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Long-term behaviour of multi-recycled reclaimed asphalt pavement mixtures

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Summary

Reclaimed Asphalt Pavement (RAP) multi-recycling is a step forward in the circular economy by the reuse of materials in successive phases of the life cycle of infrastructures without downgrading their functionality. The sustainable and economic benefits of RAP recycling in bituminous mixtures are now well-known. Nonetheless, its application continues to be faced with some challenges and barriers that are yet to be overcome to enable its widespread application, as well as to extend its use to different pavement courses and increase the incorporation rates up to 100%. With the increment in applied solutions with RAP mixtures, the RAP multi-recycling capacity will be a near future problem.

This thesis evaluates the RAP multi-recycling capacity in new bituminous mixtures (RAP mixtures) in terms of both functional and mechanical short- and long-term performances. A dense graded hot bituminous mixture with a maximum aggregate size of 14 mm and a neat 35/50 nominal penetration bitumen was taken as reference. Two percentages of RAP incorporation (25% and 75%) and two recycling cycles for the highest percentage were evaluated. To recover the RAP bitumen properties a bio-based rejuvenator (Crude Tall Oil – CTO) was used. The effects of ageing and long-term performance of the RAP mixtures were assessed by laboratory short- and long-term ageing. The mechanical behaviour was evaluated by stiffness, fatigue resistance, permanent deformation, water sensitivity and retained Marshall stability. The functional performance was assessed by measuring pavement surface macrotexture and skid resistance. Additionally, the bitumen recovered from the RAP multi-recycled mixtures were evaluated using the dynamic shear rheometer.

The results demonstrated the potential of RAP multi-recycling in dense graded hot bituminous mixtures considering high incorporation percentages. With a proper design, RAP mixtures can present similar or better performance than the traditional and usually applied solutions. The developed qualitative methodology made it possible to evaluate the mobilization degree of RAP bitumen and blending. The proposed design led to a greater control over RAP mixtures even for high incorporation percentages. The road construction and rehabilitation solutions with RAP mixtures showed increased environmental benefits, which is in line with sustainability goals defined across the Globe.

Keywords

Reclaimed asphalt pavement, multi-recycling, bituminous mixtures, long-term performance, Life-Cycle Assessment.