ADDING FIBRE TO ASPHALT MIX TO INCREASE STRENGTH AND DURABILITY

by James Careless

Fibre-enhanced asphalt mix at Toronto Pearson International Airport.
Around the world, roadbuilders are adding fibres to asphalt mixes in a bid to improve asphalt pavement strength and durability, and to forestall the emergence of cracking, rutting, and shoving. In doing so, these contractors and their clients are attempting to lower the cost of maintaining roads by reducing annual repairs and ensuring that roadways achieve their planned lifespans before replacements are necessary.

Although the practice of using fibre-enhanced mixes is relatively new, the technique of adding fibres to asphalt dates back thousands of years. According to the National Cooperative Highway Research Program (NCHRP) report “Fiber Additives in Asphalt Mixtures”, the earliest use of fibres in asphalt was the use of straw in ancient Egyptian building specifications.

In the road construction industry, paving companies added asbestos fibres to asphalt pavement from the 1920s until the 1960s, when the health risks associated with asbestos became known. Cotton fibres were used in the 1930s, but fell out of favour when it was discovered they tended to degrade over time. Today, a number of different types of fibres are being used to enhance asphalt mixes.

**WHY ADD FIBRES TO ASPHALT MIXES?**

Adding fibres to asphalt mixes is intended to make roads stronger and last longer. When blended evenly into a mix at the plant, these fibres improve the tensile strength of the mix. This results in an increased resistance to cracking and a reduced severity of cracking when it does occur.

Fibres in asphalt mixes spread the load on specific areas of a roadway undergoing stress due to heavy traffic by sharing this stress more widely throughout the larger asphalt pavement structure. Fatigue resistance is increased due to increased strength in the asphalt pavement, and rutting resistance improves because of increased lateral restraint within the mixture. Roads show increased abrasion resistance due to the roadway being tougher and more resilient.

Due to their large surface area, adding fibres may lead to a higher asphalt content, resulting in increased roadway durability and potentially lower life cycle costs arising from a longer service life and fewer repairs. Fewer repairs also mean fewer disruptions to traffic during the roadway’s life cycle.

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A WIDE SELECTION OF FIBRE OPTIONS

There are a range of fibres that are being added to asphalt mixes for roadway use. Each have their benefits and drawbacks.

Cellulose fibres are derived from woody plants or, in some cases, recycled newspaper. They are highly absorbent, which means cellulose fibres are effective at soaking in asphalt binder, thus providing more durable bonds to aggregates within the mix. Cellulose fibres are also inexpensive and widely available, but they lack tensile strength. So if the roadway is expected to undergo considerable stress, other fibres may be a better choice.

Mineral fibres from natural sources are also used. Asbestos, though popular in the past, is no longer used due to health concerns. Other manufactured fibres are created by melting minerals such as steel, then spinning them like candy floss into mineral wool. Mineral fibres are stronger than cellulose, but not as absorbent and can be prone to degradation when exposed to water. As well, mineral fibres can result in asphalt mixes that can be difficult to compact and may cause tire damage if used in surface coats.

Although more expensive than other options, synthetic polymer fibres such as polyester, polypropylene, aramid (related to nylon), and aramid/polyolefin provide the strength benefits of adding fibres to mixes. They provide higher tensile strength than cellulose fibres without the environmental degradation issues associated with steel fibres.

One such synthetic fibre product is ACE Fiber™, which is comprised of aramid fibres and Sasobit wax coatings. Lightweight aramid fibres are coated with Sasobit to provide weight while the fibres are added to the hot aggregate so that they are not pulled out of the drum by the dust collector. The Sasobit has a very low melting temperature and starts to melt as soon as it comes in contact with the heated aggregate. In higher doses, Sasobit is an asphalt warm mix additive. Distributed in Canada by Nilex, ACE Fiber™ mixed directly into the mix disperses over 20 million aramid fibres throughout each tonne of mix.

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| AHMED, SNC-LAVALIN PROJECT MANAGER |
“This mechanically strengthens the hot mix,” says Michael Simons, Nilex’s Product Manager for Roadway Systems. “The aramid fibres have really small fibrils on them which are exposed after the wax coatings melt in the hot mix. They bind to anything, holding the asphalt binder and the aggregate together.”

According to Nilex, testing using the Texas A&M Transportation Institute’s (TTI) Balanced Mix Design Method has shown that ACE Fiber™ mixed with hot mix asphalt (HMA) delivers 50 per cent more rut resistance and 140 per cent more crack resistance than regular mixes. Tests conducted by TTI, Hi-Tech Asphalt Solutions (2015), and Advanced Asphalt Technologies (2014) have also shown ACE Fiber™-enhanced HMA to offer a 150 per cent increase in strength and resistance to thermal cracking, and a 290 per cent increase in fatigue life.

HOW FIBRE-ENHANCED ASPHALT MIXES ARE BEING USED

In the chapter entitled “Survey Results: Current US and International Experience”, NCHRP Synthesis 475 reported the results of a 2014 survey in which government road departments were asked about their use of fibres in paving materials. Forty-eight U.S. states responded to the survey as well as Ontario and Manitoba.

Of the states that used fibres, the most common applications were in stone mastic asphalt (SMA) and porous mixes (open-graded or porous friction courses). Fibres were added to SMAs to prevent drain down of the asphalt binder from the mixture, thus lengthening its lifespan. In addition to using fibres to prevent drain down (cited by 27 of the states that use fibres), the states of Georgia, Oklahoma, Tennessee, New Hampshire, Ohio and Virginia also add fibres to roadway asphalt to reduce rutting and cracking. In Canada, Manitoba does not add fibres to its asphalt mixes, and Ontario has.

“In the past, MTO has used Polyethylene Terephthalate (PET) fibres to strengthen mixes on Highway 655, 417, and 427,” says Pamela Marks, MTO’s Head of Bituminous Section. “We did experience melting of these fibres on one project and re-clumping of the loose PET fibres during mix production, and balls of fibres encased in the mix were torn open by the rollers and traffic,” she says. “Changes made in both cases were effective in eliminating both issues from reoccurring. But even with these changes, the performance results of these PET fibre trials have been mixed.”

To date, MTO has allowed the addition of aramid fibres to asphalt mixes by two distribution methods: by blending them with polyolefin fibres or by coating them in Sasobit wax. “Adding uncoated fibres usually requires the use of more asphalt cement (AC) in the mix,” says Marks. “While this is considered a disadvantage due to increased costs for the fibres and additional asphalt cement, it is perceived as a benefit as mixes with more AC are considered more durable.”

MTO has tendered over ten contracts for fibre-reinforced asphalt pavement trial sections using aramid fibres since 2016. “Two of these trials started to exhibit reflective cracking in their first winter within a few months of being placed,” says Marks. “Now that the oldest of these trials is two years old, we will continue to monitor them to determine potential long-term benefits.”

FIBRE-ENHANCED HMA AT TORONTO PEARSON INTERNATIONAL AIRPORT

Toronto Pearson International Airport experiences a very high volume of traffic on its asphalt runways and taxiways. In July 2018 alone, the airport’s asphalt surfaces experienced 43,613 aircraft movements according to the Greater Toronto Airports Authority (GTAA) that operates Pearson. (In 2017, 47.1 million passengers transited through Pearson, making it the busiest airport in Canada and the second busiest international airport in North America.)

The movement of fully-loaded passenger and freight aircraft, combined with the many heavy vehicles that service them, puts the asphalt at the airport under constant stress. This is particularly true in the holding position area where aircraft wait to enter the runway and take off.

“The asphalt we’ve been using in this area has been showing issues such as shoving and rutting,” says Kevin Chee, the GTAA’s Senior Civil Engineer. “This is why we are constantly reviewing and testing new asphalt mixes for the airport to improve pavement durability and to increase the pavement lifespan. After all, if we have to close a critical manoeuvring area for repairs, it will cause a major disruption to our already-busy traffic flows.”

Working with Nilex and SNC Lavalin, the GTAA’s mix design consultant, three aramid fibre-enhanced HMAs were developed using three different types of aggregates that are commonly available in Ontario. These HMAs were formulated using Superpave P-401, tested in the lab, and then applied in the holding position area.

“The lab study showed about a 20 to 30 per cent improvement in rut resistance using fibres in HMA, and we expect the field validation to show similar or better improvement,” says Mohammed Ahmed, SNC-Lavalin’s Project Manager.

To assess which aggregate blend shows the best performance over time, SNC-Lavalin worked with three different Ontario quarries. The final HMA mixes selected were as follows:
The three fibre-enhanced Superpave mixes, including a control section using regular airport surface mix, were laid down on Pearson’s Alpha taxiway in 2018. The GTAA and SNC-Lavalin will be monitoring their performance over next two years to see if using these special blends better resists rutting and shoving at the holding position area.

If it does, the benefits for Pearson will be significant. Longer-lasting pavement service life in this critical area will mean less money spent to rehabilitate this area on a more frequent basis (three to four years versus the non-critical area of ten years life span), less operation disruption to aircraft traffic flows due to construction, and happier passengers due to minimum construction delays.

**EVALUATIONS OF FIBRE-ENHANCED MIXES ARE ONGOING**

The added durability, reduced cracking, rutting and shoving, and longer pavement lifespan promised by fibre-enhanced mixes explains the interest shown in this formulation by owners and industry. However, it is still too early to say conclusively whether fibre-enhanced mixes will deliver on this promise.

According to the NCHRP, studies of the laboratory and field performance of fibre-reinforced dense graded mixtures have yielded mixed results. In some cases, the addition of fibres to asphalt mixes improved the asphalt roadways’ performance over time, especially in terms of resisting cracking and rutting. In other instances, fibre-enhanced mixes did not deliver significant performance improvements over asphalt-only mixes. The NCHRP has observed that adding fibres to marginal or lower-quality mixtures that are prone to rutting and cracking tend to show improved roadway performance. This suggests that fibres may be compensating for performance issues in such mixes that do not occur in higher-quality mixes.

MTO is also in the evaluating phase of this technology. “Based on MTO’s experiences with fibre-reinforced asphalt mixes to date, pavement designers should not expect the use of fibre additives in asphalt pavement overlays to delay the propagation of underlying working cracks (cracks that expand and contract putting stress on the overlying roadway),” says Marks. “Meanwhile, MTO’s review of non-working cracks – cracks that do not move, expand or contract – is inconclusive at this stage. All told, MTO is still in the exploratory phase when it comes to the use of aramid fibres in today’s mixes.”

The fact that fibre-enhanced mixes have achieved mixed results so far does not mean this approach is without merit. What it does mean is that agencies such as NCHRP, MTO and GTAA will continue to evaluate fibre-enhanced mixes and other similar solutions as they seek to extend asphalt pavement lifespans and curtail premature cracking, rutting, and shoving. The analysis to date suggests that fibre-enhanced mixes deserve a place in the asphalt pavement toolkit, but that the specific instances in which this material can provide the best results remains to be determined.