PLASTIC MODIFIED ASPHALT

Researchers at TU Braunschweig in Germany and Italian chemical additives producer Iterchimica show how recycled plastic-based modified asphalt mixtures perform at low temperatures*.

Increasing awareness of environmental issues - apart from the many benefits of creating a circular economy – is focusing the minds of road engineers on the use of recycled material in pavement layers. In this context, waste plastic has been one of the most used materials in asphalt pavements. To date, much research has been carried out showing different types of waste plastic as promising asphalt-mix modifiers.

According to the latest global surveys and investigations[1], the type of waste plastic and how it has been introduced into a bituminous mixture – using either the dry or wet process - can have a huge influence on an asphalt mixture's properties. However, regardless of this, almost all literature has consensus on the increment of the stiffness of the mixture, when waste plastic is used[2].

One point of view is that this increment in stiffness provides higher resistance to permanent deformation, making the asphalt suitable for heavy-duty pavement and pavement in hot-climate regions. But another point of view shows there is concern by engineers about the mixture's low-temperature cracking tendency and its crack propagation resistance[3].

The following discussion considers two case studies: the low-temperature cracking resistance and the crack propagation of stone mastic asphalt (SMA) mixtures modified with a recycled plastic asphalt modifier were investigated.

RECYCLED SUPERMODIFIER

The asphalt supermodifier used in this investigation is a patented product, called Gipave, a compound of hard plastics - PE, PP and PVB (see box) - and graphene nanomaterials, as well as other active components. It is noteworthy that no low-melting point plastic (such as water bottles) was included in the composition of the product. *Table 1* summarises some of the properties of the asphalt supermodifier. The product is used via dry method and it is added to the hot aggregates before adding the bitumen and filler in the batch. The dosage could vary from 4-10% on the mass of the design bitumen content. It depends on the level of modification and design criteria. The dosing of the additive in the asphalt plant could be carried out either by low-melting point bags or any dry dosing systems usually available for dosing the fibres.

Table 1. Some of the given technical properties of the asphalt supermodifier

Properties	Unit	Value/Aspect
Material State	-	Granules
Colour	-	Black
App. density	g/cm³	0.4 – 0.6
Softening Point	°C	160 - 180

CASE STUDY 1: RESISTANCE TO LOW-TEMPERATURE CRACKING

The thermal stress restrained specimen test (TSRST), according to EN 12697-46, was selected to evaluate the low-temperature cracking resistance of asphalt mixtures. In principle, as shown in *Figure 1*, while the prismatic specimen is kept from the two ends, it is subjected to decreasing temperature from 20°C, with a constant cooling rate of ΔT = -10K/h. Due to the prohibited thermal shrinkage, the specimen is subjected to an increasing (cryogenic) tensile stress. The cracking appears when the cryogenic stress reaches the tensile strength of the asphalt sample.

The experiment, developed at TU Braunschweig in Germany, involved two wearing courses of stone mastic asphalt (SMA) mixtures. The testing mixture contained 50/70 PEN graded bitumen and 5% of the asphalt modifier (in this case, by the weight of bitumen). The control mixture contained 25/55-55 SBS PmB with the same

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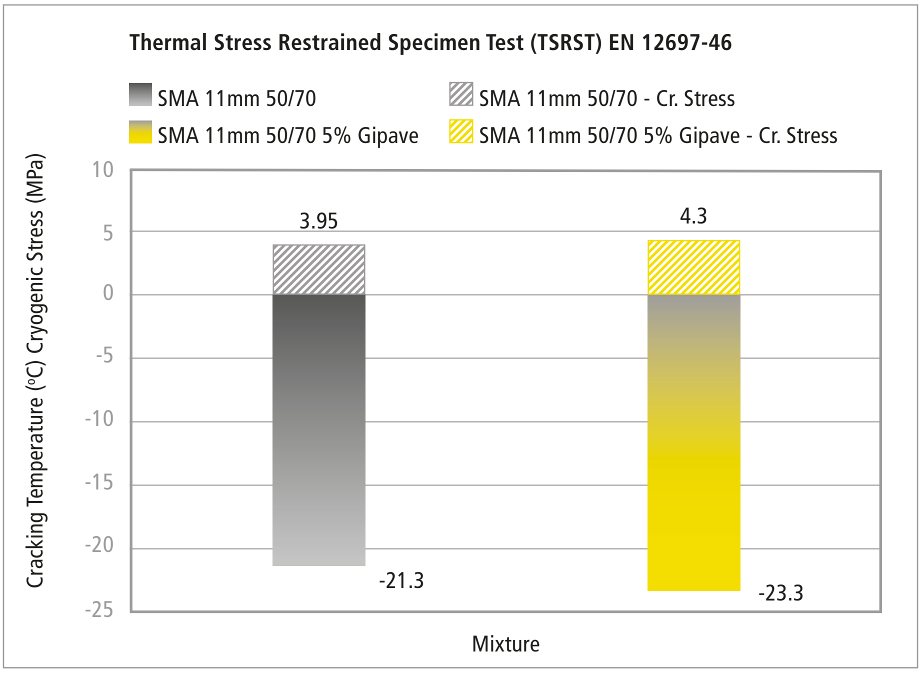
Figure 1. Typical TSRST test set-up and theory

Figure 2. TSRST test results



binder dosage to avoid any variable.

According to the results, as shown in *Figure 2*, the presence of the recycled plastic asphalt supermodifier, has not only worsened the mixtures' low-temperature performance, but improved it to some extent. As far as the modulus of the mixtures is concerned, the mixture containing the asphalt supermodifier showed a higher stiffness modulus. Therefore, it can be deduced that the higher modulus does not necessarily impact the low-temperature performance.

CASE STUDY 2: CRACK PROPAGATION RESISTANCE

The Semi-circular Bending (SCB) test is commonly used to evaluate the crack propagation resistance of an asphalt mixture. The SCB test has proven to be adequate for evaluating the fracture properties of both laboratory-compacted samples and field cores due to simplified specimen preparation[4]. As shown in *Figure 3*, the SCB test includes the testing of a half-cylindrical asphalt concrete specimen with a notch in the centre loaded

KNOW YOUR PLASTICS

PE - Polyethylene or polythene is the most commonly produced plastic. It is a polymer and used primarily for packaging, such as plastic bags, plastic films, geomembranes and containers including bottles.

PP – Polypropylene, also known as polypropene, is a thermoplastic polymer used in a wide variety of applications. It is produced by chain-growth polymerisation from the monomer propylene. Polypropylene belongs to the group of polyolefins and is partially crystalline and non-polar. Its properties are similar to polyethylene, but it is slightly harder and more heat-resistant. It is a white, mechanically rugged material and has a high chemical resistance. Polypropylene is the second-most widely produced commodity plastic after polyethylene.

PVB - Polyvinyl butyral is a resin that is used mostly for applications that need strong binding, optical clarity, adhesion to many surfaces, toughness and flexibility. It is prepared from polyvinyl alcohol by reaction with butyraldehyde. The major application is laminated safety glass for automobile windshields. Trade names for PVB films include KB PVB, Saflex, GlasNovations, Butacite, WINLITE, S-Lec, Trosifol and EVERLAM.

in a way that the middle of the base of the specimen is subjected to a tensile stress. The test results are provided as strain (ε) at the fracture point, representing the stiffness and fracture toughness (K_{IC}), representing the fracture susceptibility of the mixture.

Figure 4 shows the test result of an SMA 11mm mixture with and without the recycled plastic asphalt supermodifier (5% of the weight of bitumen). This case study was carried out at Iterchimica's facilities and the design was based on the Italian specifications. For this purpose, the cylindrical specimens were manufactured using 100 gyrations (N2, design level) of gyratory compactor. The resulting air-void content was 4±0.5%.

According to the results, the stiffness modulus of the mixtures containing the recycled plastic asphalt supermodifier was around 25% higher at intermediate temperature than the one without Gipave. It can also be seen that both mixtures showed similar resistance to crack propagation.

From another point of view, considering the strain values, the mixture without the asphalt modifier resulted 21% higher. This is attributed to the stiffness modulus of the mixtures with and without the asphalt modifier, 9001 and 7163, respectively. The same trend has been recorded in several research projects where different types of asphalt mixtures were studied.

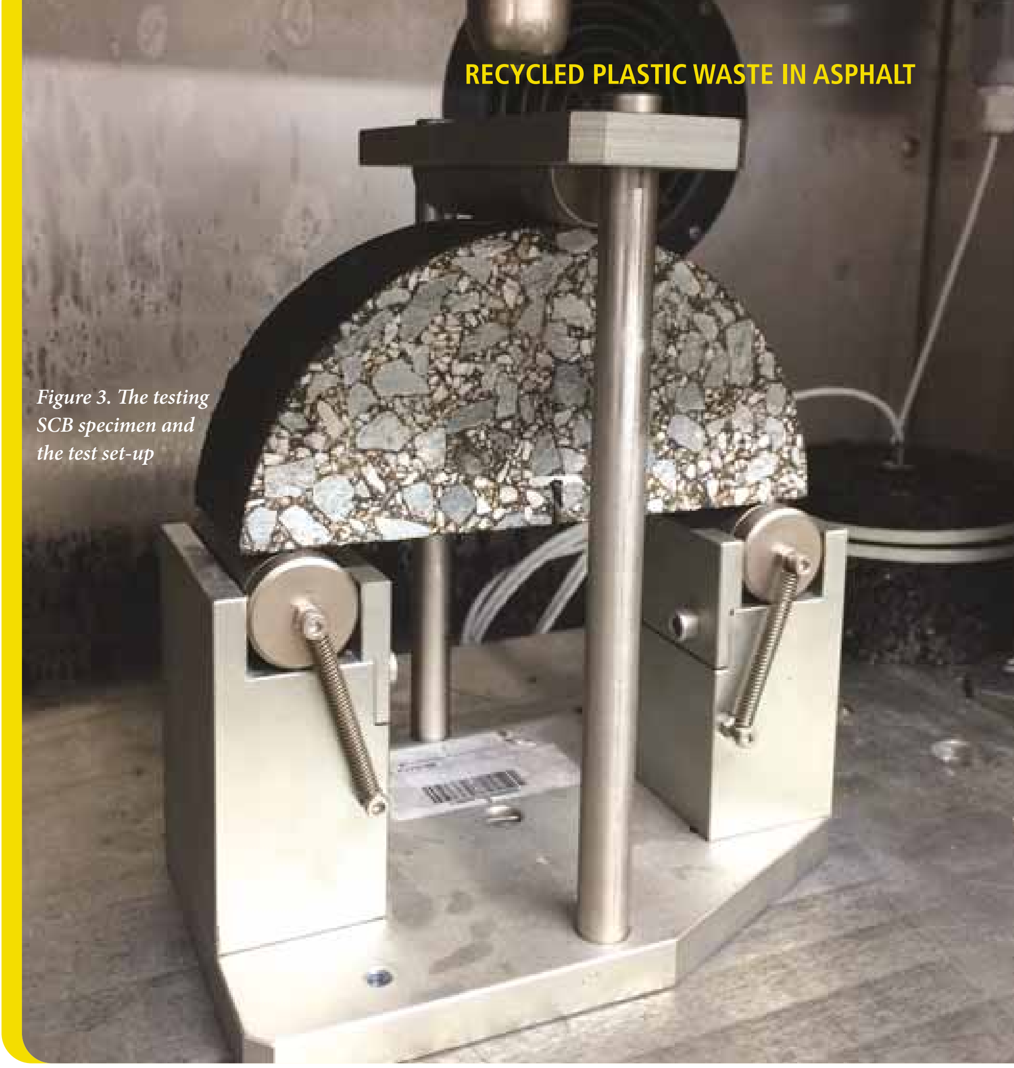


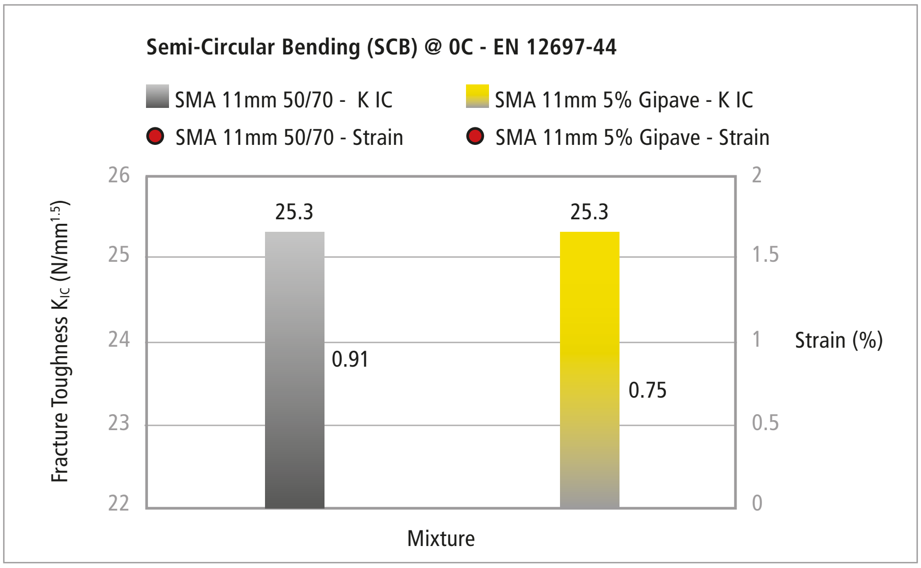
Figure 3. The testing SCB specimen and the test set-up

CONCLUSION

According to research literature, there is a consensus on the higher stiffness and consequent resistance to rutting of recycled plastic modified asphalt mixtures. However, the low-temperature performance is yet to be confirmed. According to this paper's two case studies, it can be deduced that:

- in line with the literature, the addition of the recycled plastic asphalt supermodifier increases the stiffness, which is necessary for design targets and resistance to rutting;
- the presence of the recycled plastic asphalt supermodifier would not impact the resistance to low-temperature cracking characteristics and the difference with the reference mixture is insignificant.

Figure 4. SCB test results



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https://iterchimica.it/en

References

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