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The influence of milling asphalt rates from wearing surface to the flexural strength applied to a recycled layer with Portland cement

Cassio E.L. de Paiva *, Paulo Cesar Arrieiro de Oliveira, Creso de Franco Peixoto

UNICAMP, Brazil

HIGHLIGHTS

- Stabilization with cement.
- Mixtures with coarse and fine gravel and lateritic wastes of milled asphalt.
- Testing of resistance to bending tensile.

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ABSTRACT

The reclaimed asphalt pavement (RAP) on the added cement recycled base can influence on resulted material behavior; because as the RAP tax increases the recycled mixture stiffness and resistance reduces. The RAP acts as a black aggregate or as asphalt lumps on the resulted material depending on the main asphalt cement (AC) characteristics. This suggests that the AC rheological properties from the milling wearing surface can affect the behavior of the cement recycled base. According to a technical bibliography review this issue is rare and not so researched. It is not known until today the level of influence of the AC content and RAP tax on the cement recycled pavement on the structural performance. The authors developed a lab experience according two RAP samples, one with conventional AC and the other with rubber AC, to evaluate the flexural strength. In this case the mixture was stabilized with 3% in cement weight. To realize this study there were molded prismatic samples, 10 × 10 cm × 40 cm dimensions, to be submitted to dynamic essays, of flexural strength. These prismatic samples, composed by 30%, 50% and 70% of RAP in weight in relation to the base material, behave as beams, under the specific essays. The particle size distribution of each studied RAP samples is offered in this work and also the AC tax and the physical properties, as the asphalt penetration test, melting point and elastic recovering. The resulted data can bring new alternatives to the building process in regions with tropical soils.

1. Introduction

At present, it is common in Brazil the full depth recycling for damaged roads and highways pavements, applied from low to high traffic forecasts. The Portland cement (PC) added to the recycling material is the most applied technique. The first activity is to mill the old wearing surface to produce material to be recycled. Next, this material is brought to a special plant to be analyzed and to produce a new material for recycling. Grading curve and PC tax are determined on samples, to adjust lab experiences in order to achieve adequate cement tax.

The final mixture, which is the ground milling material with PC, is produced directly on the road. This material is compacted in order to conceive a more resistant and higher capacity layer in relation to the former wearing course, aiming to absorb traffic stresses and strains. This service reduces the need for new materials, costs and time to incorporate the forecasted service. This also promotes better approach to environmental issues.

Despite the good Brazilian acceptance about this technique there are challenges until today to achieve the design results. This statement is due to the quality dispersion of crushed material. Bigger and smaller particles generate a non-homogeneous media and, therefore, higher flexural behavior variance. Thickness variations applied to grade correction also increase these problems.

The intrinsic recycled material heterogeneity is the biggest obstacle to reach the minimum required for mechanical qualities. In general, it is mandatory to conceive a specific controlling model which has load capacity, resistance and resilience behavior as tools to control samples quality. The main feature in this model is how

* Corresponding author.
E-mail address: celpaiva@fec.unicamp.br (C.E.L. de Paiva).

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and when they are collected along the *production line*. A specific feature in this study is the PC content activity in the reclaimed asphalt pavement (RAP), commonly known as the ground milling material.

The RAP is a kind of *black aggregate* BA), the milled aggregate and aged AC, where the coexistence of aged asphalt cement globules and rock particles develop a solid skeleton which works as the building structure [13]. The asphalt particles inside the recycled base can contribute to form asphalt globules, although when active, inside the surface, they can start the breakdown process. Cooley [4] highlights RAP viscosity and asphalt percentage importance in order to influence particles cohesion and resistance, after compaction. According to Cooley, high PC taxes and low viscosities can generate high strains. This effect can be higher, due to high temperatures and heavy traffic.

It is important to analyze the RAP particle angularity, because surface course performance will be influenced by intermixed particles. This fact also influences the layer bearing ratio. The particle angularity increases internal friction contributing to a higher mechanical strength because the solid skeleton will work under higher interweaving and reduces plastic strain. In some cases, RAP contributes to compose the new layer with more than 50% in weight, so, it is very important that particles shape and angularity could guarantee adequate internal friction counterbalancing lower asphalt cement taxes in relation to conventional services.

The material strength is mainly influenced by grain size distribution and grain to grain internal friction, not to the PC tax which has an inferior importance position. The new base course must work as a granular one, but under higher tensile traction strength. Massad et al. [7] consider shape, texture and angularity as main features to influence shear strength; applied for both aggregate fractions, coarse and fine ones, because the added PC produces adhesion between surface particles, an extra resistance in relation to their friction and interweaving features, applied for coarse base and sub-base. Tongji University researchers showed that well dense mineral skeleton helps to increase the shear resistance, minimizing cracks and fissures due to the cementitious reaction, because the necessity of PC will be lower to the stabilization [10].

The research of Brown [2] is focused on the maintenance of minimum uniaxial tension compression testing for different RAP percentages in the mixture.

There are some papers that mention that the use of RAP does not increase quality to the recycling asphalt pavement [12]. Even adding PC to the mixture, the RAP did not provide improvements to the new pavement. There is no RAP maximum percentage among main researched authors.

According to Scullion et al. [9] it is better to use the RAP in asphalt mixtures due to the asphalt cement content. These authors reported that the resistance diminishes as the RAP percentage increases. It is proposed to add a special stabilizing to balance the resistance loss and also to limit to 50% the maximum RAP, even considering the possibility to determine the adequate percentage inside a common project. It is also proposed to apply complete essays to develop this new study.

Brazilian researchers studied the mechanical properties of this new mixture applied to cement recycled base [1,5,6,11]. In general, as the compaction energy increases there is also a tendency to the stiffness and resistance increase. Nevertheless, as the RAP tax increases the stiffness and resistance reduce. However, none of these studies analyzed granular layer with gravel, RAP mixtures and cement.

The recycling technique with cement is very common in Brazil, but the RAP tax influence and also the asphalt cement activity level are not so known on the flexural strength of recycled materials added with cement. Premises as adequate execution, better technique specifications and higher success level of construction, constitute the main reasons to develop this research. This study fulfills a lack of the technical literature on the stabilized mixture with gravel, cement and pavement milling residues, subjected to two different kinds of asphalts to determine flexural strength.

This study is also justified by the high number of Brazilian roads which pavement composed by granular stabilization with fines in the base and wearing surface with asphalt and even near the useful end of life. So, it is analyzed the option of recovering with milling asphalt with cement. The resulted material is made of gravel from the original base, milling residues from the original wearing surface and cement, as an agent of stabilization. With this procedure, the residues will be embodied to the new recycled base, avoiding piles of rubble.

The experimental program was made by means of single and conventional laboratory tests, according to traffic load simulation and dynamic tests of flexural traction. The samples were prepared with granular soil from a selected pavement base and two different kinds of milling asphalt. The selected milling asphalt samples were collected from the 76th km of SP 079 and from the 175th km of SP 352, both from Sao Paulo State highway network. The pavement base from each selected highway was composed by lateritic gravel and the wearing surface with concrete asphalt of conventional and rubber-asphalt.

There were compared the results of material fatigue when stabilized with 3% of cement and with different percentages of milling asphalt and soil. This cement content corresponds to the highest value used in Brazilian recycling works. There were molded prismatic samples with $10 \times 10 \times 40$ cm to the dynamic tests, according to the Australian Protocol AP-T101/08 [14] to mixtures with light cement content.

The beans were made with 30, 50 and 70% in weight of milling asphalt to the soil base. When the results were analyzed it was highlighted the activity of the milling asphalt to the flexural strength tests.

2. Materials and methods: Experience program and results

The milling asphalt as mentioned before has its origin from an aged wearing surface. In this research, there were applied two samples of RAP, one with conventional asphalt cement (Fig. 1) and the other, asphalt cement with rubber (Fig. 2). Both materials were collected from two Sao Paulo highways, SP 079 and SP 351.

There were developed bitumen asphalt tests to the selected RAP samples, Method B from ASTM D 2172, and also grain size distribution from Brazilian pattern NBR NM 248/03, grain shape classification according to another Brazilian rule NBR 7809/06. The asphalt content from samples was determined to evaluate their rheological properties, according to Abson Method, AASHTO T 170-93 and ASTM D 1856-95 procedures.

The asphalt was aged with trichloroethylene and recovered by Abson Method which matches heating and carbon dioxide addition. This method extracts all solvent from the asphalt until remaining just asphalt. The rheological properties from the studied material are shown at Table 1.

Fig. 1. RAP with conventional AC.

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