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# Performance Evaluation of Asphalt Concrete Modified by Polyolefins Through Dry and Wet Process

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**Abstract**

Polymer modification in road paving applications enables significant improvement in road service life as regards main distresses such as rutting, fatigue and thermal cracking. Polymer modification can be performed through a dry or wet process, and it may lead to mixtures with different mechanical properties depending on the modification process employed. In this context, this paper presents a laboratory investigation concerning the effect of a polyolefinic additive (PO) on the mechanical response of asphalt concrete produced by dry and wet process. Mechanical characterization consisted of wheel tracking tests at 40 and 60 °C for rutting resistance analysis and semi-circular bending tests at 10 °C for cracking behaviour analysis. Results showed higher rutting resistance of PO modified asphalt concretes (AC) compared to the control mixtures, but they were found to be more temperature sensitive denoting a penalized rutting response at higher temperature. PO modified ACs also showed higher fracture toughness and reduced fracture energy. In particular, the dry process seems to guarantee an ability of deformation such as better endurance of cracking propagation with respect to the mixture produced by the wet process.
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*Keywords:* polymer modification processes; plastomer; polymer-modified asphalt mixture; rutting; fracture behaviour;

## 1. Introduction

During the entire service life, asphalt pavements are subjected to a several numbers of loads and environmental conditions that can lead to different distresses such as rutting, fatigue and thermal cracking. Enhanced asphalt

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pavement performance can be obtained by using polymer modified asphalt concretes PmAC [1, 2]. Polymer modification provides significant benefits in terms of relief of the above-mentioned distresses, thus ensuring higher durability of the pavement. Polymers that are currently used in the asphalt industry can be divided into two main categories: elastomers and plastomers. Elastomers, such as styrene-butadiene-styrene (SBS) and styrene-butadiene rubber (SBR), have the ability to significantly stretch under load conditions and to quickly recover their initial shape when the load is removed, thus ensuring more flexible and resilient asphalt pavements. On the other hand, polyolefinic plastomers such as polyethylene (PE), polypropylene (PP) and ethyl vinyl acetate (EVA), are characterized by a rigid three dimensional network that quickly exhibit strength under loading but may fracture under strain. The use of plastomers generally allows a significant increase in stiffness of pavements and enhances resistance to permanent deformation [1]. The polymer modification of ACs can be produced throughout two processes that may lead to mixtures with different properties. Polymers can be added directly to the bitumen phase prior to the mixing with the aggregates (wet process). The blend between polymers and bitumen is generally carried out at elevated temperatures for a consistent period of time in order to promote both chemical and physical interaction. On the other hand, both polymers and bitumen are added at the same time to the aggregates directly in the mixing chamber without any previous blending (dry process). In this case, the mixing window is reduced and the interaction between the two components is carried out within the aggregates blend. As a consequence, the bitumen and the polymers are not allowed to interact to the same degree as the wet process and the resulting bitumen of the dry process is not truly a modified bitumen [3]. In this context, the effects of a polyolefinic additive (PO) on the mechanical response of AC were investigated through a laboratory study. In particular, ACs modified by polyolefin were produced through both dry and wet modification process. Rutting and fracture cracking response of the modified ACs were investigated through a laboratory mechanical characterization, taking also into account the influence of the modification process (wet and dry). An unmodified and a SBS polymer-modified AC were selected for performance comparison purpose.

## 2. Experimental study

### *2.1. Materials and Specimen Preparation*

A typical dense-graded curve for binder courses ($D_{max}$ = 20 mm) was considered as design gradation [4]. Limestone aggregates and a bitumen content of 5% by aggregate's weight were employed to produce all ACs. ACs selected included one unmodified mixture and one SBS modified mixture (control mixtures) and two PO modified mixtures. The unmodified and SBS modified ACs were produced by using a neat bitumen (70/100 pen grade) and a SBS Pmb, respectively. Both ACs modified by PO included 4% of a granulate polyolefin additive (ethylene and propylene blend with a density of 0.94 $g/cm^3$) and were obtained through two different production processes: wet and dry. In the wet process, the neat bitumen was first modified by PO using a ROSS high-shear mixer [5] and then added to the aggregate blend during the mixing process. In the dry process, the polyolefin granules were directly incorporated into the hot aggregate blend and mixed together before adding the bitumen in the mixing process. Two laboratory compaction procedures were employed to produce two different shaped AC specimens. Specifically, a gyratory compactor, according to EN 12697-31, was employed to produce 150 mm diameter cylindrical samples from which half cylindrical specimens of thickness 50 mm, required for semi-circular bending (SCB) tests, were obtained after suitable cutting. An artificial notch (Figure 2a) was then cut in the middle of the base of each specimen (EN 12697-44). Whereas, a roller compactor, according to EN 12697-33, was employed to compact 50 mm height AC slabs (305 × 305 $mm^2$) required for Wheel Tracking (WT) tests. All AC specimens were compacted with a target air void content of 5%.

### *2.2. Test program and methods*

Rutting resistance of the ACs was assessed by means of WT tests with a small size device according to EN 12697-22. During the test, each slab is subjected to a wheel load of 700 N which moves backwards and forwards at 26.5 cycles/min. The cumulative permanent deformations developed in the specimen as a consequence of repeated load passing are recorded as a function of the number of loading cycles. Final rut depth RD, final proportional rut depth PRD (ratio between final rut depth and specimen thickness) and wheel-tracking slope WTS (the asymptotic rate of

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