

Highly Modified Asphalt (HiMA)

Next Generation in Asphalt
Pavement Design

Paving Durability with HiMA

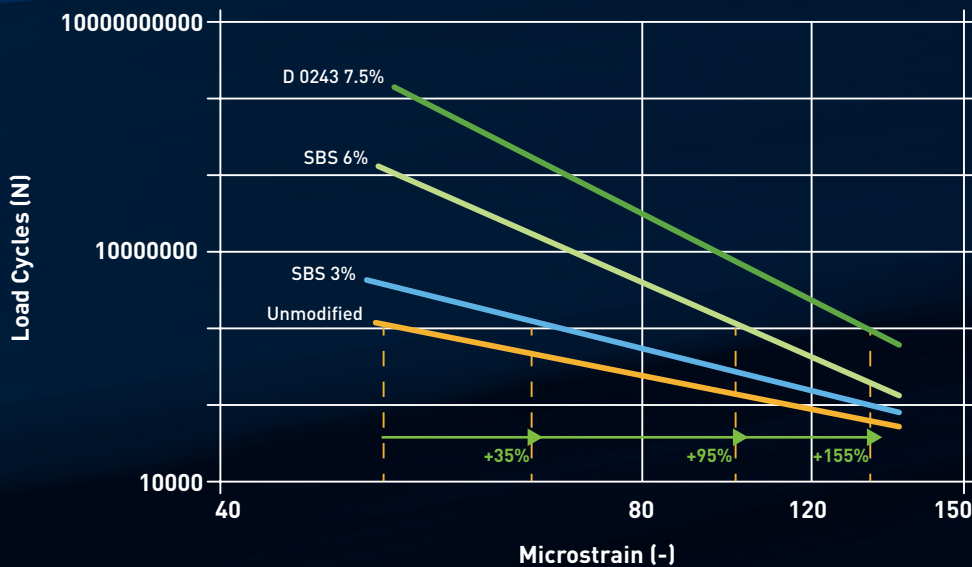
Highly Modified Asphalt (HiMA) is a tool that can be used to solve a variety of problems in asphalt pavements. It gives a combination of permanent deformation and fatigue cracking resistance that can be applied to: thinner structural pavements; thinner, longer lasting overlays; tougher, more crack-resistant emulsion products; and high strain applications such as bridge decks.

Kraton™ D0243 polymer gives exceptional compatibility and low viscosity. Conventional styrene butadiene styrene (SBS) polymers can be blended into bitumen at 7-8 percent; however, compatibility is a problem in all but the softest bitumen, while viscosity can be too high for a workable mix at conventional temperatures.

Conventional SBS polymer loadings give improvements to properties, but as shown, the dominant phase is still the bitumen and so the properties are mostly like bitumen. However, if the polymer content increases, the phases invert so the binder now behaves much more like rubber. This has a profound effect on physical properties. As shown, the softening point increases dramatically and mixture fatigue resistance improves.

Effect of SBS Polymer Content on Beam Fatigue Performance

100X Improved Fatigue Resistance versus Unmodified

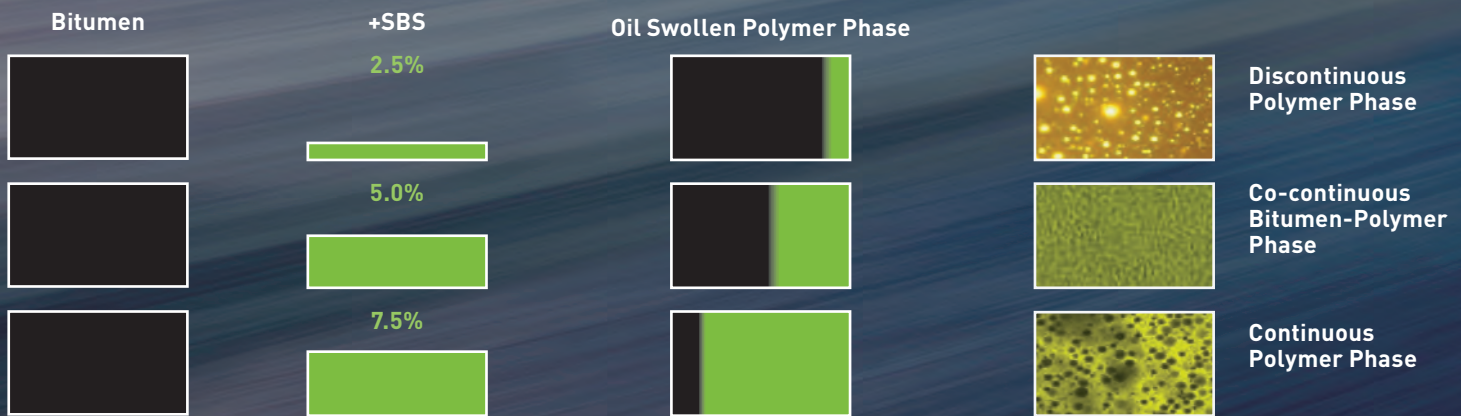


Testing at Delft University

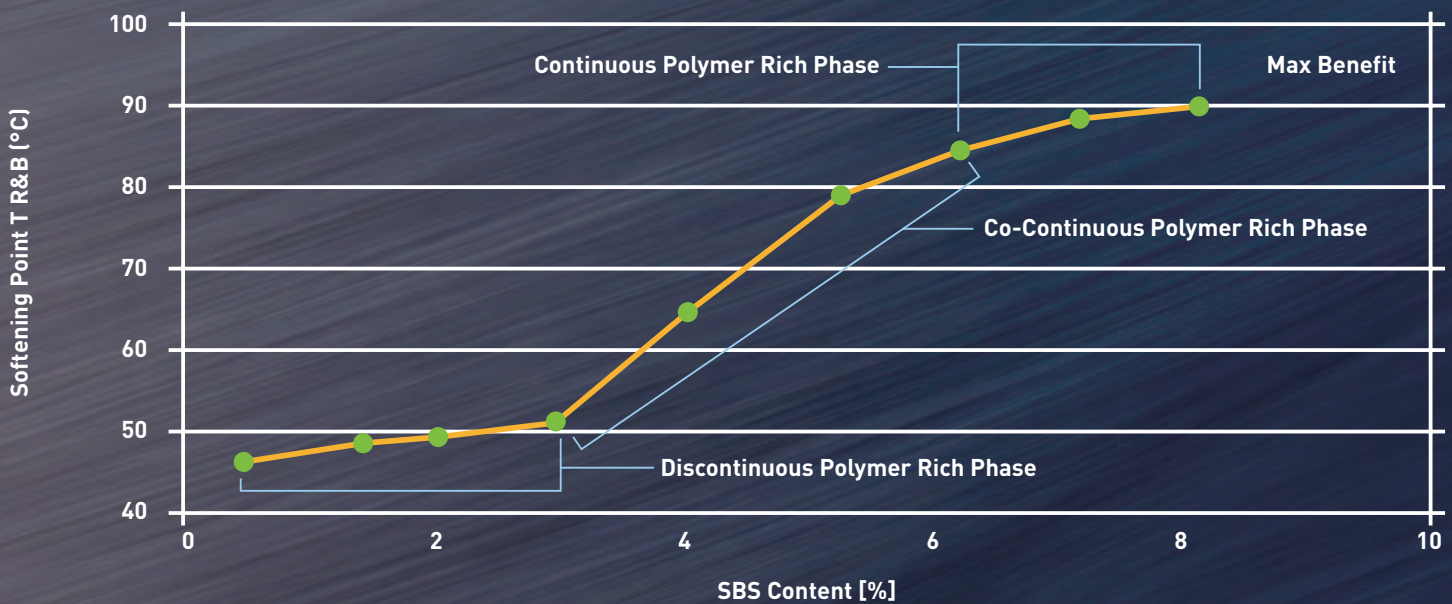


30/50 pen bitumen with 7.5% Kraton D0243 in 22 mm mix
Full sine loading, 8Hz, 20 °C
100x load cycles same micro-strain

Effect of Increasing SBS Polymer Content on Bitumen/Polymer Morphology



Effect of Increasing SBS Polymer Content On Softening Point



The Solution for Thinner and Longer-Lasting Pavement

Structural Pavements

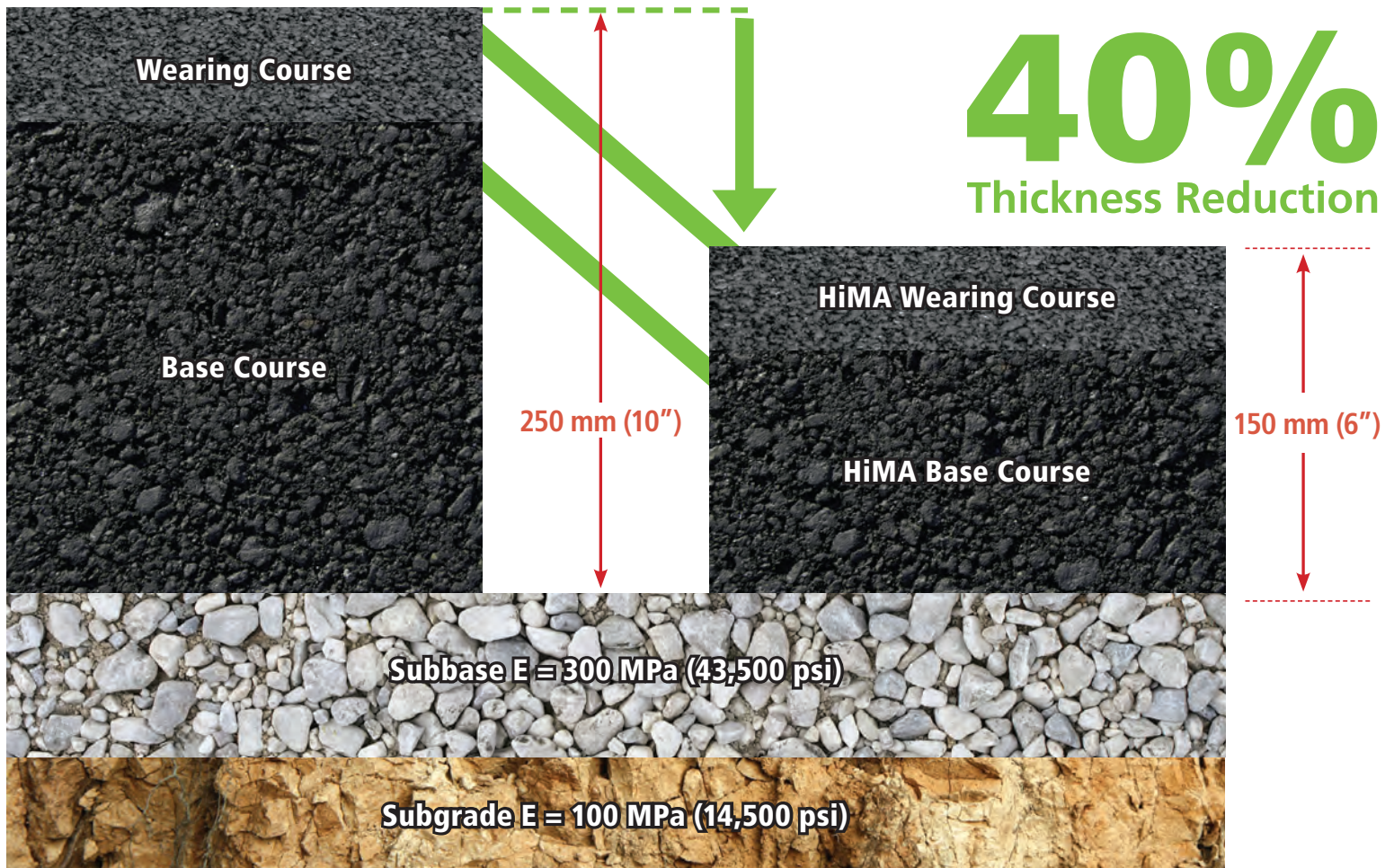
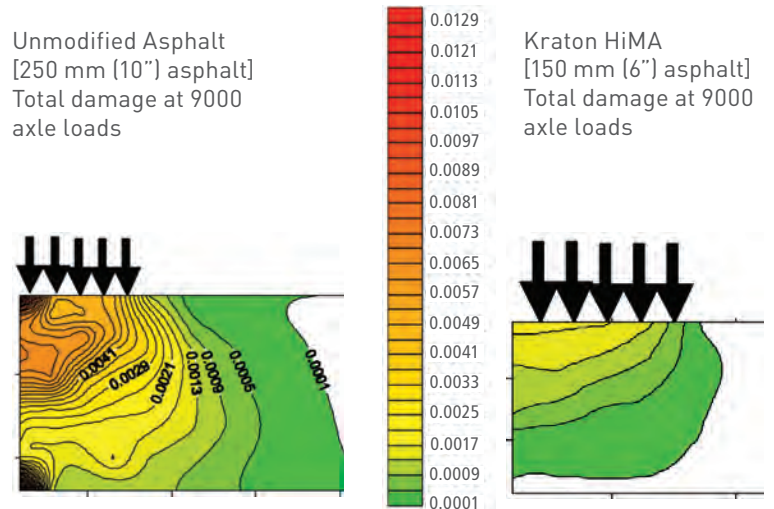
Upfront and life cycle cost reduction, pavement durability, and environmental impact will continue to be key concerns for the paving industry. Kraton has developed a solution to improve durability while reducing costs and resource use in road construction and maintenance.

HiMA technology for asphalt base courses allows pavement thickness reductions of 30-40 percent compared to standard asphalt mixes, which may deliver cost savings upfront. Laboratory tests and Finite Element modeling by Delft University of Technology in The Netherlands demonstrated that a 40 percent pavement thickness reduction may be feasible without increasing in damage.

This concept is validated at the National Center for Asphalt Technology (NCAT) at Auburn University with exceptionally good results to date.

Pavement design calculations for stiffness values and fatigue results for a given mix demonstrated that data from Delft University and NCAT can be predicted with HiMA mix's material properties.

Delft University Finite Element Modeling



Case Studies

United States

BEFORE



To reduce noise and improve the look, the 30-year-old concrete roadway at First Avenue in New York needed a new surface.

AFTER



In 2014, First Avenue received the resurfacing. A high performance thin overlay (HPTO) mix with HiMA was used. After three years, the road is still in a great condition, making First Avenue safer, quieter and more attractive.

Poland

BEFORE



The first HiMA trial in Poland was in Kalety, with a 2.5 cm overlay (SMA 5 DSH with 65/105-80 HiMA binder) on a severely damaged road. The damaged pavement was specially chosen to verify HiMA performance in an extreme situation.

AFTER



The road performs very well after four winters.

Case Studies

Brazil

BEFORE



Paraná State needed a solution to fix a badly cracked section of highway PR-092.

AFTER



The highway achieved 45 percent thickness reduction after 30.5 cm. (12 in.) of old asphalt pavement were replaced with 16.5 cm. (6.5 in.) of HiMA.

New Zealand

BEFORE



A container loading area in the port of Napier, New Zealand had a severe pavement rutting.

AFTER



A new HiMA base course was paved to reconstruct the port's loading area.

United States

BEFORE



The NCAT Section N8 conventional rehabilitation after 10 months, 4 MM ESALs. The 250 mm (10") pavement was paved in August 2006, and a 125 mm (5") rehabilitation was done in August 2009. The first crack appeared at 2.7 MM ESALs.

AFTER



NCAT Section N8 with 140 mm (5½") HiMA rehabilitation after 13 months, 5.3 MM ESALs. Oklahoma sponsored this section through the 2012 test track cycle to monitor deterioration and evaluate preservation strategies. The pavement lasted 16 MM ESALs.

To create adequate stiffness, hard base bitumen is used. The SBS modification boosts fatigue resistance.

Hard base bitumen with high SBS content typically leads to workability and compatibility problems, but Kraton™ D0243 can be used in high concentrations without issues during mixing, paving and compacting. This product also allows the use of softer base bitumen in rehabilitation to mitigate reflective cracking.

Advantages of Kraton D0243:

- Enables low viscosity binders
- Superior compatibility with a wide range of bitumen
- Self-crosslinking that eliminates the need for sulfur, minimizing hydrogen sulfide (H₂S) emission
- Proven track record in paving applications since 2006
- Global supply capability

Innovation in pavement design:

- 30-40 percent thickness reduction that delivers upfront cost savings
- Superior fatigue resistance and durability
- Allows for height-restricted applications such as bridge underpasses
- Lower viscosity binder offers contractors greater ease-of-use and workability
- Eco-friendly solution consumes less raw materials and energy
- Increases durability and service life at standard thickness levels

Superior fatigue resistance while maintaining high stiffness is key to the concept of HiMA for thinner pavements.



Thin Overlays

Delft University of Technology’s lab and modeling work success, in combination with NCAT pavement test track’s data, suggested that HiMA is a promising solution for pavement preservation applications, such as surfacing asphalt paving and bitumen emulsion surface treatments.

In 2011, Minnesota, New Hampshire and Vermont placed demonstration projects as part of the AASHTO TSP2 HiMA thin surface paving program sponsored by the National Center for Pavement Preservation at Michigan State University. The plant-produced mixes were sampled during field installation and tested at the Highway Sustainability Research Center (HSRC) at the University of Massachusetts Dartmouth. All mixtures used a polymer modified asphalt binder consisting of a soft (PG -34) neat binder modified with 7.5 percent HiMA polymer.

The HiMA mixes’ performance characteristics were determined using the following:

- Resistance-to-reflective cracking, which is measured with the Texas Overlay Tester (OT);
- Mixture thermal cracking characteristics, calibrated using the Thermal Stress Restrained Specimen Test (TSRST);
- Rutting characteristics, measured through the Asphalt Pavement Analyzer (APA); and
- Moisture damage, calculated with the Hamburg Wheel Tracking Device (HWTD).

According to the posted AASHTO TSP2 results, HiMA mixes are expected to retard reflective cracking, resist low temperature cracking up to an estimated temperature of -28 °C, and show minimal rutting and moisture damage in the field.

HiMA formulations allow for more durable asphalt pavement with reduced pavement thickness that lowers costs, allowing for larger resurfacing opportunities within fixed budgets. HiMA technology enables the installation of roads that last longer and require less maintenance. To help make pavements more cost effective, HiMA formulations allow for higher polymer loading in the mix to achieve up to a 30-40 percent reduction in asphalt thickness.

Results Summary from Testing the HiMA Mixtures Placed in Minnesota (MN), New Hampshire (NH), and Vermont (VT)

Mixture	Average OT Cycles to 93% Load Reduction	Average TSRST Failure Temperature	Average Rut Depth from APA after 8,000 Cycles	HWTD – Stripping Inflection Point
MN HiMA Mixture	434	-31.8 °C	5.92 mm	16,700
MN Control (No Polymer)	133	-32.2°C	6.20 mm	14,600
NH HiMA Mixture	2,000*	-33.1 °C	5.16 mm	10,000
VT HiMA Mixture	2,000*	-30.1°C	2.03 mm	10,000
VT HiMA Mixture + 24% RAP	1,144	-27.8°C	2.87 mm	None

* Mixture did not reach failure criteria at the conclusion of 2,000 cycles in the OT device.

Emulsions

Based on the data generated on structural HiMA mix test sections at NCAT and during the AASHTO TSP2 program for highly polymer-modified thin mix surfacings, this technology platform was translated for potential use in highly pre-modified micro surfacing emulsion surface treatments.

In the case of highly pre-modified micro surfacing emulsions, a balance between ease of emulsification and polymer loading level must be maintained. In the case of the HiMA polymer option, it was determined that 6 wt% loading level in the micro-emulsion base asphalt provided this balance. The polymer network becomes continuous in most bitumen in the 6–8 wt% range. Emulsification can be achieved easily at typical micro surfacing emulsion residue contents, primarily due to the low viscosity imparted by the Kraton™ D0243 polymer.

Additionally, the HiMA particle droplet’s low viscosity leads to the technology’s low residue upon application with concurrent reformation of the polymer network in place.

Improved resistance to thermal cracking and reflective crack propagation may be achieved in the field, as well as resistance to shoving from high load vehicles, especially when turning at intersections or in residential streets.

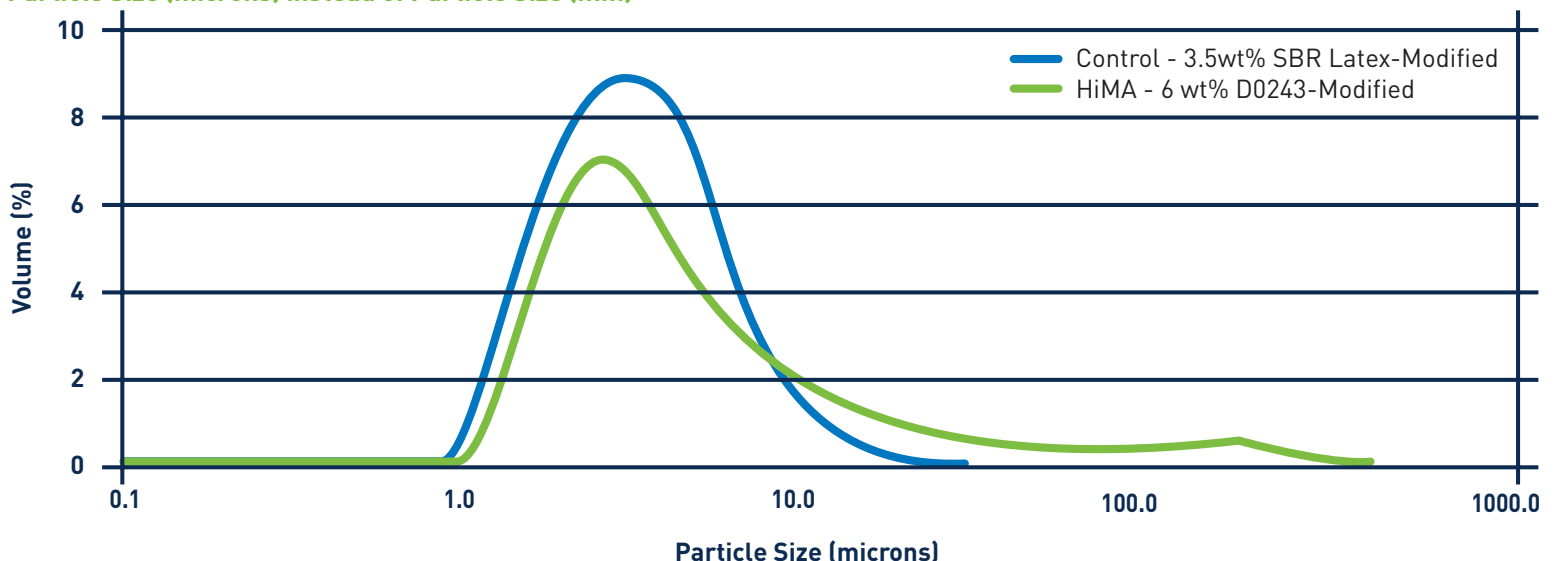
To maximize the durability and fatigue resistance of the micro surfacing mat in place, a one grade softer binder is incorporated with the HiMA polymer in these highly pre-modified emulsion formulations. Since the HiMA emulsion residue’s softening point can be up to 15-20 °C (30-40 °F) higher than conventional latex-modified micro surfacing emulsion residue, flushing resistance is improved.

Particle size and particle size distribution are typical of conventional latex-modified micro surfacing emulsion using a harder, unmodified bitumen. Additionally, ISSA A143 micro surfacing mix properties, such as wet track abrasion, are equivalent or better than reference latex-modified micro surfacing emulsion systems.

Control + HiMA Micro Surfacing Emulsion SP and WTAT (Wet Track Abrasion Test) Results

Emulsion ID	ASTM D36	ISSA TB 100	
		WTAT Loss (g/m ²) / (g/ft ²)	
	SP [°C] / SP [°F]	1 Hour	6 Days
Control	62 / 144	293 / 27.2	410 / 38.1
HiMA	83 / 181	95 / 8.8	171 / 15.9

Particle Size (microns) instead of Particle Size (mm)



HIGHLY MODIFIED ASPHALT (HiMA) NEXT GENERATION IN ASPHALT PAVEMENT DESIGN



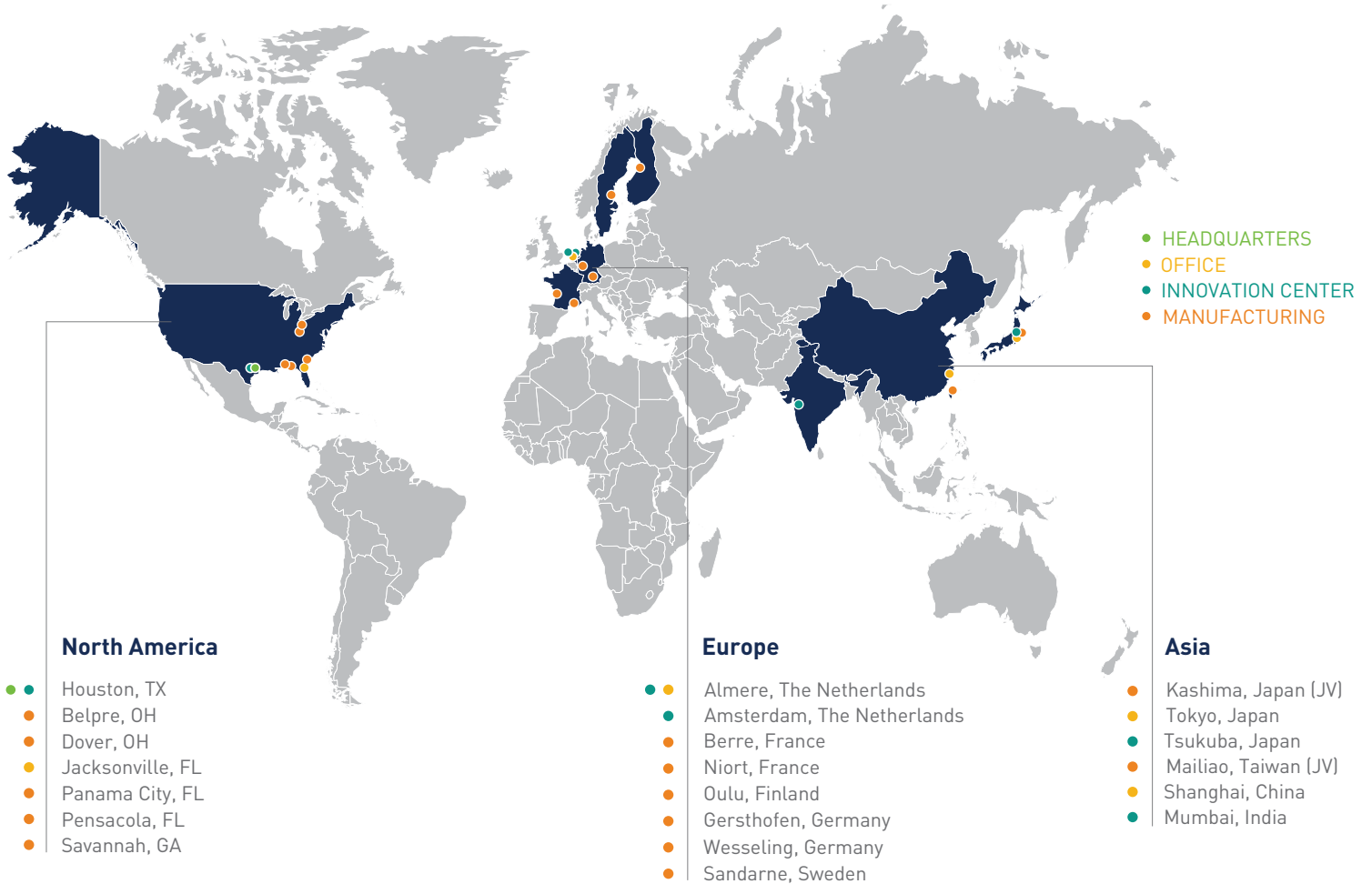
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