Warm Mix Asphalt / Low temperature asphalt

Experiences in Argentina with the use of warm asphalt mixtures

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Abstract

This document summarizes several results and experiences of WAM (Warm Asphalt Mixes) applications realized in Argentina. The objective of this paper is to show the important improvement obtained in terms of workability issues (main target) and sharing the laboratory results of the asphalts produced which have indicated that compaction temperature can be reduced up to 30°C keeping asphalt properties performance (WTT, ITT) at an acceptable level.

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1. INTRODUCTION

This document summarizes both laboratory results and field experiences based on the use of Warm Asphalt (WA) technologies in Argentina.

WA are successfully used in our country from 2010 and mainly associated with the use of Polymer Modified Binders (PMB), in order to improve the workability during compaction process and keeping the asphalt behaviour in terms of rutting performance, durability, etc.

Lately, there is interest to combine WA technology and high rates of reclaimed asphalt pavements (RAP), due to, among other things, environmental aspects and cost issues: especially if the available RAP comes from old pavements (with more than 10 years of use) in which PMB has been used, which begins to be frequent.

2. LABORATORY RESULTS

The evaluation of four CAC D-19 R dense asphalt and two thin asphalt MAC F10 R according to the Argentinean standards [1] [2], were performed. The detail of the tested designs is summarized as follows:

Table 1: different asphalt tested in laboratory

Asphalt Type	CAC D19 R	MAC F10 R
RAP content	25% comes old dense asphalt based on PMB	44% comes old SMA based on PMB
Binder grade	CA 30 CA 30 LT AM3 AM3 LT	AM3 AM3 LT

Where:

CA 30 is a viscosity grade a/IRAM 6835 [3]; CA 30 LT is a "Low Temperature" version of CA 30 grade; AM3 is a PMB grade a/IRAM 6596 [4] and AM3 LT is a "Low Temperature" version of AM3 grade.

The evaluation of the properties of the different constituent materials (RAP, binders) as well as the resulting gradation of both CAC D19 R and MAC F10 R asphalts, are shown in sub-section 2.1.

The comparison of the mechanical properties on the several asphalts evaluated in terms of water sensitivity (a/ AASHTO T-283 method) and Wheel Tracking Hamburg test, are shown in sub-section 2.2.

2.1. Materials evaluation

2.1.1. RAP characterization

As we said before, the RAP used comes from old dense asphalts (RAP I) and SMA (RAP II) and both, based on PMB. It was retired from homogeneous stockpiles and separated in laboratory in two fractions to be characterized. The Table 2 presents the RAP properties obtained after extraction via Abson´s method and Roto vapor process.

Table 2: RAP characterization

	RAP I		RAP II	
	Fine fraction	**Thick fraction**	**Fine fraction**	**Thick fraction**
Average bitumen content, % s/m	4.9	3.2	5,98	3,56
RAP bitumen properties				
Penetration (25 ºC, 100g, 5s), 0.1 mm	23	22	50	53
Softening point, ºC	74.5	76.2	70,1	70,8
Torsional elastic recovery (25°C), %)	26	24	61,1	65,0
Brookfield viscosity (at 170ºC) mPa s	480	530	350	370

2.1.2. Asphalt design composition

The composition of both CAC D19 R and MAC F10 R, can be seen in Table 3:

Table 3: CAC D19 R and MAC F10 R design composition

Material (%)	CAC D 19 R (RAP I)	MAC F 10 R (RAP II)
Granitic aggregate 6-20	27	---
Granitic aggregate 6-12	12	49.8
Granitic aggregate 0-6	30	
Lime as filler	1.5	1
RAP aggregate	25% (40% f fraction + 60% of thick fraction)	44% (68% fine fraction + 32% of thick fraction)
Virgen binder	3.45	2.9
RAP binder	1.05	2.3

The resulting gradation of both asphalts, are shown in Figure 1 and Figure 2

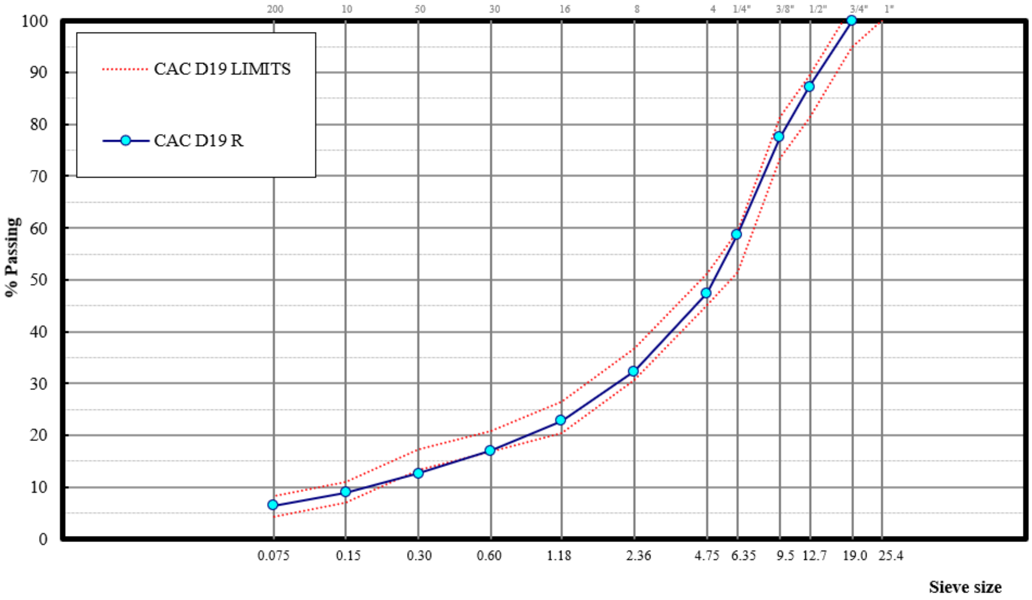

Figure 1: Resulting gradation of CAC D19 R asphalt

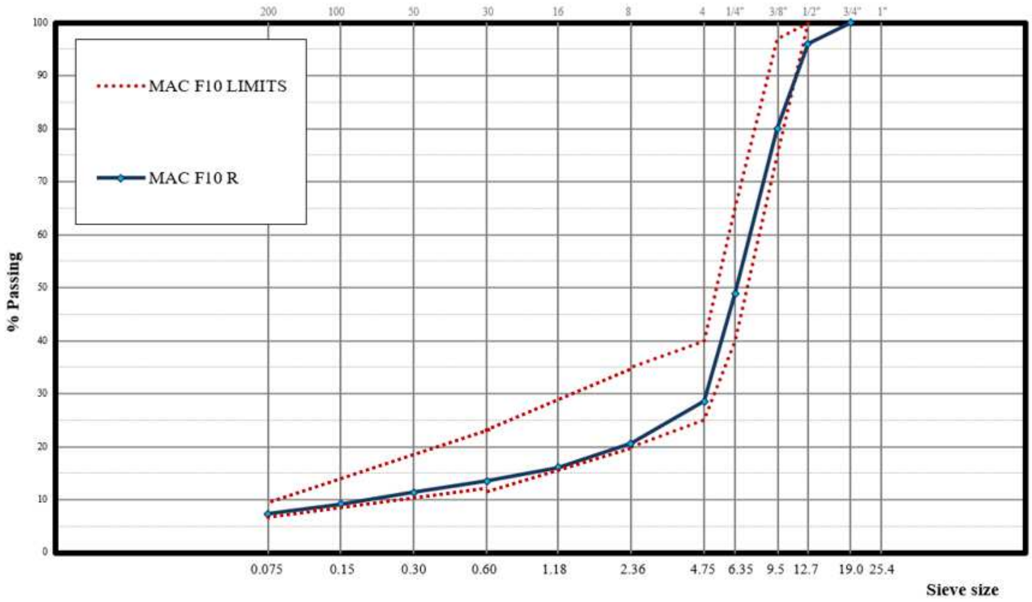

Figure 2: Resulting gradation of MAC F 10 R asphalt

For both asphalt mixtures tested, the compaction temperature was 150°C in those based on CA 30 grade, 160°C for AM3 binders while was 120°C for both LT versions.

In order to reproduce the worst manufacture conditions, virgin aggregates and RAP were vigorously mixed at room temperature for 15 minutes. After that, the new binder was incorporated while the blending process continued until ensuring a total coating of the aggregates. The mixing time for “R” asphalt was slightly higher than the time needed for conventional ones.

2.1.3. Virgins binder’s characterization

The evaluation of CA 30, CA 30 LT, AM3 and AM3 LT grades are shown in Table 4:

Table 4: CA 30, CA 30LT, AM3 and AM3 LT properties

	CA30	CA30 LT	AM3	AM3 LT
Original binder				
Penetration a 25 ºC (100g-5s), 0.1 mm	53	57	68	65
Softening point, ºC	52.6	50.6	70	84.5
Torsional elastic recovery at 25ºC, %	---	---	84	88
Brookfield viscosity at 60ºC, dPa.s	2960	2730	---	---
Brookfield viscosity at 135ºC, mPa.s	---	---	2300	2280
Punto de rotura Fraass, °C	---	---	-13	-13.5
After RTFOT				
Penetration a 25 ºC (100g-5s), 0.1 mm	39	40	51	54
Ring and Ball, ºC	54.0	55.2	76.4	70.2
Torsional elastic recovery at 25ºC, %	---	---	77	68
Brookfield viscosity at 60ºC, dPa.s	5800	5815	---	---
Brookfield viscosity at 135ºC, mPa.s	---	---	5075	3525

2.1.4. Recovered binder´s characterization

The evaluation of the recovered binders, can be seen in Table 5:

Table 5: recovered binder’s properties

	CAC D19 R		MAC F10 R	
	AM3	AM3 LT	AM3	AM3 LT
Binder content, %	4.8	4.7	5,2	5,3
Penetration a 25 ºC (100g-5s), 0.1 mm	41	77	64	83
Softening point, ºC	78.2	72.3	63,4	62,6
Torsional elastic recovery at 25ºC, %	52.2	68.3	70,6	68,9
Brookfield viscosity at 170ºC, mPa.s	475	365	340	360

2.2. Asphalts evaluation

2.2.1. Water sensitivity

The results over asphalt mixtures evaluated and according to AASHTO T-283 method, are shown in Table 6. As we can see, WAM-RAP mixtures present an acceptable performance (in all cases above limit value of 80%).

Table 6: Water sensitivity for CA 30 and CA 30 LT binders

	CAC D19 R				MAC F10 R	
	CA 30	CA 30 LT	AM3	AM3 LT	AM3	AM3 LT
Indirect Tensile Test (average)	1050	975	1150	1020	968	689
Blows each end of specimen to reach air void % under method	30	35	32	36	22	25
Retained resistance (saturated + 24 hs at 60 ºC), %	100	95	100	93	95	90
Retained resistance (saturated +16hs. at -18°C + 24 hs at 60 ºC), %	100	88	100	85	85	83

2.2.2. Hamburg test evaluation at 50°C (AASHTO T-324)

Results for both CAC D19 R and MAC F10 R asphalts based on all binders tested, are shown in Figure 3, Figure 4 and Figure 5

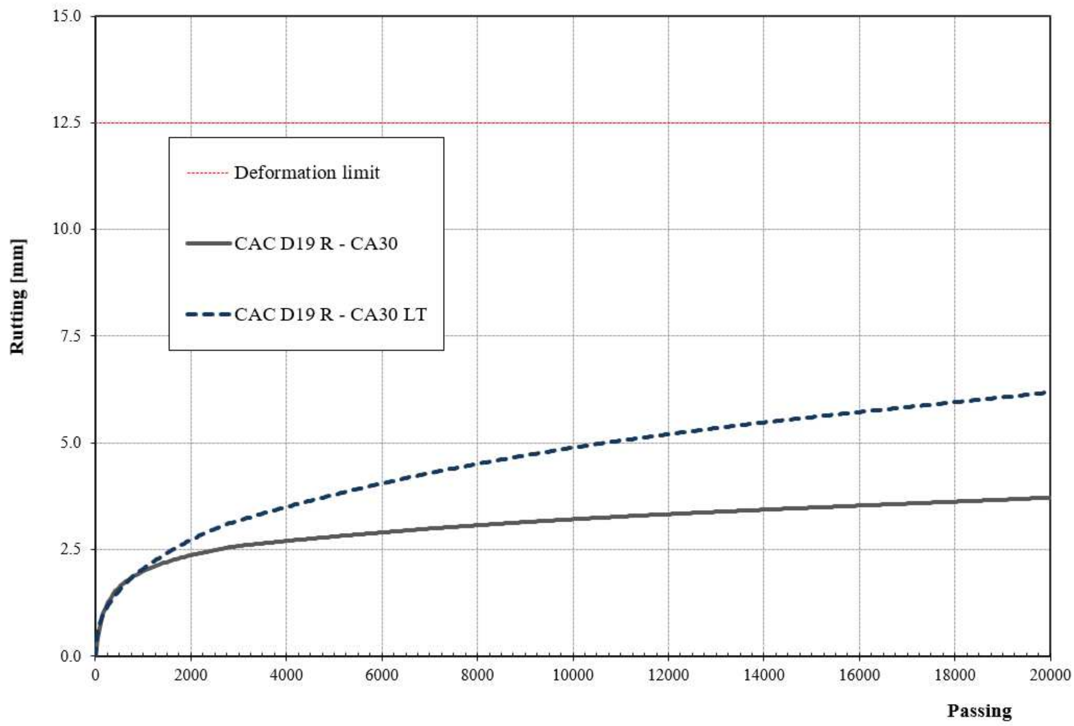

Figure 3: WT Hamburg Test for CAC D19 R based on CA 30 and CA 30 LT binders

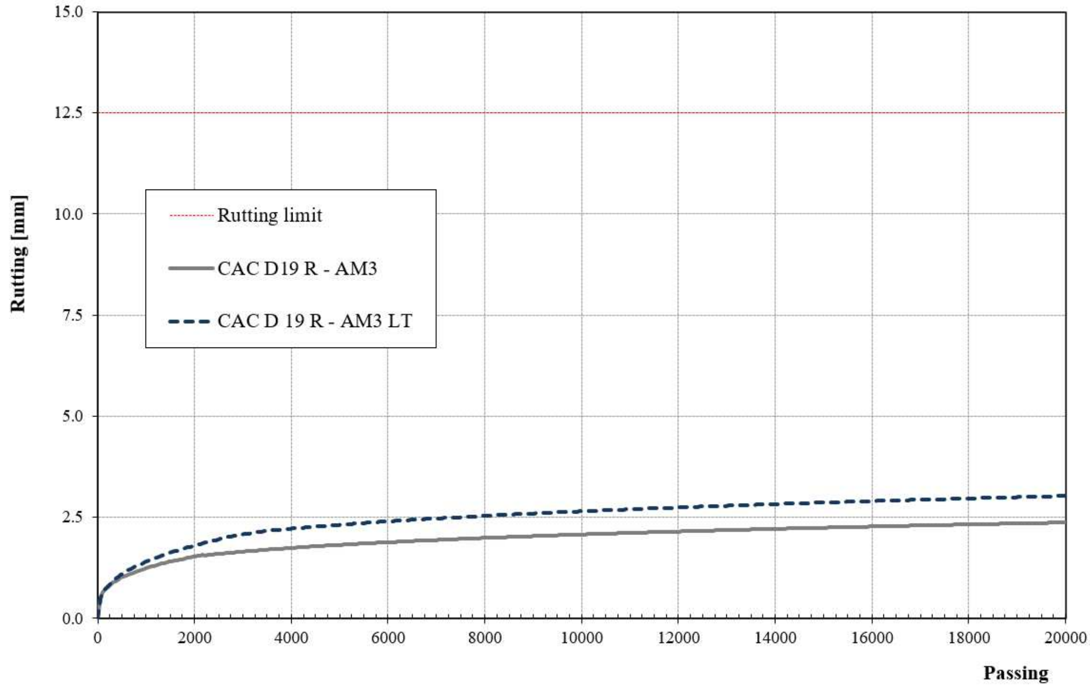

Figure 4: WT Hamburg Test for CAC D19 R based on AM3 and AM3 LT binders

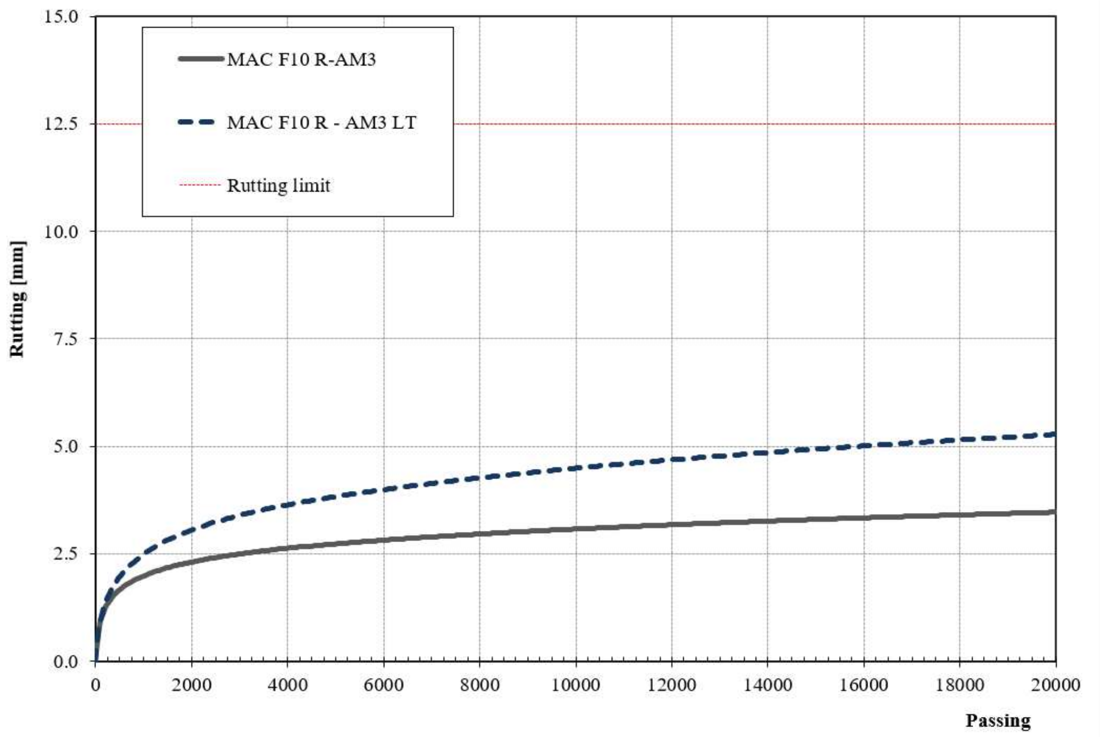

Figure 5: WT Hamburg Test for MAC F10 R based on AM3 and AM3 LT binders

In all asphalts evaluated the rutting/deformation limit (12,5mm) is not reached in any case and not water damage was observed.

CAC D 19 R and MAC F10 R asphalts based on CA 30 LT and AM3 LT binders show greater deformation than those designed with conventional CA 30 and AM3 grades.

3. FIELD EXPERIENCIES WITH WA-PMB IN ARGENTINA

3.1. General comments

Since 2017, the authors have been involved in the advice, design and placement of more than 120,000 tons of CAC 19 and MAC F10 based on CA 30 and AM3 binders in Argentina.

The main target was to get an important improvement in terms of workability issues during the laying and compaction processes demonstrating that compaction temperature can be reduced up to 40°C, keeping asphalt properties performance (WTT, ITT, etc.) at an acceptable level.

The Table 7 presents the typical properties of the PMBs used in Argentina during the period mentioned, which were formulated to satisfy the requirements of the local specifications.

Table 7: Typical PMB Properties for Argentina Demonstration

Properties	Specifications	Reference AM3 PMB	AM3 LT
Penetration at 25℃, dmm)	50-80	63	56
Softening Point, °C	Min. 65	84	87
Elastic Recovery at 25℃, %	Min. 70	82	79
Brookfield viscosity at 135℃ (mPa.s)	NA	3800	3800

3.2. Typical field compaction and performance results for Argentina WM-PMB sections

Figures 6 and 7 shows rutting performance (mm) and dynamic stabilities values (a/BS 598 at 60°C) for core samples extracted from several WA-PMB sections.

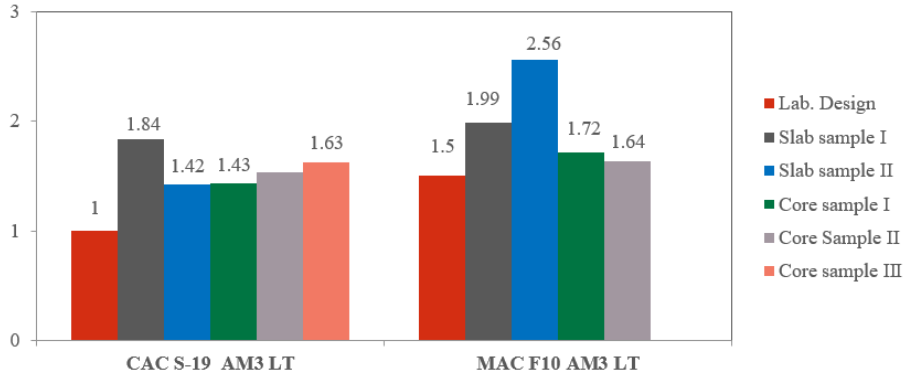

Figure 6: Rutting depth (mm) for core samples

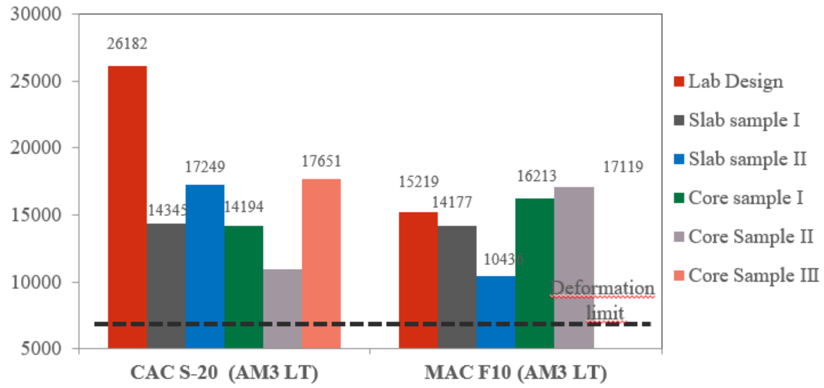

Figure 7: Dynamic stability for core samples

The dynamic stability results for different sections were significantly higher than the minimum requirement of 8000 pass/mm, demonstrating their excellent rut resistances. This is not the expected correlation between the air voids content and mechanical performance for conventional mixtures, suggesting that the WA design approach should be further studied.

Images about laying and compaction processes in different sections, can be seen in Figures 8 and 9

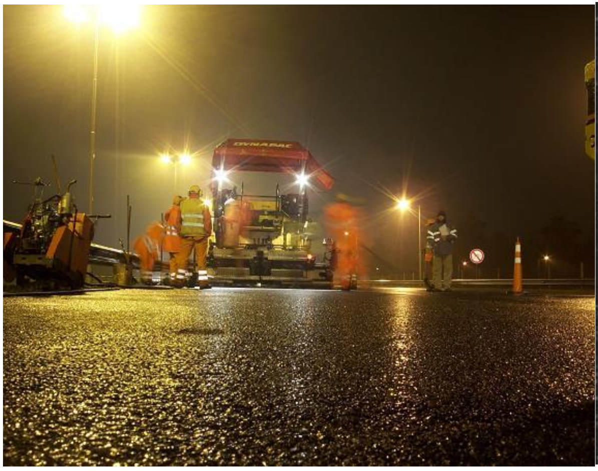

Figure 3: No emissions observed during paving with WA-PMB at night under cold ambient conditions

Figure 4: Laid material cooled to below the targeted 120℃ compaction temperature during night paving

4. CONCLUSIONS

This paper shares laboratory results obtained during the evaluation of four CAC D-19 R dense asphalt and two thin asphalt MAC F10 R according to the Argentinean standards and on the other hand, performance results on WA-PMB experiences carried out in Argentina in the last 9 years [5] [6] [7].

The aim was to observe the mechanical performance of the asphalts tested for the purposes of evaluating its sensitivity for the use of "special" RAP (comes from old PMB pavements) and LT (Low Temperatures) binders.

Key points are summarized as follows:

- Low temperature bitumen grades (CA 30 LT and AM3 LT) are available in Argentina and meet local standards (IRAM 6835 and IRAM 6596 respectively). Basically, based on chemical additive route.
- After the excellent experiences based on WA-PMB, there is interest to combine the use of WA and RAP technics to take advantage the benefits of both technologies such as environmental aspects and cost reduction.
- Reduction temperatures up to 30°C during compaction process can be reached without affecting asphalt mechanical properties.
- Regarding to water sensitivity WA-RAP asphalts presented an acceptable performance, exceeding in all cases the required limit value limit of 80%
- Rutting performance improves due to the use of RAP in all asphalt evaluated regardless the type of bitumen used (CA 30 or AM3). Not significant changes in rutting behavior were observed for the use of their LT versions.
- In the Hamburg test, CAC D 19 R and MAC F10 R asphalts based on CA 30 LT and AM3 LT binders show greater deformation than those designed with conventional CA 30 and AM3 grades, but in all cases evaluated the rutting/deformation limit is not reached and not water damage was observed.
- Field trials have shown important improvement in terms of workability issues (main target) and laboratory results for asphalts produced have indicated that compaction temperature can be reduced up to 30°C, keeping asphalt performance (WTT, ITT) at an acceptable level.
- Volumetric parameters (air voids, etc) in WA-RAP asphalts performed LT grades do not have the same correlation with the mechanical properties performance as when conventional binders are used. So, a better knowledge about LT binder effect should be studied and considering a possible new approach about WA-RAP design.
- The compaction temperature rate definition should be part of asphalt design data, due to the fact the effects of LT technology used could be different, depending on asphalt evaluated.
- Finally, additional production of WA will generate more information/data to share and at the same time will allow adjustments in protocols and standards to ensure good results.

5. BIBLIOGRAPHY & REFERENCES

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