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The wear of Stone Mastic Asphalt due to slow speed high stress simulated laboratory trafficking

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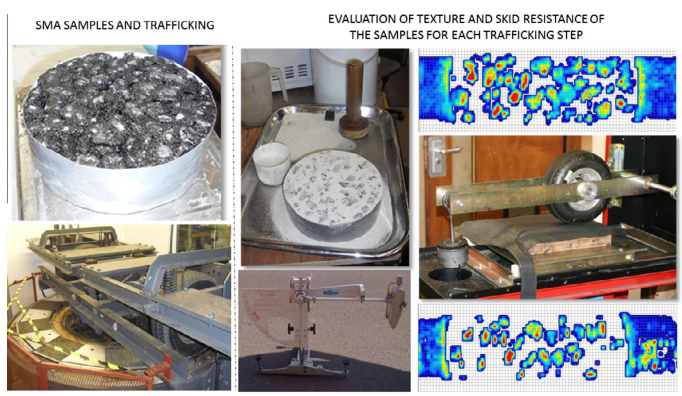
HIGHLIGHTS

- An investigation into the wear SMA road surfacing material has been proposed.
- The Wear Test using the Road Test Machine has used.
- The relationships between SMA design and surface properties have been investigated.

GRAPHICAL ABSTRACT



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ABSTRACT

This paper summarizes a laboratory investigation into the wear of Stone Mastic Asphalt road surfacing material. Review of harmonized European test methods found no specific Wear Test and this is an important knowledge gap relating to laboratory prediction.

The UK Wear Test using the Road Test Machine was applied to assess Stone Mastic Asphalt test specimens. This uses full size pneumatic tires to wear asphalt test specimens, under slow speed high stress conditions. This found 14 mm and 10 mm SMA to behave in similar ways.

Relationships between variables for newly compacted test specimens quickly change with the onset of simulated trafficking. This raises issues with laboratory investigations that do not involve some aspect of tire/test specimen wear at their interface.

Contact area is a better property to measure than macrotexture. Poor relationships between contact area and pendulum tester suggest that either something additional at the contact interface has to be measured or there are limitations with the pendulum tester. More research is required to better understand wear at the tire–asphalt interface and the prediction/measurement/monitoring/modeling of properties such as skid resistance, rolling resistance and noise generation.

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1. Introduction

Stone Mastic Asphalt (SMA) was developed in Germany about 40 years ago to be a hardwearing material for use on heavily

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trafficked roads. SMA is now specified in a harmonized European Standard and it is used in many countries around the world [1].

It has a high stone content, which forms a gap-graded skeleton-like stone structure. The voids of the structural matrix are filled with a high viscosity bituminous mastic of bitumen and filler, to which fibers are added in order to provide adequate stability of the bitumen and to prevent drainage of the binder during transport and placement.

SMA, properly designed and produced, has excellent properties. The stone skeleton, with its high internal friction, gives excellent shear resistance. The aggregates, in fact, have a high angularity that improves interlocking, packing and stone-on-stone contact between grains [2–4]. The mastic, voidless and binder rich, gives to the mix good durability, resistance to cracking and good stability at high temperatures. The high concentration of large aggregate particles, three to four times higher than in a conventional dense graded asphalt, gives to the mix superior resistance to wear [5–7]. The surface texture is rougher than that of dense graded asphalt and it assures good skid resistance, proper light reflection, reduced water spray and lower traffic noise [8]. The possibility of reusing recycled aggregates in SMA mixtures as a partial replacement of coarse and fine aggregates assures a low environmental impact regarding its construction and maintenance [9,10]. The use of recycled materials has become important because of the limited availability of aggregates and the difficulties and excessive disposal costs for milled materials [11,12].

The harmonized European Standard for SMA is currently being revised to make it compliant with the European Construct Products Regulation [13]. The Construction Products Regulation (CPR) was fully adopted on 1st July 2013 and relates to 35 named product areas. Product area 23 is Road construction products and product area 24 is aggregates. The CPR has four main elements: a system of harmonized technical specifications, an agreed system of conformity assessment for each product family, a framework of notified bodies and CE marking of products. CE marking implies a product that is consistent to its Declaration of Performance (DoP).

Seven basic requirements are stated: mechanical resistance and stability, safety in case of fire, hygiene, health and the environment, safety and accessibility in use, protection against noise, energy economy and heat retention, sustainable use of natural resources.

These seven basic requirements of the CPR pose challenges if reliance is placed on current harmonized European Standards, particularly with respect to the long-term performance and durability related properties of road surfacing materials such as SMA. Although many countries monitor road surface wear as part of their highway asset management programme, there is no specific laboratory test method to adequately predict what happens due to pneumatic tire trafficking.

This paper describes a laboratory investigation into the wear of Stone Mastic Asphalt road-surfacing material, based on better understand in-service wear conditions and the types of texture related change that may occur. Review of harmonized European test methods found no specific Wear Test and this is an important knowledge gap relating to laboratory prediction.

2. Background

Surface texture characteristic is a common indicator for evaluating the performance of road pavements in terms of riding comfort, fuel consumption, safety and noise abatement. In the wavelength ranges of macrotexture, the most significant impacts of texture are in the areas of rolling resistance, tire–road friction and noise [14].

Pavement surface texture can be assessed through intrinsic and extrinsic indicators, evaluated mainly by volumetric methods [6,15,16] and linear 2d laser-based methods [17–20].

Volumetric methods and their related indicators are based on the ratio between a volume and a surface area, while linear 2d laser-based methods and their related indicators rely on the ratio between a surface area and a length.

The volumetric patch technique is suitable for bituminous courses and concrete pavement surfaces with texture depth greater than about 0.25 mm and it is affected by the surface and inner structure of the mixture (air voids distribution, shape, tortuosity) [7].

Laser-type measurements are affected by the complex shape of a pavement surface, but they do not depend on what the laser cannot "see" from its position. In more detail, a laser beam is projected onto the surface and then the immediate reflection along the same ray-path is returned. The result is a diffraction pattern. This pattern is frequency analyzed and the distance to the measured surface (pavement surface) is consequently derived. The main advantage is that only a single ray-path is needed for measuring, thus giving an opportunity to measure deeper areas of surface texture. There are issues relating to beam dimensions and to the fact that the beams describe straight lines without any possibility of investigating pore properties.

The laboratory measurement of road surface texture related performance properties and how they change due to wear during their life is less understood. The polished stone value (PSV) test method [21] is a harmonized European Standard and has been used for many years to assess microtexture of 10 mm sized aggregate particles. The volumetric patch technique [22] ban be used to assess macrotexture of compacted test specimens. While these methods are simple and quantify texture related properties as a single number, they are limited in their ability to predict levels of performance that would be measured onsite during the life of a road construction product.

They do not consider how different scales of texture develop with time for different types of asphalt mixture under differing levels of compaction, trafficking and environmental conditions. Although the Friction after Polishing test (FAP) has recently become adopted as a harmonized European Standard [23] to assess either aggregates or asphalt mixtures, Dunford [24] has suggested that the rubber rollers used in the device are possibly too stiff to replicate how a pneumatic tire interacts with a road surface. While the FAP method may provide a measure of friction for asphalt mixtures, this restricted simulation of tire/road surface texture interaction is an important issue if considering how these mixtures wear with time over their life cycle.

Given that there is no standardized European test method to measure the wear of road surfacing materials, the analysis of how an asphalt material may change as it wears during its in-service life becomes very important.

For this purpose, this paper describes a laboratory investigation using SMA test specimens, based on trying to better understand in-service wear conditions and the types of texture related change that may occur.

This subjected 14 mm and 10 mm SMA specimens to accelerated simulated trafficking under conditions of slow speed high stress. This used the Road Test Machine (RTM) located at the Ulster University. The RTM equipment is shown in Fig. 1. It consists of a 2.1 m diameter horizontal table that rotates at 10 rpm. Ten test specimens can be fixed on this table. Trafficking is simulated using two vertically mounted 195/70R14 tires, each applying a load of approximately 5 kN. The temperature of test equipment room is maintained at 10 ± 2 °C. As the table rotates, the two test tires track back and forth across the width of the test specimen subjecting the test specimen to slow speed high stress.

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