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"Use of Reclaimed Asphalt Pavement (RAP) and oily residues as pavement at low temperatures for low traffic roads"

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Abstract

In different low-traffic roads in regions close to the LEMaC, surface layers with 100% RAP have been used for some years, with variations in some details regarding various aspects. These interventions do not have any type of technical study that allows their optimization. This short report presents a local study that seeks to give an initial theoretical framework to the subject, in view of future performance studies that allow its conclusions to be generalized or adapted.

Introduction

On some pavements in commercial lots, and in low-traffic roads in the LEMaC's area of influence, the use of asphalt layers made up of RAP compacted by heavy equipment or the use of the construction trucks themselves is observed. On certain occasions, this layer is constituted, in addition to the RAP, by some oily residue, applied in order to reduce the viscosity of the asphalt cement that contains the RAP and allow a greater degree of consolidation. This practice is carried out by tentatively incorporating that oily residue, and making the mix by means of the hopper of a finisher. In the latter case, the hopper being heated gives the mixing a slight increase in temperature that facilitates the mixing of the oily residue with the asphalt cement provided by the RAP. From Figure 1 to Figure 3, images of different works in which the aforementioned applications have been made are observed.

Figure 1. RAP use only, distributed with a motor grader and compacted with a smooth roller in a suburban area in the Municipality of Berisso (Buenos Aires, Argentina)

Figure 2. RAP use only in a suburban area in the Municipality of San Pedro (Buenos Aires, Argentina)

Figure 3. RAP use plus used car oil, distributed with a finisher in a suburban area in Gran Buenos Aires (Argentina)

These applications lead the LEMaC to carry out a study that allows optimizing the work methodology used, increasing the use of RAP in the constitution of new pavements, and evaluating the possible structural response expected for the layer.
For this, the mixing and placement methodology constituted by the use of the finisher and the compaction of the mixture by means of a pneumatic roller of sufficient weight is established as the desired situation. In this way, it is considered that these are mixtures that would allow reaching a minimum mixing temperature of 60 °C and with a density comparable to the Marshall Density obtainable in the laboratory, which for the purposes of this work gives rise to what we will call as "Asphalt mixtures of RAP and oily residues at low temperatures".
According to the above, the use of a modified Marshall Method methodology is established for the study to obtain the optimal contents of various oily residues to be used with a reference RAP, and its associated volumetric and structural characterization.
A simple tool to use for the structural characterization to be faced is the AASHTO93 Guide, which in its original version (AASHTO, 1993), establishes the mechanical response assignable to the asphalt bearing layers from their structural coefficients a_i. Previous versions of the Guide, such as the 1986 version (EICAM, 1998), have graphs that allow

associating the a_i to the Marshall Stability value of the asphalt mix in question. The logarithmic regression formula to the values of the said graph, with an R^2 of 0.96, is observed in Equation 1.

$$a_i = 0{,}1364 \ln E - 0{,}8268 \qquad (1)$$

Where:

a_i = structural coefficient of the asphalt bearing layer [1/inch]
E = Marshall Stability of the asphalt bearing layer [N]

Methodology

Samples of 3 Marshall cores plus the determination of the Rice Density are made. The RAP dried in an oven at 60 °C is taken with the incorporation of the oily residues in predefined percentages. The percentage of residue is expressed as a percent of residue weight with respect to 100% of the dry RAP weight. The samples are processed at laboratory temperature and left for 24 hours to allow the action of the oily residue; then the mixture is placed in molds (plus sample on a tray to determine the Rice Density) in an oven at 60 °C for a period of 24 hours. After this period, it is compacted with a Marshall tamper with 75 strokes per face, the set is placed in a container with cold water for a period of 1 minute, the core is extracted and left in the laboratory environment for 24 hours. Finally, the density of the specimens is determined following Standard VN-E12-67, the theoretical maximum specific weight (Rice Density) following Standard VN-E27-84 and it is tested according to Standard VN-E9-86. The optimum content of oily residue in each one of the mixtures is established as the one that allows reaching the highest Stability values; although also observing the associated values of the E/F Ratio and Voids. To relatively analyze the structural responses for each of the optimal contents of the oily residues analyzed, it is decided to use Equation 1.

Materials

<u>The RAP:</u> A sample of RAP is obtained in sufficient quantity from a road in the periphery of the city of La Plata (Buenos Aires, Argentina). On this sample, the Asphalt Cement Content of 4.0% using the LEMaC-A01/06 procedure (LEMaC, 2019) and the granulometric curve of the recovered aggregates that is located between the limits established for the CAC-D12 mixtures (DNV, 2017) (it is a conventional hot mix asphalt, with aggregates of maximum size 12 mm) are determined.
<u>Used car oil:</u> It is an oil brand El Aion, type 15W40, from the replacement of a gasoline car, after having been used for 10,000 km.
<u>Used edible oil:</u> It is a mixture of sunflower oil of the Caracas brand, from the replacement in an industrial fryer used in the preparation of meals.
<u>Soy degumming:</u> This product is a waste that is obtained in the plant of a company located in the Rivadavia district (Buenos Aires, Argentina), in which the extraction of soybean oil is carried out. During a visit to said plant, LEMaC personnel take a representative sample of said material.

Results

According to the results obtained, for the analyzed materials, the summary table in Table 1 can be reached.

Table 1. Summary of structural contribution results
Source: self-made

Dosage	Structural coefficient of the asphalt bearing layer [1/inch]
100% RAP	0.18
100% RAP + 1,0% used car oil	0.23
100% RAP + 1,0% used edible oil	0.20
100% RAP + 3,0% soy degumming	0.19

EICAM (1998) cited that it is common to accept at least 2220 N Stabilities, which is achieved with the maximum Stability obtained (2357 N) for the case of used car oil. This implies that materials of low aptitude would be obtained but that could be of acceptance.
On the other hand, the AASHTO 1971 version of the guide allows to give to a bearing layer made up of a triple surface treatment (in a thickness close to one inch) a structural contribution coefficient of 0.16; therefore, the structural contribution coefficients obtained in all cases are up of this condition.

Preliminary study of the potential for permanent plastic deformation

With the mixture with the highest structural contribution coefficient, that is, the one that uses used car oil, it was decided to study its potential resistance to permanent plastic deformation (rutting). This characteristic can be assessed, for example, through the Wheel Tracking Test (WTT) by means of the UNE-EN 12697-22 (AENOR, 2008) and UNE-EN-12697-33 (AENOR, 2007) standards.
In relation to these determinations, the PETG-2017 (DNV, 2017) establishes in the CAC-D12 mixtures used in bearing layers, limit values of certain parameters, on roads with a T4 traffic index (this is the lowest level of traffic and corresponds to a level of demand lower than 199 heavy vehicles per day). These benchmarks are the Wheel Tracking Slope in the range of 5000 to 10000 cycles (WTS) and the Proportional Ruth Depth (PRD).
A specimen is then molded with the mixture under analysis and subjected to the specified test, as shown in Figure 4.

Figure 4. WTT specimen tested
Source: self-made

As this test reaches a deformation close to 20 mm (limit by standard) in approximately 2,000 cycles, the indicative values cannot be obtained at 10,000 cycles. For this reason, and only for comparative purposes, the curve obtained is shown in the graph of Figure 5, together with the curve obtained in the LEMaC in a previous experience with a CAC-D12 mixture that verifies the requirements for the T4 traffic level.

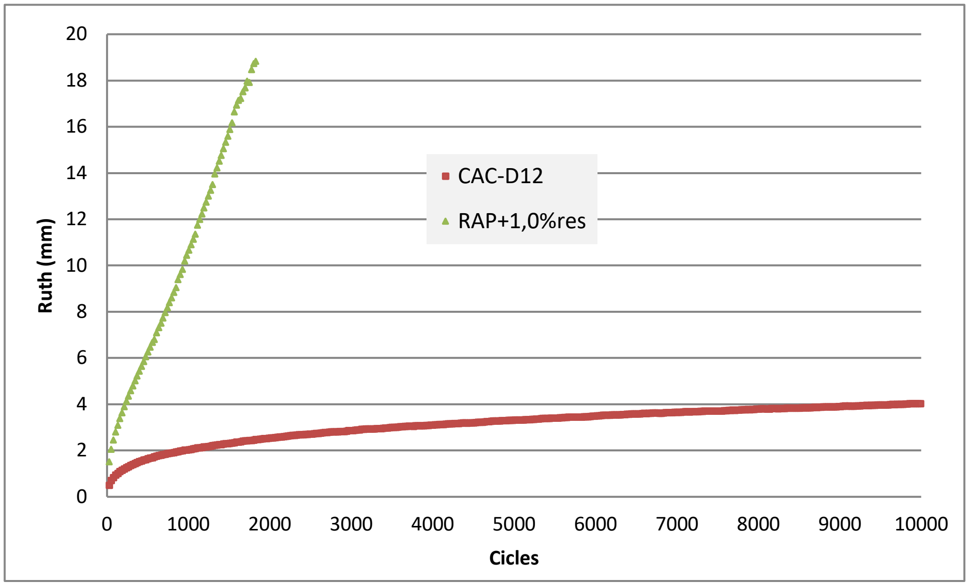

Figure 5. Graph of the WTT test for both mix configurations
Source: self-made

According to the experience carried out, it is not possible to think about using this type of mixture in rural roads (whether they are under national jurisdiction, nor in those under provincial jurisdiction), even if these roads have minimum levels of heavy traffic. This would narrow its scope to the current field of existing employment.

Conclusions

Through this research, it is possible to give a theoretical framework, with processes and methodologies, to a practice in this line of thought that was already being carried out; that is, the constitution of rolling layers by means of RAP compacted at low temperature.
The results of the experiments carried out show that there is an improvement in the structural contribution that RAP has with some oily additive compared to that which it had under natural conditions. It is also observed that the best response, from the point of view of Stability, is obtained with the inclusion of a low content of used car oil, arriving in this case study at a structural contribution coefficient of 0.23 1/inch.
This technology should be used only on suburban roads, or others, with low traffic, preferably exclusively light.

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