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True Grit:
Embedded Gritting Trials on Stone Mastic Asphalt (SMA) Surface to Enhance Initial Early Age Friction

The Ontario Ministry of Transportation (MTO) is always looking for innovative technologies to enhance highway safety and improve highway performance. Stone Mastic Asphalt (SMA) was adopted by MTO as a premium surface course mix due to its excellent proven performance. One concern that the ministry has encountered with newly placed SMA is that it exhibits lower initial frictional properties that improves over a short period of time. Similar findings have been reported by other agencies in USA, Europe and Australia. To obtain enhanced friction immediately after construction, the ministry trialed the use of embedded gritting sand on the SMA surface during paving. This embedded gritting technology is new to Canada and the ministry's trials in Burlington, Ontario, in 2011, were the first ever conducted on a provincial highway.

Stone Mastic Asphalt (SMA)

SMA has been used as a premium surface course mix on major highways in Ontario since 2002. It provides high textured, durable and rut resistant surfaces that are more resistant to cracking. SMA is a gap-graded asphalt mix that has approximately a 70 per cent coarse aggregate skeleton. When properly designed, produced and placed, SMA's stone skeleton bound by rich mastic delivers the following benefits:

- Stone-to-stone coarse aggregate contact with high internal friction, provides excellent resistance to rutting;
- Higher binder content and rich mastic results in increased durability, good fatigue resistance and lower susceptibility to low temperature cracking;
- Macrotexture of the SMA mix provides improved surface drainage (reduced splash), good frictional resistance and surface texture characteristics with superior noise reduction compared to conventional dense graded HMA; and
- Longer in-service life, which makes it an economical and sustainable surfacing.

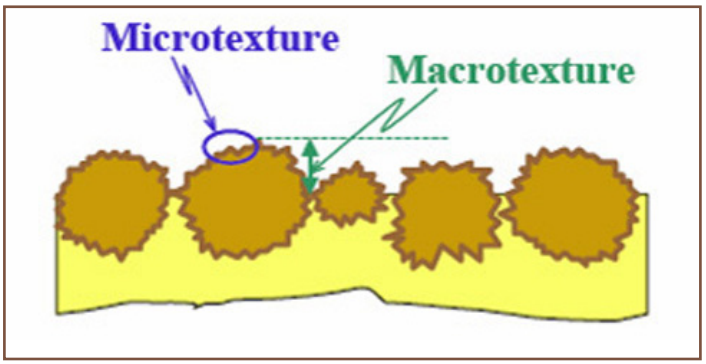

Figure 1: Illustration of micro and macrotexture (Flintsch et al., 2003)

SMA pavement has improved frictional resistance resulting from the combination of coarse surface texture (macrotexture) and the microtexture of the exposed aggregates (Figure 1). Rut resistance is provided through stone-to-stone contact. Microtexture provides pavement friction at low speed and macrotexture provides friction at high speed, reducing hydroplaning potential. Figure 2 illustrates the differences between SMA and dense-graded conventional hot mix asphalt.

Ontario's First Gritting Trials on SMA Surface

Enhanced initial early age friction on SMA surface is desired right after construction and before opening to traffic. The need to enhance initial early age friction of SMA motivated the ministry to suspend the use of SMA while investigating different methods to enhance initial early age friction. In the interim, the ministry specifies Superpave 12.5FC 2 in place of SMA. To address the surface friction issues of SMA, the ministry formed a joint SMA Task Group to investigate different methods (mix design and construction) to improve the initial early age friction of SMA. The SMA Task Group comprised of ministry staff, the industry, including the Ontario Hot Mix Producers Association, >

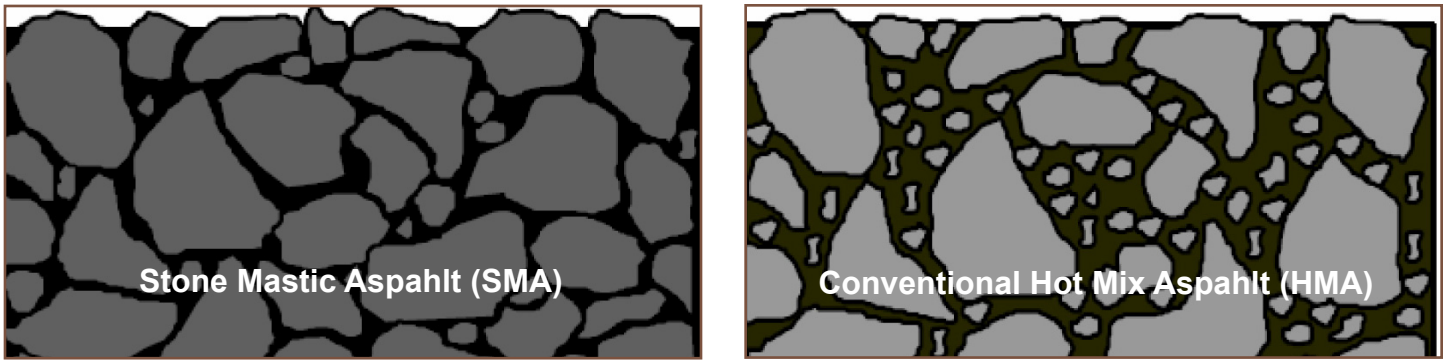

Figure 2: Comparison of SMA and conventional dense graded HMA structures

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consultants and contractors. The SMA Task Group reviewed current specifications and oversaw extensive laboratory testing resulting in a revised SMA specification.

In 2009, the ministry conducted its first trail using the revised SMA specification on a section of the Queen Elizabeth Way at Red Hill Creek, with encouraging results. Subsequently, in 2010, the ministry carried out trials on a section of Highway 400 north bound lanes between Highway 407 and Bass Pro Drive featuring three aggregate sources and two fillers. These trials on Highway 400 also included the assessment of a light application of gritting sand on the compacted SMA surface with the intent to accelerate abrasion of the asphalt binder film of coated aggregates from the fresh SMA finish surface.

The results of the ministry's Highway 400 trials indicated that use of post-construction gritting sand was not effective in improving the initial early age friction of SMA surface; the ministry then trialed the embedded gritting sand to improve initial early age friction.

2011 Embedded Gritting Trials on Queen Elizabeth Way (QEW)

In 2011, two SMA contracts were selected on the QEW, near Burlington Ontario, to evaluate embedded gritting sand technology. These contracts consisted of milling and overlaying with Superpave 19.0 binder course and SMA 12.5 surface course mixes.

A non-standard special provision was developed by the ministry for construction of the SMA gritting trials. Two SMA 12.5 mixes and three gritting materials with different application rates were evaluated including uncoated sand and sand lightly coated with asphalt binder.

For these trials, coated and uncoated gritting sand was required to be processed through a hot mix plant. Coated grit required asphalt binder content of 0.8-1.0 per cent. Both coated and uncoated grit materials were hot applied at a minimum of 80°C during placement, to ensure that the sand was free of clumps or agglomerations. For comparison purposes, the adjacent highway sections without gritting were used as control.

Gritting Roller

For both gritting trials, a specialized Dynapac tandem steel drum roller fitted with a hopper and an adjustable application rate control lever was used (Figure 3). The gritting roller's hopper is designed to distribute gritting material uniformly at pre-set application rates. The hopper was re-filled on site for continuous gritting operation and to achieve uniform grit placement. Two passes of gritting roller were required to cover the full lane width, with no overlapping between the passes.

Figure 3: Gritting roller in operation at the Burlington demonstration site and close up of the loose coated grit (bottom).

Construction

AECON Construction and Materials Limited constructed the first embedded gritting trial sections on the QEW at Burloak Drive in the 2nd and 3rd east-bound lanes. Gritting was first applied to approximately 200m long sections of both lanes of the North Service Road in Burlington, to demonstrate the specialized gritting equipment, cleanup operation and assess the resulting texture. After successful completion of the demonstration trial, the contractor carried out the actual trial sections on the QEW which are summarized as follows:

AECON used Caledon manufactured sand with the following varied application rates as verified at site (Figure 4) on bare pavement prior to paving:

- East bound lane 2: Gritted with uncoated sand (~ 1 km section)
  - First 500 m section with 1.0 kg/m^2 application rate
  - Second 500 m section with 0.75 kg/m^2 application rate
- East bound lane 3: Gritted using coated sand with 1% AC (~ 1 km section)
  - First 500 m section with 0.9 kg/m^2 application rate
  - Second 500 m section with 0.5 kg/m^2 application rate >

Embedded Gritting Trials on Stone Mastic Asphalt (SMA) Surface to Enhance Initial Early Age Friction, *continued*

Figure 4: Verification of the application rate being carried out prior to paving. For uncoated gritting sand application, the finished SMA surface was swept to remove any excess sand (float).

Figure 5: Coated grit being rolled in to hot SMA surface.

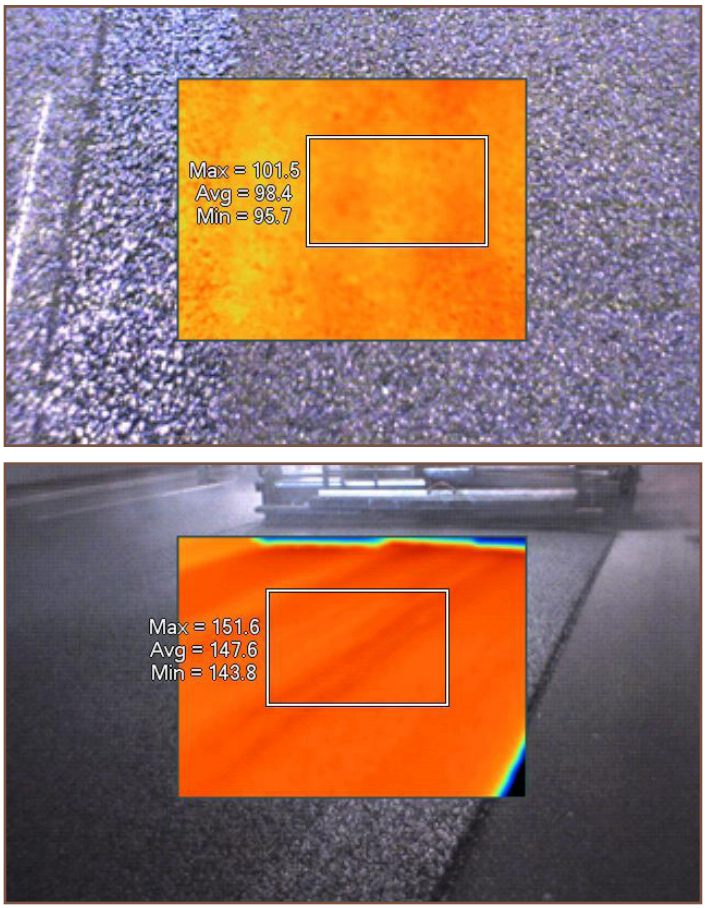

Figure 6: Thermal image of gritting sand on SMA surface during compaction (top). Thermal image of SMA placement behind the paver (bottom).

The second trial sections were constructed by Dufferin Construction Company on lane two of the east-bound QEW at Third Line, gritted with coated sand with 1% AC (~ 2 km section), using an application rate of 0.75 kg/m^2. Removal of excess grit was not warranted. The trial is summarized as follows:

- First 1000 m section: Coated grit (1%AC)
  - Gritting sand: Ontario Trap Rock (DFC Fines)
- Second 1000 m section: Coated grit (1%AC)
  - Gritting sand: High stability sand (Milton Quarry)

Measurements of gritting sand temperature in the roller's hopper ranged from 80^{o}C to 125^{o}C. Gritting sand was applied to the SMA mat after one or two passes of the initial break down rolling while it was still hot and then rolled in and compacted (Figure 5). SMA temperature during placement behind the paver was in the range of 140^{o}C to 160^{o}C (Figure 6).

Trial Challenges

The ministry's embedded gritting trial experience has been generally positive, with a few initial challenges. During the first trial, there was some pick up of uncoated gritting sand which was deposited onto the mat. The issue was resolved by reducing drum wetting; however, some areas required repairs. Also, some dust was generated during the sweeping of the uncoated gritting sand application operation which could be an issue immediately after opening to traffic.

The second trial only used coated grit. To ensure the durability of the lane markings, a one foot strip was left ungritted. Roller width can be a challenge for contractors for lane width coverage and may require some modifications such as utilizing a wider drum roller for gritting application. >

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Findings and Future Plans

The ministry surveyed the friction of the SMA gritting trials on QEW just after construction and monitored the sites in subsequent periodic friction resistance tests performed at the posted speed in June, July, August and September, 2011. MTO used a locked wheel friction tester, an ASTM E-274 Brake Force Trailer with a standard rib tire for measuring wet pavement friction in the field. For comparison purposes, the adjacent SMA sections without gritting were also tested for pavement friction and were used as control sections. Further friction testing will be performed in 2012 to assess the long term performance of gritting on SMA surface of the trials.

Friction surveys of these trials found that embedded gritting has been successful in improving the initial early age frictional resistance of SMA. Initial early age friction of SMA tested just after construction (within one to two days) for both coated/uncoated gritting materials improved by 26 to 59 per cent at various application rates. Friction measured after six to eight weeks after construction still indicate slightly higher frictional resistance (2 to 11 per cent) compared to control sections. The ministry will continue to monitor and evaluate the performance of these trials.

Based on the results, it is evident that the embedded uncoated/coated grit can significantly improve the initial early age friction of SMA surface. These trials also confirm that embedded hot gritting material using a specialized gritting roller is feasible and removal of excess coated grit was not necessary when coated gritting was used.

Following the success of the two trials, the ministry plans to reinstate SMA use on its high volume highways using the new specification that includes embedded grit. This will be done through consultation with the MTO/industry SMA Task Group and will be implemented on an incremental basis. Embedded coated gritting sand with one percent asphalt binder and 1.0 kg/m^2 application rate has proven to be an effective method to enhance initial early age friction of SMA surface. ●

Figure 7: Texture of finished SMA surface treated with coated gritting sand and a close up (left bottom) showing differences between SMA surface textures with and without gritting.

For more information please contact:
Imran Bashir, Bituminous Engineer, Bituminous Section,
Highway Standards Branch, at (416) 235-3546,
or at Imran.Bashir@Ontario.ca
OR
Anil Virani, Senior Bituminous Engineer, Bituminous Section,
Highway Standards Branch, at (416) 235-3723,
or at Anil.Virani@Ontario.ca