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ALASKA STYMIES STUDDED TIRES

by Tom Kuennen

Undulating transverse shadows across rutted pavement -- and gouged intersectionstriping -- shows rut damage caused by studded tires on Minnesota Avenue in Anchorage

Rutting caused by studded tire wear is a serious problem in the American Pacific Northwest, costing the states of Oregon, Washington and Alaska millions of dollars annually in damage to both asphalt and Portland cement concrete roads.

The Alaska Department of Transportation and Public Facilities (DOT&PF) sponsored a study at the University of Alaska-Anchorage to estimate the costs of damage caused by studded tire wear to Alaskan highways. This included collecting data to determine the rate of rutting on different roadway classifications and for different vehicle types.

The research team found that rutting caused by wear from passenger cars using studded tires is worse than deformation due to truck axle loads. "Results show higher average wear rates due to studded passenger vehicles on freeways (0.0116 inches per 100,000 studded vehicles) than the average rut rates due to heavy wheel loads (0.0049 inches per 100,000 trucks)," according to Survey and Economic Analysis of Pavement Impacts from Studded Tire Use in Alaska (2019), by Osama Abaza, PhD., C. Eng., University of Alaska-Anchorage.

Also, higher speeds worsen studded tire rutting. Abaza found lower average wear rates on arterial and collector roads (0.0062 in. and 0.0045 in. per 100,000 studded vehicles, respectively), than on highways that have higher speed limits.

"The annual damage cost associated with studded tires statewide was found to be $13.7 million, 42 times the state's fees [$318,000 annually] from studded tire sales and stud installations, not considering the cost of crashes and other safety aspects caused by ruts," Abaza found. "In 2019, the estimated total cost of mitigating road damage from studded tire use in Alaska over the next 20 years will amount to $203.2 million."

The problem exists throughout the Pacific Northwest. Abaza reported:

- Damage to pavement on Washington State highways due to studded tires is estimated to be $16 million annually.
- Damage to pavement on Oregon state highways due to studded tires is estimated to be from $8 to $10 million annually.
- The road damage caused by studded tires reduces road safety for all motorists when water collects in pavement ruts caused by studded tires, and creates dangerous driving conditions like hydroplaning and increased splash and spray.

"Rutting of pavements by studded tires is a huge issue in Alaska," says Drew Pavey, State Pavement Management Engineer, Alaska DOT&PF.

"It's a regional issue, first," says Steve Saboundjian, P.E., State Pavement Engineer. "We don't have that studded tire distress in Fairbanks in the Northern region because of the climate, the materials or the hardness of rock. But when it comes to the Anchorage 'bowl' or Juneau or Ketchikan, it's more prevalent. These are high-volume, high-traffic areas where the traffic impacts or hammers the pavement. Half of the state's population is in the Anchorage area."

"If you want to look at our region, the mass extent of our rutting concerns is from Willow to Anchorage and south down the Seward Peninsula," says Mike Yerkes, P.E., Materials Group Chief, Alaska DOT&PF Central Region. "If we don't take care of it, it will burn through the wearing surface stone and the subsurface pavement layers, and we will get into catastrophic pavement distress."

"It depends on the ADT, speed of the traffic, ambient temperatures and type of mix," Pavey says. "In some areas, we are seeing average wear rates of an eighth-inch a year."

HIGHLY MODIFIED ASPHALT

To fight studded tire rutting in asphalt pavements, the Alaska DOT&PF has turned to using highly modified asphalt (HiMA) in their wearing course mixtures, which is produced using Kraton™ D0243, an SBS modifier manufactured by Houston-based Kraton Polymers.

Alaska DOT&PF's Prall tester for studded tire damage

In North America, typical SBS-modified asphalt binders contain 2 to 4 percent SBS modifier. In contrast, the strict, performance-related specifications for HiMA usually requires 7.5 to 8 percent SBS. HiMA binders result in a significantly more durable pavement with a rubber-like flexibility to recover from the indentations created by the tire studs, while retaining mix workability during placement. In milder climates, research and experience have shown that HiMA binders result in mixtures with much greater resistance to rutting and fatigue cracking than other binders.

"HiMA is our term for a highly modified asphalt," says Bob Kluttz, Senior Scientist, Research and Development, Kraton. "Other states will call it high mod. Florida calls it High Polymer (HP). With Kraton D0243, you're going from predominantly an asphalt phase with polymer dispersed in it to predominantly a polymer phase with asphalt. With it, we change the blend from rubber-modified asphalt to asphalt-modified rubber. That is, the mix goes from a discontinuous to a continuous polymer phase, with very different physical properties resulting from that."

Lab tests confirm these performance properties, Kluttz says. The Prall test, Alaska Test Method 420, for studded tire damage was originally developed in the Nordic countries and is standardized as EN12697-16 in the European Committee for Standardization (hence the standard SI units). Test specimens are 100. mm (3.9 in.) in diameter and 30. mm (1.2 in.) thick and are tested at 5 °C (41 °F). The specimen is loaded in the test device and covered with 40 stainless steel spheres 12 mm (0.47 in.) in diameter. The test chamber is oscillated with a stroke of 43 mm (1.7 in.) at a frequency of 950 strikes per minute for a period of 15 minutes.

The standard Prall test specimen on the right shows typical abrasion with most of the aggregate clearly visible. The Prall test steel spheres progressively wear the binder and fine aggregate from the specimen surface. With the PG-40 HiMA binder specimen at left, much less of the surface is abraded due to its resilience, thus it can continue to protect the aggregate below from fracture

"What we saw with Prall testing was that the conventional material core sample has a lot of material removed," Kluttz says. "Large aggregate is pretty much all you see. The studs pick out small aggregate and binder, expose the large aggregate, and eventually that fractures and comes out. Then very quickly, the studs pick out more asphalt and fines in mastic.

"But with the HiMA sample, what you see is mostly asphalt," he says. "The test picked out some of the mastic and some of the large aggregate, but what remains is exposed asphalt that is just tougher. It's tough enough to resist being picked up by the studs."

ALASKA IMPLEMENTS HiMA

With studded tire rutting being such a problem in The Last Frontier, Alaska DOT & PF engineers inquired as to whether HiMA with Kraton D0243 would work to quell studded tire damage.

"Since they have been trying for years to come up with a solution for this kind of damage, they came to us in 2012 and said, 'Hey, do you have any ideas about how to address this damage with HiMA? Do you think it would help?'"

So in 2015 – in downtown Anchorage – a PG 64-40 E HiMA binder was used for the first time in a Superpave mix that incorporated hard aggregate. HiMA mix was placed on two busy avenues, one-way streets in downtown Anchorage. This project was a standard street resurfacing with a 1 ¾ in. (44 mm) mill and 2 in. (50 mm) fill. The HiMA overlay was placed on 5th and 6th Avenues and cross streets, with traffic ranging from 10,000 to 15,000 vehicles per day.

The PG 64E-40 HiMA binder was supplied by Denali Materials Inc. and the project was constructed by Granite Construction. Paving began for a month in September 2014 and was completed the following June. Paving was done at night and static rolling was required due to noise and to sensitive infrastructure. The temperature of the mat behind the paver averaged 310 °F (155 °C). Even with difficult conditions and equipment restrictions, the contractor achieved the required mat density of 95 percent and joint density of 93 percent.

To date, performance has been good with minimal damage caused by studded tire wear or traffic loads. In 2019, after four years of traffic including studded tires, the average rut depths were 0.204 in. (5.2 mm) on 5th Avenue and 0.198 in. (5.0 mm) on 6th Avenue in downtown Anchorage.

The wheel paths look dark much like the Prall test specimens, indicating that roughly the same behavior is occurring in the laboratory and in the field. The Alaska DOT&PF is pleased with the performance and is specifying more projects with modified PG 64-40 E binder and hard aggregates, designated as Hot Mix Asphalt, Type VH by Alaska DOT&PF.

After four winter seasons (2015-2019), 200 block of E 5th Avenue with HiMA-modified PG 64-40 E binder shows minimal rutting

HIMA FOR HIGH-LEVEL ROADWAY

The Alaska DOT&PF also is concerned about studded tire rutting on its high-level, higher-speed, higher-volume highways. Glenn Highway – which runs east of Anchorage toward Canada in a scenic setting – provided such a highway application, compared to the urban application downtown.

Due to studded tire wear, Glenn Highway has typically been resurfaced every six to seven years. "We generally say that the Glenn Highway ruts 1/8-in. a year," Yerkes says.

Earlier attempts on Glenn Highway (Alaska S.R. 1) to quell studded tire rutting did not perform as hoped. A hot mix asphalt surface using ground tire rubber and PG 64-34 asphalt binder was placed on the Glenn Highway in 2010. But in 2012, the average rut depth between Airport Heights and Hiland roads, being the most highly trafficked route in Alaska, was 0.32 in. (8.1 mm) after two winters of studded tire wear.

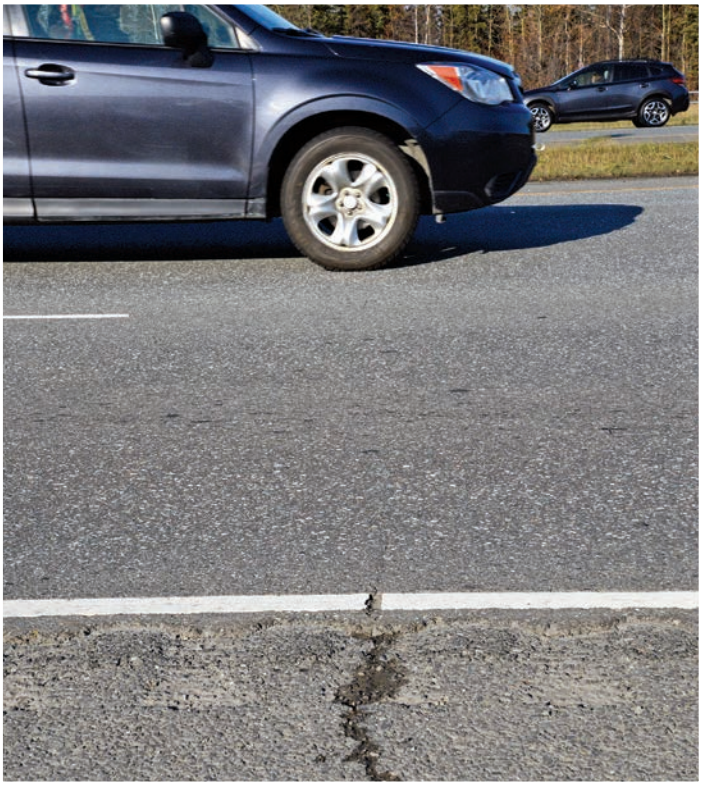
"We have been trying rubberized asphalt mixes," Yerkes says. "The rubber asphalt mixes have turned out less desirable than what we're currently seeing with our current 64-40 hard aggregate mixes."

So following the successful performance of the 5th and 6th Avenues in Anchorage, Alaska DOT&PF specified the same PG 64E-40 HiMA binder grade for resurfacing of the Glenn Highway.

In 2017, the rubberized mix was milled and replaced with 2 in. (5 cm) of Hot Mix Asphalt, Type VH for resurfacing 15.2 miles (24.5 km) of Glenn Highway. Some 50,000 tons (45,000 mt) of Hot Mix Asphalt with PG 64-40 E HiMA binder and hard aggregate were placed. In 2019, the average wear on this Superpave mix between Airport Heights and Hiland roads was just 0.21 in. (5.3 mm) versus 0.32 in. (8.1 mm) of crumb rubber asphalt, both after two years of service.

Construction of the whole project went from late 2016 to early 2018. In-place densities greater than 95 percent were consistently achieved.

HiMA mix, eastbound Glenn Highway Alaska S.R. 1 at weigh station near Eagle River shows minimal studded tire rutting after two years



In late 2019, on busy Glenn Highway, transverse crack in shoulder stops dead at HiMA mix placed two years earlier

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