

A contribution for a sustainable, resilient road infrastructure management from Brisa, a Portuguese Road Concessionaire

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Abstract. Nowadays, there are increasingly efforts to introduce an economy based on circularity principles, but there is still a gap between the intentions and the actual measures to achieve it. In Portugal, reclaimed asphalt is generally used as granular material for unbound road layers or reused mainly as asphalt mix in the municipal road network, instead of reusing this premium material in new asphalt mixes for medium/heavy traffic, mainly due to the lack of knowledge on how to use these materials without compromising the performance or durability of the pavement.

The purpose of this study is therefore to evaluate the technological suitability of using two different rejuvenator additives (rejuvenator solid additive and terminal blend bitumen with rejuvenating additive) for use with highly aged reclaimed asphalt (RA) in the production of new asphalt mixtures for motorway surface courses. To achieve this objective, three gap graded asphalt mixtures (one of reference) for surface course were produced with 20% highly aged reclaimed asphalt milled from Brisa's motorway network. The results show that asphalt mixtures with reclaimed asphalt had better performance (water sensitivity, resistance to permanent deformation) and similar surface properties compared to reference asphalt mixture (without RA), regardless of the rejuvenator additive used.

Further studies will consider pavement monitoring the asphalt mixtures studied as well as mixtures with other rejuvenator additives in order to expand the possibilities of using reclaimed asphalt in Portugal.

Keywords: Road pavements, Circular economy, Resilient infrastructure.

1 Introduction

Nowadays, there are increasingly efforts to introduce an economy based on circularity principles, but in some countries there is still a gap between the intentions and the actual

measures to make it happen. Reclaimed asphalt (RA) generated by road maintenance is equivalent to about 850 million tonnes per year in Europe, the United States and China combined [1, 2].

According to the European Asphalt Pavement Association (Europe) [3] and the National Asphalt Pavement Association (United States) [4], almost all reclaimed asphalt is reused/recycled for the construction and maintenance of new roads (96% and 99% respectively). Looking at these figures in detail, we see that in the United States, of the 99 %, only about 4 % of the reclaimed asphalt is recycled for such as granular material for unbound road layers and only 0.1 % ends up in a landfill. In Europe, the approach is slightly different, with the use of asphalt recycled as granular material for unbound road layers increasing to an average of 20% (from 0% in Croatia to an overwhelming 99% in Turkey) and 4% still ending up in landfill (from 0% in countries such as Austria, France, Germany, Hungary, Norway, Slovakia, Spain and Turkey to a remarkable 53% in Croatia).

As Europe has a consolidated road network, most of the reclaimed asphalt comes from maintenance/milling of surface courses, which have the scarcest aggregates, highest quality and therefore most expensive material for a road pavement. Landfilling these premium materials or using them as unbound materials whose properties are not so strict and not taking advantage of aged bitumen surrounding the aggregates is a luxurious prospect and shows the enormous effort needed to put us on the path of responsible valorisation of these materials, which means reusing them in surface course where they belong.

According to [3], no figures are given for Portugal, and the reality is perhaps not so different from Turkey or Croatia. In general, the reclaimed asphalt is used as granular material for unbound road layers or reused mainly as asphalt mix in the municipal road network, where the properties are not as important as in the national or motorway network, so the waste of a first-class material remains. Several factors lead to this reality, but the most important is probably the lack of openness of road concessionaires, as there are no specifications that allow the reuse of this type of material in new asphalt mixes for medium/heavy traffic due to the lack of knowledge on the use of these materials without compromising the performance or durability of the pavement.

Brisa has committed to the goal of achieving carbon neutrality by 2040 and to the promotion of circularity on the assets under its management (responsible consumption and production), and one of the steps towards that goal is maximizing the reuse of RA in surface courses, tackling issues as production and construction.

To achieve this goal, the ongoing study on new materials [5, 6] in this manuscript evaluates the technological suitability of two rejuvenator additives (rejuvenator additive and terminal blend bitumen with rejuvenating additive) for use with highly aged reclaimed asphalt (RA) in the production of new asphalt mixtures (gap graded asphalt mixes with 20% reclaimed asphalt (according to current limitations in Portuguese asphalt plant production) from an existing surface course in Brisa's motorway network) for motorway surface courses. The asphalt mixtures performance evaluation considered water sensitivity, resistance to permanent deformation and surface properties.

2 Experimental programme

An experimental programme was carried out to evaluate the technological suitability of two rejuvenator additives for use with highly aged reclaimed asphalt (RA) in the production of new asphalt mixtures for motorway surface courses. The additives used were:

- Pelletized blend of 50% cellulose fibres (type Arbocel ZZ 8-1) and 50% of rejuvenator (cylindrical pellets of type Viatop plus RC, supplied by JRS).
- Terminal blend bitumen with rejuvenating additive (Elaster BM3-C Regener, supplied by CEPSA).

The RA (see Table 1 for properties) was obtained from porous asphalt mixtures milled from 17-year-old surface courses of the A3 motorway in northern Portugal (Brisa's motorway network). The reclaimed asphalt used corresponds to the coarser-grained fraction (RA 8/16 mm) obtained after grinding the milled aged asphalt mixtures. In addition Table 1 also shows the characterization of the base bitumen (PMB 45/80-65) without/with rejuvenator additives plus RA after recovery of the bitumen in the asphalt mixtures (centrifugation, EN 12697-1).

Table 1. Base bitumen and reclaimed asphalt characterization.


RA visual aspect	Properties	Base bitumen	Bitumen in RA without/with rejuvenator additives		
		PMB 45/80-65	No additive	Viatop RC	Regener
	Bitumen content (%)	-	3.3	-	-
	Penetration (0.1 mm)	49	6	36	36
	Softening temperature (°C)	68.0	93.0	69.6	69.0
	Elastic recovery (%)	87.3	-	-	82.8

Table 1 shows that the existing bitumen in the reclaimed asphalt has very low penetration values, requiring the use of rejuvenator additives or soft polymer modified bitumen in the production of the new asphalt mixtures. As expected, the addition of Viatop RC or Regener increased the penetration and softening temperature of the recovered bitumen (centrifugation, EN 12697-1), reducing the brittleness of the bitumen in the asphalt mixture with RA. With both additives, the softening temperature could be brought to a similar value as for the base bitumen (PMB 45/80-65).

The asphalt mixtures used in the study are listed in Table 2. They consist of virgin aggregates (granite 10/16, 4/12, 0/6 mm and limestone, filler) and reclaimed asphalt (granite, 8/16 mm). The base bitumen is a polymer modified bitumen classified as PMB 45/80-65 (commonly used in Brisa's motorway network) without/with rejuvenator additives.

Table 2. Asphalt mixtures studied.

AC 14 surf ID	Aggregate nature	RAP		Binder type	Binder content (%)		Rejuvenator	
		Fraction	Content (%)		Virgin	RAP	Type	Content (%)
M1-REF		-	-		5.0 ¹⁾	-	-	-
M1.1	Granite	8/16 mm	20	PMB 45/80-65	4.7	0.3 ¹⁾	Viatop RC	1.5
M1.2							Regener	- ²⁾

1) optimum bitumen content; 2) confidential information

The performance evaluation of the asphalt mixtures considers the assessment of: Marshall properties according to EN 12697-34 at 60°C after conditioning the specimens at 60°C for 40 minutes; water sensitivity according to EN 12697-12 (method A) at a test temperature of 15°C after conditioning in air at 20°C and vacuum in water at 40°C for 72 hours (dry and wet specimens respectively). For Marshall and water sensitivity, the cylindrical specimens were compacted with a Marshall compactor with 50 strokes on each side. Resistance to permanent deformation was evaluated according to EN 12697-24 (air method, 60°C with 10000 cycles). In addition, the macrotexture depth of the asphalt mix surface was evaluated using the volumetric patch method on test specimens to assess resistance to permanent deformation in accordance with EN 13036-1.

3 Results and discussion

Fig. 1 to Fig. 4 show the Marshall properties, water sensitivity, resistance to permanent deformation and macrotexture depth of the asphalt mixtures studied (AC14 surf) without/with reclaimed asphalt plus rejuvenator additive for the optimum bitumen content.

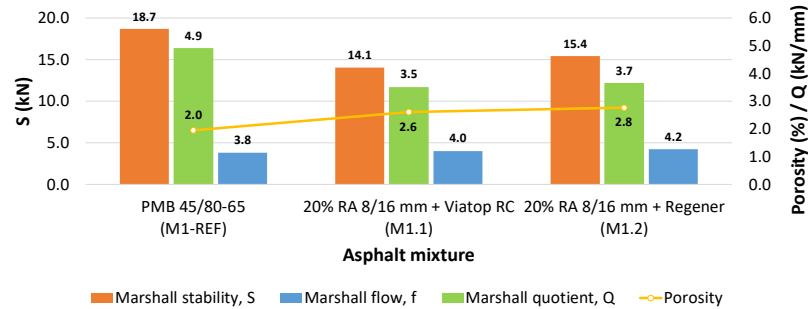


Fig. 1. Marshall results.

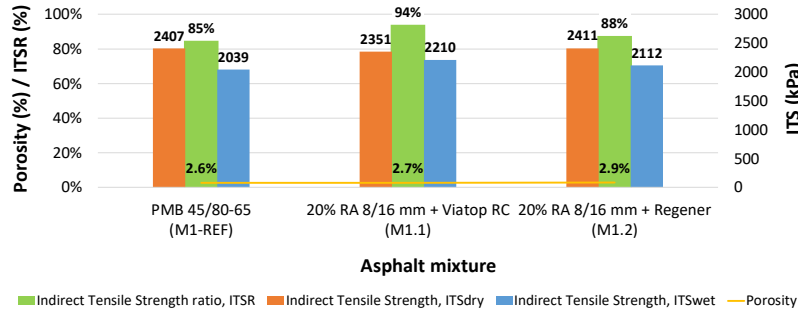


Fig. 2. Water sensitivity results.

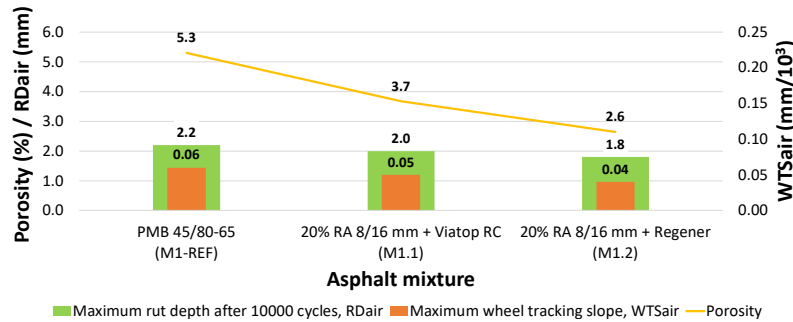


Fig. 3. Permanent deformation results.

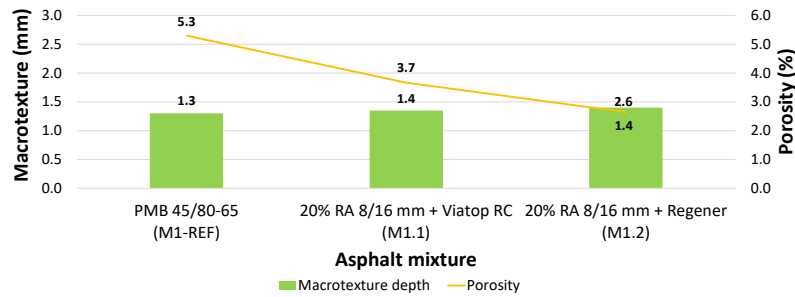


Fig. 4. Surface properties results.

As expected, the results in Fig. 1 show a reduction in the Marshall stability (S) of asphalt mixtures with rejuvenator additives. The Marshall flow behavior (F) also shows a reduction compared to the reference asphalt mixture and a slight increase in the Marshall quotient (Q), indicating that asphalt mixtures with rejuvenators tend to be more flexible than the reference mixture (without RA), despite the highly aged reclaimed asphalt used, without compromising resistance to permanent deformation. These results are confirmed in Fig. 3 by the slight reduction in permanent deformation (rut depth and wheel tracking slope) for asphalt mixtures with reclaimed asphalt and rejuvenators

(M1.1, Viatop RC and M1.2, Regener) compared to the reference asphalt mixture (M1-REF). Asphalt mixtures water sensitivity is sensitive to the use of reclaimed asphalt (e.g. due to possible insufficient blending between aged and virgin bitumen [7]), but the rejuvenator additives used were able to compensate (M1.2, Regener) and even reduce (M1.1, Viatop RC) the water sensitivity of the asphalt mix, as shown in Fig. 2, without affecting or even slightly increasing the indirect tensile strength (ITS) of the wet and dry test specimens compared to the reference asphalt mixture. As far as the surface properties are concerned, Fig. 4 shows that the use of reclaimed asphalt or rejuvenator additives has no influence on the surface properties compared to the reference asphalt mixture.

4 Conclusions

Overall, the use of reclaimed asphalt leads to a reduction in the consumption of virgin aggregates and virgin bitumen: promoting a circular economy with environmental benefits and potential economic advantages. It has been shown that the additives used can improve the behaviour of the studied asphalt mixtures with reclaimed asphalt, raising the bar for further studies on higher contents of reclaimed asphalt. However, proper laboratory characterisation is required to correctly determine the type and content of rejuvenator additives. Further steps need to be taken to increase knowledge in Portugal, while in parallel further specifications and proper management of reclaimed asphalt need to be developed.

References

1. Sohail Jameel M, Hassan Khan A, ur Rehman Z, Akhtar Tarar M (2023) Evaluation of performance characteristics of asphalt mixtures modified with renewable oils and reclaimed asphalt pavement (RAP). *Constr Build Mater* 375:130925. <https://doi.org/10.1016/J.CONBUILDMAT.2023.130925>
2. Gao J, Yang J, Yu D, et al (2021) Reducing the variability of multi-source reclaimed asphalt pavement materials: A practice in China. *Constr Build Mater* 278:122389. <https://doi.org/10.1016/J.CONBUILDMAT.2021.122389>
3. EAPA (2023) Asphalt in figures 2021. Brussels
4. Williams BA, WJR, SJ (2022) Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt Usage 2021. Greenbelt
5. Miranda HMB, Domingues D, Rato MJ (2023) The influence of recycled plastics added via the dry process on the properties of bitumen and asphalt mixtures. *Transportation Engineering* 13:. <https://doi.org/10.1016/j.treng.2023.100197>
6. Domingues D, Carvalho T, Miranda H (2022) Impacto da melhoria da afinidade entre agregado e betume na sensibilidade à água das misturas betuminosas. In: 10º Congresso Rodoferroviário Português. pp 1–9
7. Mogawer W, Bennert T, Daniel JS, et al (2012) Performance characteristics of plant produced high RAP mixtures. *Road Materials and Pavement Design* 13:183–208. <https://doi.org/10.1080/14680629.2012.657070>