or HiMA, pavement incorporates a high-performance bituminous binder modifier, Kraton™ D0243, a tailored high vinyl styrene-butadiene-styrene (SBS) polymer manufactured by Kraton Corporation. This SBS polymer can be used in significantly larger amounts in asphalt mixes than conventional polymer modifiers, up to 7.5 to 8 percent while retaining workability.

Surface wearing course placed following HiMA base layer

While it's common industry knowledge that bituminous binder modification with elastomeric polymers improves resistance to rutting and raveling of asphalt mixes, there is a practical limit to polymer concentration. Usually, as polymer concentration increases, the binder viscosity increases such that the mix can become more difficult to produce in the plant and less workable for the paving crew.

However, Kraton D0243 can be used in significantly larger amounts in bituminous binders and hot mix asphalt than conventional polymer modifiers, while retaining workability.

A typical, conventional SBS modified binder would contain 3 to 5 percent SBS modifier. A full implementation of a Kraton HiMA mix would be in the 7.5 to 8 percent range. The latter results in a significantly more durable pavement with a rubber-like flexibility to recover from the indentations created by heavy truck traffic, while not posing placement or compaction difficulties.

"HiMA is our term for a highly modified asphalt," says Dr. Bob Kluttz, Senior Scientist, Research and Development, at Kraton. "With Kraton D0243, you're going from a predominantly bitumen phase with polymer dispersed in it, to a predominantly polymer phase with bitumen. With it, we change the binder from rubber-modified bitumen to bitumen-modified rubber. That is, the binder goes from a discontinuous to a continuous polymer phase, with very different physical properties resulting from that."

ROADWAY APPLICATIONS

"In total, since 2010, Higgins has paved approximately 1 million m² (1,200,000 yd²) of pavement containing the SBS polymer Kraton D0243," Bearsley says. "About 110,000 m² (130,000 yd²) have been in fully fledged HiMA applications, with the other 900,000 m² (1,100,000 yd²) being used in polymer modified asphalt mix for wearing courses." Kraton D0243 consumption accounts for approximately 25 percent of Higgins polymer usage.

Included in that 110,000m² is the main road at Lindale Village, Kapiti, 53km (33 miles) north of Wellington. At the time, this pavement was part of State Highway (S.H.) 1 but has since been handed over to the control of Kapiti Coast District Council for use as a local road. Higgins paved a single lane each way on a dual-lane highway carrying 25,000 vehicles per day.

Higgins placed a 90 mm (3.5 in)-deep SP 19 base course mix, and 60 mm (2.4 in) SP 12.5 binder or intermediate course incorporating HiMA, topped with a 30 mm (1.2 in.) open grade friction course asphalt on the surface. Because of the toughness that Kraton D0243 provides to the hot mix asphalt, the contractor was able to achieve a 25 percent reduction in pavement thickness over a conventional design, saving money for the owner.

Also paved for the state agency by Higgins with Kraton D0243 are S.H. 1 (Waikato Expressway) at the Ngaruawahia Bypass, and S.H. 2 roundabouts in Hawkes Bay.

Higgins compacts section incorporating HiMA at Port of Auckland

Municipal work includes critical intersections in Palmerston North that cannot afford prolonged disruption; arterial and industrial routes in Palmerston North; and the cities of Tauranga, Hamilton and Auckland, the country's largest metro area.

Higgins has also done HiMA pavements at other port facilities as well, including the Port of Tauranga and Port of Auckland.

Higgins places HiMA lift on Kapiti Expressway, S.H. 1 at Lindale Village

REDUCING TRAFFIC DISRUPTION

Kraton D0243 not only permits thinner lifts of asphalt with the same degree of durability as deeper conventional mixes, it also provides durable pavement surfaces, the flexibility of which lets them perform over inadequate pavement structures. This permits resurfacing without the added expense and time of reconstruction of the base layers while tying up traffic.

"We have adapted Kraton's HiMA technology to produce very flexible wearing courses that can be used over structurally weak pavements," Bearsley says. "This defers the need for expensive and time consuming reconstruction, and is generally used on heavily trafficked urban streets where there is a low tolerance for disruption to the traveling public."

For this purpose, the mix type typically is a Superpave designed (M 323) fine-graded dense mix with nominal minimum aggregate size (NMAS) of 7 or 10 mm (0.27 to 0.4 in). Layer thickness typically is 30 to 50 mm (1.2 to 2.0 in), and surfacing life is typically extended from five to six years to eight to 10 years, Higgins says. In North American Superpave terms, the asphalt binder grade is PG 76-28 (AASHTO M 320) or PG 64V-28 if using the AASHTO M 332 designations.

On S.H. 1 at Lindale Village, Higgins paved a single lane each way on a dual-lane highway carrying 25,000 vehicles per day

In 2007, the loading area was rutted, failing and in need of replacement

NAPIER PORT PAVING

The original H8/K1 port pavement – ultimately replaced by the HiMA pavement – was constructed from 2001 to 2002. Its structure consisted of:

- A 250 mm, 0-65 mm (10 in, 2.6 in.) crushed river gravel lower subbase,
- A 250 mm, 0-40 mm (10 in, 1.6 in) crushed river gravel upper subbase modified with 2 percent portland cement,
- A single layer of geotextile paving fabric,
- A 250 mm, 0-40 mm (10 in, 1.6 in) crushed river gravel base course modified with 2 percent Portland cement, and
- Topped with a 100 mm (4 in) Marshall designed Mix 20 (AASHTO NMAS 12.5). The bituminous binder used was a penetration grade 80/100, which would be equivalent to an AASHTO M 320 PG 58-22 bitumen (AASHTO M 332 PG64S-22).

Because it was deforming and shoving, this asphalt was replaced with the same mix type in 2007.

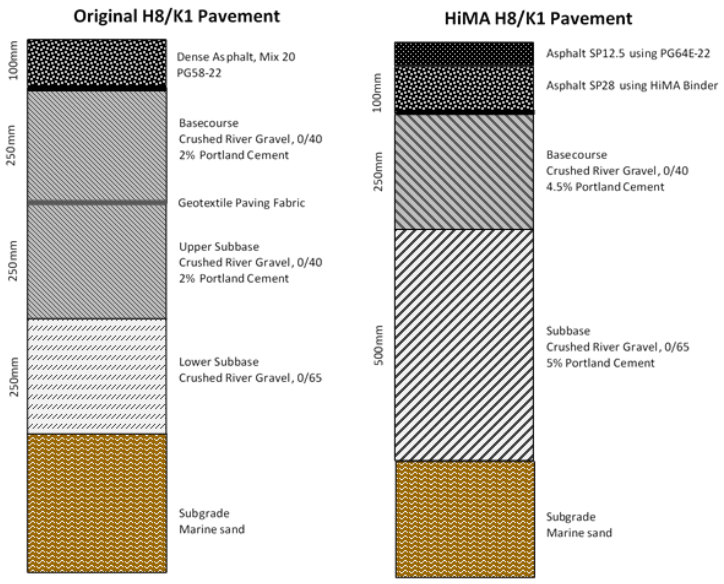
Finally, this original H8/K1 pavement was completely reconstructed in 2010 after the mix had severally deformed and shoved with rut depths of 80 – 100 mm (3.1 – 4.0 in). "This is when we introduced Kraton's HiMA technology," Bearsley says.

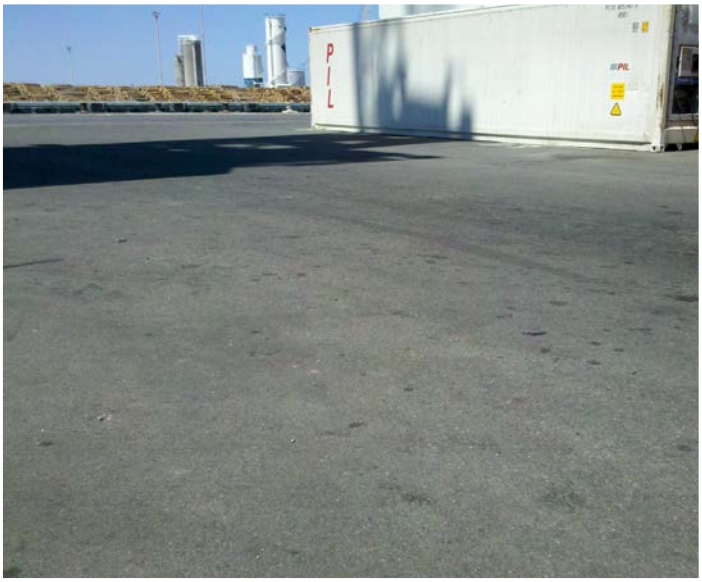
A finished section with HiMA layers at the Port of Napier in December 2010

The new HiMA H8/K1 pavement structure consisted of:

- 500 mm, 0-65 mm (20 in, 2.5 in) crushed river gravel lower subbase modified with 5 percent Portland cement
- 250 mm 0-40 mm (10 in, 1.6 in) crushed river gravel base course modified with 4.5 percent Portland cement
- 100 mm (4 in) Superpave-designed (M 323) NMAS 25 mm (1 in, called SP28 in New Zealand) HiMA asphalt concrete base course incorporating Kraton D0243 modifier. The base bitumen was a 40/50 (equivalent to AASHTO M 320 P 70-16 or AASHTO M 332 PG 64H-16) to which 7.5 percent Kraton D0243 was added.
- A 50 mm (2 in) SP12.5 asphalt concrete wearing course. The bituminous binder used was 5 percent SBS modified with an AASHTO M 320 grading of PG 76-22 or AASHTO M 332 grading of PG 64E-22.

"The resultant base layer polymer modified bitumen probably had a performance grade of PG 88-16 under AASHTO M 320, or PG 64E-16 under AASHTO M 332 specifications," Bearsley says. Compacted air voids averaged 4.3 percent.





In 2013, three years after placement, freight facility surface shows no visible imperfections

NO STRUCTURAL DISTRESS

Following nine years of intensive use, pavement inspection in late 2019 showed no visible deformation or cracking.

"We have done no maintenance on the pavement for 10 years, because we haven't had to," Curtis says. "We haven't had ruts develop, and we haven't had potholes develop.

"We've obviously had quite a capital outlay devoted to heavy duty payments, which comes at a bit of a premium compared to what we had done previously," he adds. "But with the traffic loadings, there are little signs of wear and tear happening, and we haven't had to do overlays. We haven't had to go in and fix potholes or fix ruts. The HiMA pavements are standing up to what they were designed to do."

"There is some raveling beginning to occur in the SP12.5mm wearing course and this may need replacement in the next two to five years," Bearsley says. "However, the 100 mm SP25 HiMA layer is still looking good, and is expected to last for its 20-year design life and beyond."

During this time, this pavement section has carried an estimated traffic volume of 700,000 TEU with axle loads up to 100 tonnes (110 short tons).

"The pavement was designed and constructed by Higgins and is the first of many such high modulus pavements constructed around the country that enable a reduction in pavement thickness of 30 to 50 percent," Bearsley says.

"Resource and energy consumption is reduced and user disruption is minimized, without compromising performance," he adds. "The innovative spirit shared between Napier Port, Kraton and Higgins is delivering results that are standing the test of time."

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