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HIGH PERFORMANCE ASPHALT PAVEMENTS INCORPORATING RECYCLED POLYMERS AS AGGREGATES AND BINDER MODIFIER

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ABSTRACT
The main objectives of the European road administrations are to develop long-term bituminous pavements and guarantee the environmental preservation. These objectives include the development of new solutions, technically and environmentally sustainable, which can be reached simultaneously through the promotion of the use of recycled polymers in bituminous mixtures, in order to improve its performance and the durability of the pavement.

Thus, this work will contribute to the improvement of life quality through the integration of recycled polymers in bituminous mixtures, mainly when its use is more difficult or not so viable in other industries. In fact, many recycled polymers are sent to landfill, incinerated or used as reducing agents in furnaces. They could be applied with larger technical, economic and environmental advantages in the construction of road pavements. These residues can work as additives to be introduced in bituminous binders (polyethylene, PE) or as aggregates in bituminous mixes (crosslinked PE or PEX/XLPE), so as to improve certain performance characteristics and increase the durability of road pavements.

In order to improve the performance of the bituminous mixes with recycled polymers, the research team presents different competences (road materials, polymers, rheology, physics and chemistry) will carry out a study of the bitumens, of the recycled polymers, of the modified binders and of the affinity between them when used in asphalt mixes. The global performance of the mixtures incorporating recycled polymers will be also evaluated in lab

This work will make use of chemical techniques of separation and quantification (chromatography), physical evaluation of materials, surfaces and contact energies (microscopy and spectroscopy), assessment of the affinity between the different materials (thermal analysis) and rheological characterization of binders. Nanoindentation techniques will be also used to characterize the stiffness modulus of small polymer particles and fine films of bitumen. Finally, the mixtures incorporating recycled polymers will be characterized concerning the main mechanisms of degradation of the pavements, namely through their disaggregation resistance.

The work will lead to the development of new high performance mixtures incorporating residues of difficult reuse and will contribute to a larger durability of the mixtures, thus increasing the period of life of the pavement and reducing the negative impact associated with the rehabilitation of the road network. At the same time, a useful reuse of residues will be possible, which would be probably deposited in sanitary embankments for special materials, thus diminishing the use of new materials in paving and contributing to the sustainability in the road construction.

In the end of this work, a new mix incorporating wasted polymers should be obtained and patented.

LITERATURE REVIEW

The world-wide production of polymers amounts to more than 100 Mton per year. Most polymer waste originates from packaging and automotive/electrical cable industries, which can be contaminated and the costs involved in separation for further reutilization are higher than the virgin polymers. Thus, for the majority of the polymer waste, recycling is not yet an option [Struik and Schõen, 2000].

Usually polymers are divided in three classes: thermoplastics (can be reprocessed but the costs involved in separation are high), thermosets and rubbers (cannot be reshaped and are almost never recycled) [Ashby et al., 2007]. Within the mentioned polymers are present the rubbers, essentially used in tires. These tires bring sanitary problems in its final deposition [Campos, 2007]. Other examples are the crosslinked polyethylene (PEX/XLPE) and other polymeric mixtures, used in cable industry (due to its excellent dielectric strength, low dielectric permittivity, good dimensional stability, solvent resistance, and thermo-mechanical behaviour [Raghava, 2008]), that in Portugal are sent to landfill.

The use of waste plastic materials in pavement structures is the only market with high potential for expansion that could be developed for optimum environmental recycling of the actually unrecyclable scrap plastics (as aggregates – XLPE or binder modifier – PE), justifying the necessity of this research work. Other polymers potentially useful in the road construction are thermosets, like polyurethane and the porcelain [Ashby et al., 2007].

High performance asphalt pavements can be obtained by improving the binder, namely with PMBs. Its properties are dependent on polymer characteristics and content, bitumen nature, as well as the blending process. Microscopy techniques (UV or infrared) are the most suitable to study PMBs [Mouillet et al., 2008].

An increased understanding of asphalt microstructures and chemical constitution can provide guidance for further improved asphalts for use in pavements [Zang and Greenfield, 2007]. Some good relations between the chemical composition of bitumen and its engineering and rheological characteristics have been reported [Oyekunle, 2007].

In order to evaluate properly the bitumen-polymers interaction, advanced characterization must be performed on PMB (DSR test [Peralta et al., 2009, Hilliou et al., 2004] and nanoindentation tests). Other tests should be carried out to correctly evaluate PMBs, namely TLC/FID, gas and liquid chromatography, infrared microscopy, AFM [Mouillet et al., 2008], SEM and DSC [Stangl et al., 2007].

Other classical pavement constituents are the aggregates, which physic-chemical interactions with other paving materials remain poorly studied [Bagampadde et al., 2005]. These can also be replaced by recycled polymers, like XLPE.

Asphalt mixes modified with an extensive set of all types of polymers have been studied. The viscous behaviour and microstructure of recycled EVA and HDPE were studied in order to obtain the optimum Marshall Stability [Hinislioglu and Agar, 2004]. [Jew and Woodhams, 1986] confirmed that polyethylene (PE) is a potentially useful modifier for increasing the low temperature fracture toughness of asphalt mixes. [Lenoble and Nahas, 1994] affirmed that PMB mixtures are expected to have four times greater resistance to traffic.

Although the PMBs present significant benefits for road construction, very few researchers studied recycled waste polymers for use as modified binders [Murphy et al., 2001], even if [Fuentes et al., 2008] have shown that mixes with recycled polymers (for example, PE) may show similar performance to those containing virgin polymers, with lower costs. This is the main motivation to carry out this work and to believe that new findings will be achieved.

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