INVESTIGATION ON RAP BINDER IN RECLAIMED ASPHALT CONCRETE UNDER DIFFERENT BLENDING LEVEL: DEVELOPMENT OF A GRADUAL BINDER EXTRACTION METHOD

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ABSTRACT

In order to meet their environmental goals, civil engineering firms reduce their environmental impact by developing solutions to save raw materials and energy. The combine use of these solutions enables a decrease ranging up to 40% of the energy induced by the production of asphalt mixes.
With the aim of monitoring the re-melting of the asphalt to be recycled during the recycling process of asphalt mixes, a gradual binder extraction method was developed. Gradual extraction of the binder is obtained by pulverizing solvent on a thin layer of reclaimed asphalt concrete (RAC). Infra red spectrometric analysis of chemicals functions in extracted solutions makes the characterization of homogeneity level of reclaimed asphalt concrete possible.
In complement, photography of a non conventional reclaimed asphalt concrete are presented. These pictures are used to represent visually the homogeneity level of constituents, at a binder scale of the RAC.
This innovative approach should enable to control the mix of components and therefore to ensure the quality of the asphalt mixes with high recycling rate. This approach will be correlated with mechanicals performances of asphalt mixes.

1. INTRODUCTION

In order to make their contribution to improving the protection of the environment, the road construction industry has been developing asphalt concrete production techniques over the last forty years, and optimising the recycling of road surface materials recovered during maintenance operations by incorporating them into hot mix production process. Reclaimed Asphalt Concrete (Rac) so produced is made up of a mixture of virgin material (Virgin Aggregates -VA- and Virgin Binder -VB-) and reclaimed asphalt pavement (Rap made up of Rap Aggregates -RapA- and Rap Binder -RapB-). The reclaimed asphalt concrete is therefore made up of a mineral part (RacA) and an organic part (RacB).

Nowadays, industrialists are focusing their efforts both on maximising recycling rates and reducing the temperatures of asphalt concrete under 160°, while maintaining exactly the same quality of a HMA without Rap. There has therefore been a cumulative reduction in the environmental footprint of road as not only has the consumption of raw materials been reduced, but energy consumption too [1-3].

Given the current state of our knowledge on this subject, the properties of the added virgin materials (VB and VA) are adjusted empirically until the desired mechanical performances are obtained. This empirical method is justified in technical terms because it is not known exactly how the reclaimed material (Rap) mixes with the new materials. The formulation of a Rac with a low Rap content is based on the notion of a perfect combination of virgin binder (VB) and reclaimed asphalt pavement binder (RapB). The Rac is then considered to be identical to a traditional asphalt concrete with no Rap and its formulation is defined by the proportion of mineral and bituminous materials it contains, with no distinction between reclaimed and virgin materials [4].

It is essential to understand that with a high Rap content, the Rac binder is made up for the most part of RapB, which, because it has already undergone ageing on the road surface, is necessarily very viscous at the traditional production temperatures. Virgin binder (VB), which is then present in small quantities, is chosen for its low level of viscosity compared with that of the binders used to produce asphalt concretes with a low recycled content, or with no reclaimed material at all [4-6].

In addition, the bituminous nature of VB and RapB means that their viscosity is very sensitive to fluctuations in temperature. When the viscosity of RapB increases as a result of lowering the temperature of manufacture, then this alters its ability to mix with the VB. There is therefore part of the VB (and of the RapB) that does not participate in the mixing of the binders; this proportion is greater the shorter the production process (mixing time). For some authors [6-8] the presence of this "pure" VB, of a soft consistency at an ambient temperature, is a weakness in the product in terms of mechanical resistance. Because combining a maximum recycled material content with a decrease in production temperatures may lead to a drop in the quality of the finished product, a system therefore needs to be put in place to monitor the characteristics of the product during the manufacturing process and to adjust the quality of the finished product.

A key element in making these adjustments is knowing the quantity of RapB and VB that combine to create a perfect mixture [9,10]. Over the last thirty years, this need to know the characteristics of the mixture of these two binders has led to several studies on reclaimed asphalt concretes (Rac). The technique used involves the repeated soaking of samples of asphalt concrete in a bitumen solvent as they come from the production plant, before the

material is compacted during road construction; during these successive soakings the binder is gradually and completely extracted from the Rac. In particular, in 1979, Zearley [11] obtained two solutions in succession (mixture of solvent and binder – VB + RapB) by double soaking asphalt concrete, then he completely evaporated the solvent that they contained [12] and finally studied the consistency of the binder that was recovered [13,14]. As a result of this experiment he concluded that the VB and RapB mixture was homogeneous (perfect) when it was produced hot (production temperature higher than or equal to 160°C). The following year, using the same method as Zearley, Carpenter [15] was able to demonstrate that even when the initial mixture of VB and RapB binders (reclaimed asphalt concrete produced at a low temperature: 116°C) was not perfect, it tended to become gradually more and more perfect by diffusion over a period of about 3 months after manufacture. More recently (1992), Bicheron [16] carried out quadruple soaking tests on samples of Rac that were produced either hot, or at an ambient temperature; by analysing the composition of the bitumen mixtures extracted by gel permeation chromatography the author was able to confirm Zearley's observations [11] for hot mix production and to show an idealised double coating phenomenon for production at ambient temperatures (a layer of "pure" VB coating the "pure" RapB on the RapA).

The studies described above are based on total and gradual recovery of the Rac binder by multiple soakings in a solvent. This recovery "by layers" is followed by an analysis of the properties of the binder recovered during each soaking which provides information on the ability of the VB and the RapB to mix together during the Rac production process. The aim of this paper is to present an original experimental system to carry out a gradual extraction of binder from a Rac and to analyse the extracted products quantitatively. The experimental system and measuring the proportions of VB and RapB are described and a analysis of the measurements taken of Rac samples is done.

2. EXPERIMENTAL METHOD

2.1. System to extract reclaimed asphalt concrete binder by lixiviation

Figures 1 and 2 show the experimental extraction system by lixiviation. This system is made up of the following elements.

- A circuit supplying solvent, of which the main elements are:
    - a system for spraying the solvent (**1**) consisting of an air atomising nozzle (type 1.5 GPH / DELAVAN SPRAY TECHNOLOGY) with a conical cover to protect the user; the solvent flow rate from this nozzle (4.3 litres per hour) is controlled by measuring the load upstream with a needle gauge (**2**) ;
    - a single-piston pump (**3**) (type GAMMA / L (PROMINENT) which draws the liquid solvent from a tank (**5**), and a discharge valve (**4**), which combine to ensure the supply of solvent upstream from the nozzle;
    - an expansion tank (**6**) (Teflon tube 6 mm across and 1200 mm long, closed at one end) filled with air and connected in the upper part of the experimental system to the solvent circuit (its purpose is to lessen the pressure fluctuations caused by the pump).

- A lixiviation cell consisting of:

    - a vertical tube (**7**) with an internal diameter of 200 mm and 400 mm in height, closed at the bottom by a funnel which recovers the leachate, and covered by the spray system;
    - a sieve consisting of a steel woven wire mesh (**8**) with a mesh size of 63 µm, placed on a steel grid (**9**) with a mesh size of 2 mm; the Rac sample (**10**) is placed on this sieve (see Figure 2b).

- A system for sampling the collected leachate consisting of:

    - A vacuum pump (**11**) creating a depression under the sieve and drawing the collected leachate towards a sampling station with two storage units (flasks **12** and **13**) with filling controlled by two 3-way control valves (**14**, **15**). The flasks can be filled here, as a vent-valve (**16**, **17**) combination is associated with each one so that the flask is replaced at atmospheric pressure (during lixiviation and at the desired sampling rate) ;
    - a container (**18**) upstream from this pump to protect it in case of accidental aspiration of the leachate.

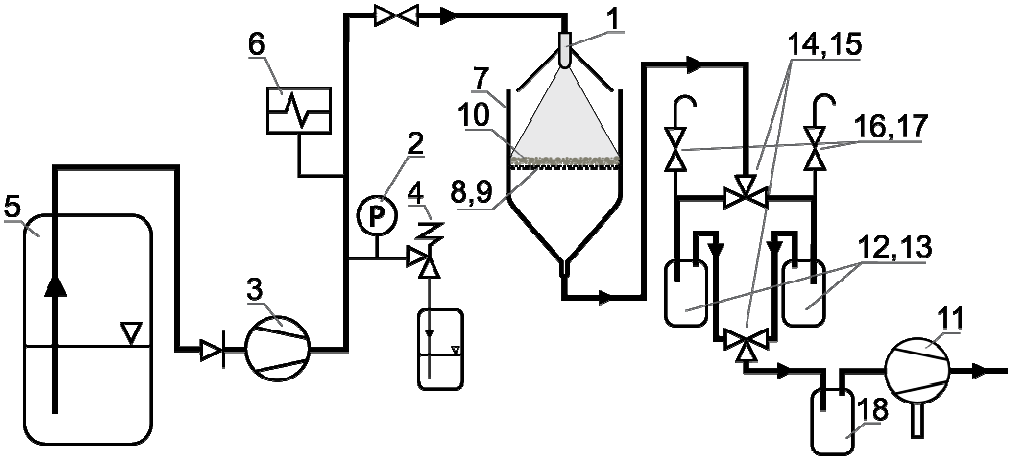


Figure 1 - Diagram showing the experimental extraction system by lixiviation.

Figure 2 - Picture showing the experimental extraction system by lixiviation

Because Tetrachloroethylene is classified CMR (Carcinogenic, Mutagenic and Reprotoxic), the experimental equipment was designed to reduce the volumes of solvent used as far as possible. After a test was carried out and the associated measurements completed, the bitumen was removed from the solvent by evaporation-condensation, then the solvent was recycled.

2.2. Preparation of reclaimed asphalt concrete samples

The main purpose of the results obtained in this study was to show that the experimental system can differentiate between reclaimed asphalt concrete samples with exactly the same formula, but where the production has differed in terms of mixing temperature T_m and mixing time t_m.

To ensure a constant composition of all samples of Reclaimed asphalt concrete, Rap had been fractionated in 0/4 mm, 4/6 mm and 6/10 mm. Each sample corresponds to an asphalt mixture with a high Rap content and the same bitumen / aggregates ratio:

- mass fraction of RapA reclaimed aggregate in the Rac aggregates C_{RapA}^{RacA} = 0.700 ±0.001,
- mass fraction of RacB in the reclaimed asphalt concrete C_{RacB}^{Rac} = 0.054 ±0.002,
- mass fraction of RapB in the RacB C_{RapB}^{RacB} = 0.67 ±0.04.

In the aim to make these reclaimed asphalt concrete sample in laboratory, Rap were heated in the oven 2 hours 30 mn before mixing at 110°C. This preheating allow to heat virgin aggregates at the maximum laboratory possible temperature (300°C) to get a mixing temperature at 160°C for a 70% Rap content. The temperature of virgin aggregates is calculated using a simple law of thermodynamic equilibrium under adiabatic conditions.

The virgin binder is a PG52-34 (penetration grade 160/220) in order to get a blend penetration of 32 1/10mm. The Rap and the VA were put into a mixer (GZM-12+ / FREUNDL rotation speed 60 revolutions/mn) and mixed for 30 seconds before adding virgin binder and counting down the mixing time t_m.

At the end of the mixing process, these reclaimed asphalt concrete samples (Rac) were spread in thin layers to cool down to ambient temperature (about 20°C). They were then sieved so that only the 0/14 mm granulometric fraction was retained.

Next, four samples, called $RAC_{T_m,t_m}^{0/14}$, were considered. They corresponded to two production temperatures T_m (110°C and 160°C), two mixing time t_m (40 s and 240 s) and the RacB binder was extracted from the samples using the experimental system previously described. For each gradual extraction, eleven filtered (6 µm) solutions written as Sol_1 to Sol_10 and Sol_Im (immersed) were obtained.

Next, the concentration of these solutions was adjusted by a visual control of the clearness during evaporation and measurement of the RacB concentration by UV-VIS attenuation. After this measurement was carried out, the RacB concentration in the solutions was known. These phases allow precise adjustment to the needed concentration by dilution. We were able to obtain solutions with a concentration within the interval [0.0076; 0.0084] able to be analysed by infrared spectroscopy.

2.3. Measuring the mass fraction of reclaimed asphalt pavement binder in the binder in solution

Measurements were taken using Fourier Transform Infrared spectroscopy (FTIRs), type *Spectrum 400FT-IR/FT-NIR / PerkinElmer*. The range of wave numbers explored was 450 cm^{-1} to 4000 cm^{-1}. The transmission cell had two sodium chloride windows spaced 500µm apart. Petroleum hydrocarbon compounds are often studied using IR spectrometry in order to show how their chemical composition changes with ageing (artificial or natural) [22,23].

In particular, the ageing of bituminous binders typically involves the creation of carboxyl (C=O) chemical function produced by the interaction between the bituminous binders and the oxygen in the air. This chemical oxygenated function is detected by IR at wave number 1700 cm^{-1}. In figure 3 we can compare three bituminous solutions of the same concentration (0.008±0.0002).

dashed line: VB solution

bold solid line: RapB solution

fine solid line: VB + RapB solution

Figure 3 - Peak corresponding to the carboxyl function at 1700 cm^{-1}

This peak was analysed in detail to obtain a measurement for the C_{RapB}^{RacB} concentration of reclaimed asphalt pavement binder (RapB) in the binder in solution RacB.

Firstly, we standardised each solution's spectrum using the attenuation peak centred on n=2950 cm^{-1} as an internal standard; the area below this peak can be considered to be unrelated to the nature of the binders considered here (RapB or VB) [19-20].

Secondly, the peak corresponding to the carboxyl function (around n=1700 cm^{-1}) for each standardised spectrum was used to compare his height in each solution using surfaces presented in figure 4. The sum of the hatched and the grey surface witch represent the solution was then compared to the sum of the black and the hatched ones witch correspond to the maximum possible oxidation level in solution.

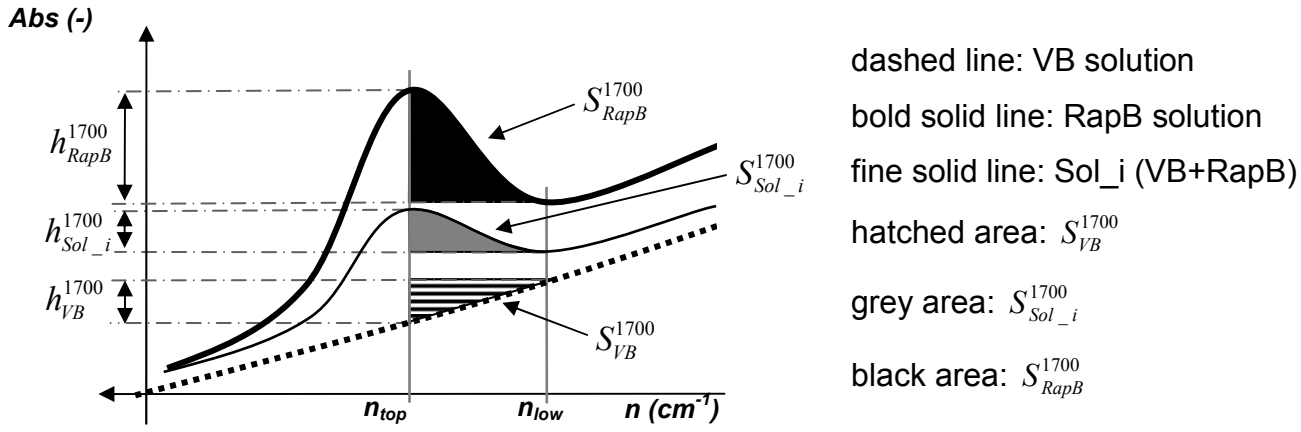


Figure 4 - Graph showing the areas used when defining the ageing measurement of a bitumen Sol_i sample

The way this measure had been taken is described in the PhD Thesis related to the presented work. The expanded uncertainty with a 95% confidence interval, determined for measurement of the percentage of the Rap binder in the Rac binder in solution, was ±0.023.

3. EXPERIMENTAL RESULTS

3.1. Laboratory results

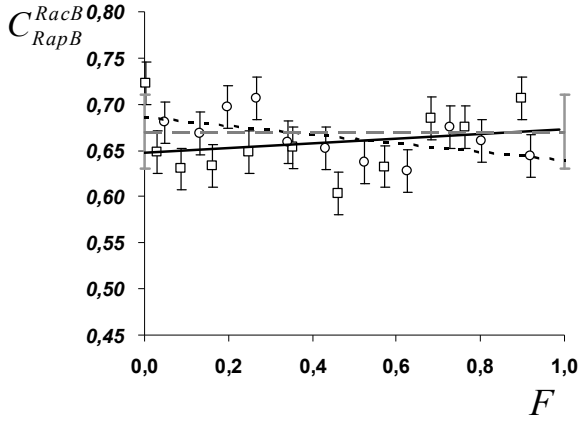
Figures 5 and 6 show the concentration C^{RacB}_{RapB} of reclaimed asphalt pavement binder (RapB) in the lixiviated reclaimed asphalt concrete binder (RacB), as a function of the mass fraction *F* of lixiviated binder, for the samples of Rac. Samples $RAC^{d/D}_{T_m,t_m}$ at two production temperatures T_m (110°C and 160°C), two mixing times t_m (40 seconds and 240 seconds) previously made are used to validate ability of the gradual extraction test to differentiate between reclaimed asphalt concrete samples with exactly the formula, but where the production has differed in terms of mixing temperature T_m and time t_m.

Figures 5 corresponds to a production temperature of 160°C (empty markers ○ *or* □), figures 6 corresponds to a production temperature of 110°C (solid black markers ● *or* ■). In each figure two series of experimental points emerge: one for a mixing time of 40 seconds (squares), one for a mixing time of 240 seconds (circles).

We should remember that the formulation for the reclaimed asphalt concretes correspond to an average concentration of reclaimed asphalt pavement binder C^{RacB}_{RapB} equal to 0.67±0.04. This average concentration is represented by the dashed grey line horizontal to the ordinate 0.67; an error bar has been added to this line, in grey, representing an uncertainty of ±0.04. It should be noted that the main source of the uncertainty of C^{RacB}_{RapB} is the heterogeneity of this Rap (C^{Rap}_{RapB} = 0.052 ± 0.002).

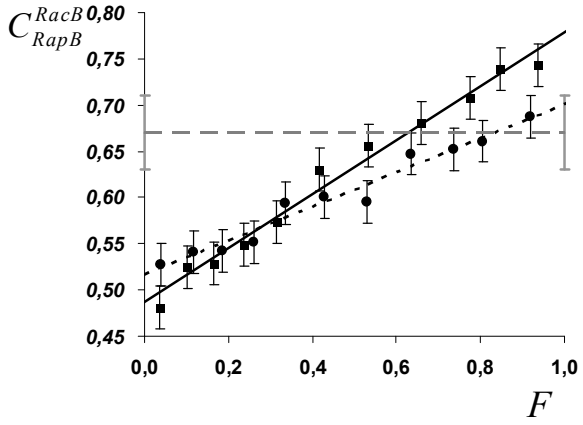
Mean experimental values were calculated for concentrations of reclaimed asphalt pavement binder C^{RacB}_{RapB} in the 0/14 mm granulometric fractions of the four reclaimed asphalt concretes considered in this study from the experimental results shown in figures 5

and 6. For the samples tested, $RAC^{0/14}_{160,40}$, $RAC^{0/14}_{160,240}$, $RAC^{0/14}_{110,40}$ and $RAC^{0/14}_{110,240}$, these concentrations were 657, 0.660, 0.633 and 0.609 respectively.
Because of the uncertainty over the heterogeneity of the manufactured asphalt mixtures (C^{RacB}_{RapB} =0.67±0.04) and uncertainties also surrounding the spectrometry values for the concentration of reclaimed asphalt pavement binder in the reclaimed asphalt concrete binder C^{RacB}_{RapB} (±0.023), these mean experimental values are coherent with what is intended to be used in the formula of these asphalt concretes.



□: sample $RAC^{0/14}_{160,40}$
○: sample $RAC^{0/14}_{160,240}$
solid line: linear trend curves associated with the values for $RAC^{0/14}_{160,40}$
dashed line: linear trend curves associated with the values for $RAC^{0/14}_{160,240}$
dashed grey line: mean concentration of reclaimed asphalt pavement binder for the formulation selected.

Figure 5 - Concentration C^{RacB}_{RapB} of reclaimed asphalt pavement binder (RapB) in the lixiviated binder as a function of the mass fraction F of lixiviated binder.



■ : sample $RAC^{0/14}_{110,40}$
● : sample $RAC^{0/14}_{110,240}$
solid line: linear trend curves associated with the values for $RAC^{0/14}_{110,40}$
dashed line: linear trend curves associated with the values for $RAC^{0/14}_{110,240}$
dashed grey line: mean concentration of reclaimed asphalt pavement binder for the formulation selected.

Figure 6 - Concentration C^{RacB}_{RapB} of reclaimed asphalt pavement binder (RapB) in the lixiviated binder as a function of the mass fraction F of lixiviated binder.

In figure 5 it can be seen that the concentration of RapB present in the lixiviated binder C^{RacB}_{RapB} for samples of Rac produced at 160°C is apparently not dependent to any great extent, if at all, on the stage the lixiviation process has reached and, for the range of mixing times considered here, it does not depend on this time: 40 seconds of mixing are apparently sufficient to obtain a perfectly homogeneous binder for the Rac (we shall see below that this was not exactly the case). This statement is based on the fact that, apart from a few measurement errors, we consider that both trend curves shown in this figure

are horizontal. The calculated slope corresponding to 40 s and 240 s trend curves are respectively 0.02 ± 0.05 and 0.00 ± 0.05.

To conclude, analysis of the experimental results shown in figure 5 suggests that the RapB contributes fully in the agglomeration of the mineral components in the Rac even for a short mixing time.

Figure 6 shows that for samples of Rac produced at 110°C, the concentration of RapB present in the lixiviated binder C_{RapB}^{RacB} is definitely dependent on the stage the lixiviation process has reached.

At the beginning of lixiviation (*F*=0), whatever the mixing time, the leachates contained, on average, a smaller proportion of RapB than was present in the reclaimed asphalt concrete. Indeed, for samples corresponding respectively to 40 s and 240 s of mixing, we observed lower concentrations of RapB in the RacB C_{RapB}^{RacB}=0.486 and C_{RapB}^{RacB}=0.516 than the expected mean value C_{RapB}^{RacB}=0.67±0.04.

When lixiviation was complete (*F*=1), the opposite was observed: the proportion of RapB was higher than the mean for the reclaimed asphalt. For samples corresponding to 40 seconds and 240 seconds of mixing respectively, we observed higher concentrations of RapB in the RacB C_{RapB}^{RacB}=0.779 and C_{RapB}^{RacB}=0.701 than the expected mean value C_{RapB}^{RacB} =0.67±0.04.

Figure 6 also shows that the evolution of C_{RapB}^{RacB} depends closely on the mixing time. The calculated slope corresponding to 40 s and 240 s trend curves are respectively 0.26 ± 0.08 and 0.17 ± 0.07. To sum up, if the Rac are thoroughly mixed at 110°C this does not produce a homogeneous RacB binder, in contrast to mixing at 160°C; in addition, the heterogeneity of this RacB binder is accentuated when the mixing time is short.

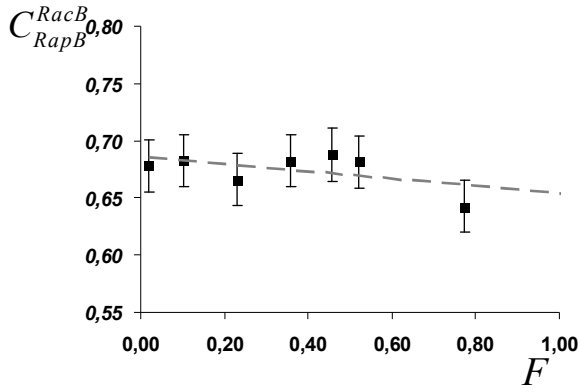
The above remarks concerning the experimental results in figures 5 and 6 are in agreement with observations by those authors whose work was described in the introduction [11,15,16]: these experimental results show that production temperature has a preponderant effect on mixing time insofar as these production parameters affect the heterogeneity of the binder present in the reclaimed asphalt concrete; the participation of RapB in the RacB during blending process depends mainly on production temperature.

3.2. Plant mix results

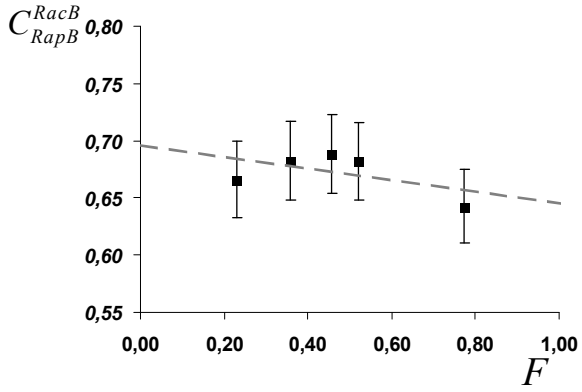
Homogeneity level of asphalt plant produced samples was characterized. These samples are identified RAC^1 and RAC^2.

The RAC^1 sample had been made using a 20/30 penetration grade bitumen in a counter flow drum mixer with no rap preheating. Its Rap content is 50%. The production temperature was 160°C.

The RAC^2 sample had been made using a 13/20 PMB in a parallel drum with additional mixer. Its Rap content is 40%. The production temperature was 180°C.
Results are presented in figure 7 and 8.



A - Uncorrected figure of *RAC*[1] sample
Slope equals to -0,03±0,04

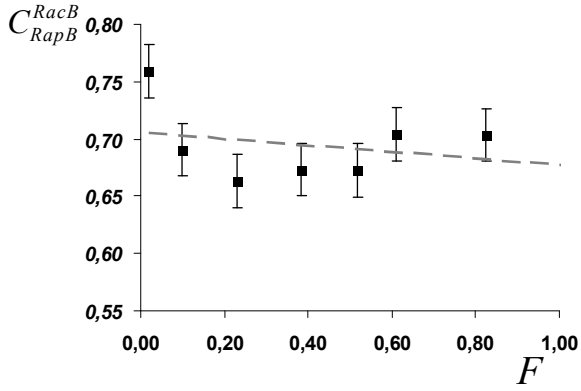


B - Corrected figure of *RAC*[1] sample
Slope equals to -0,05±0,04

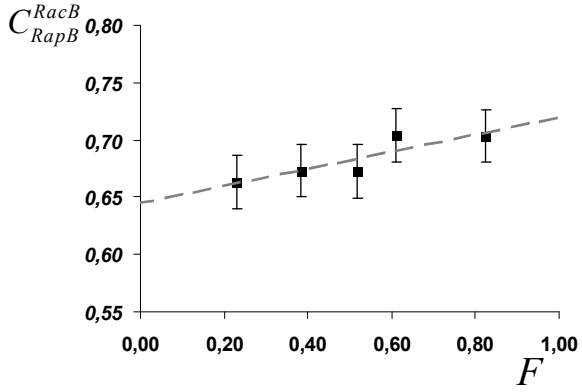
Figure 7 - Uncorrected and corrected figures corresponding to the *RAC*[1] sample

In figure 7 A and 8 A corresponding to the analysis of lixiviates respectively collected from to *RAC*[1] and *RAC*[2] samples, it can be seen that the mean oxidation level asphalt plant produced sample are higher than the one it could be supposed in corresponding formulas. Furthermore, in figure 8 A, first 30% of the collected reclaimed asphalt concrete binder is over oxidized. It could be the result of ageing of virgin binder during plant production process indicating that laboratory making condition are different in terms of oxidation.

In order to overtake this fact and to calculate an appropriate slope, first 30% of the collected reclaimed asphalt concrete binder is not taken into account. The resulting figures corresponding to *RAC*[1] and *RAC*[2] samples are presented in the right side of figure 7 B and 8 B.



A - Uncorrected figure of *RAC*[2] sample
Slope equals to -0,03±0,04



B - Corrected figure of *RAC*[2] sample
Slope equals to 0,07±0,06

Figure 8 - Uncorrected and corrected figures corresponding to the *RAC*[2] sample

Concerning the *RAC*[1] sample (figure 7), there is no significant modification of the slope induced by the suppression of the first 30% of the collected reclaimed asphalt concrete. According to previous remarks the slope indicates a good homogeneity level between the virgin and the Rap binder.

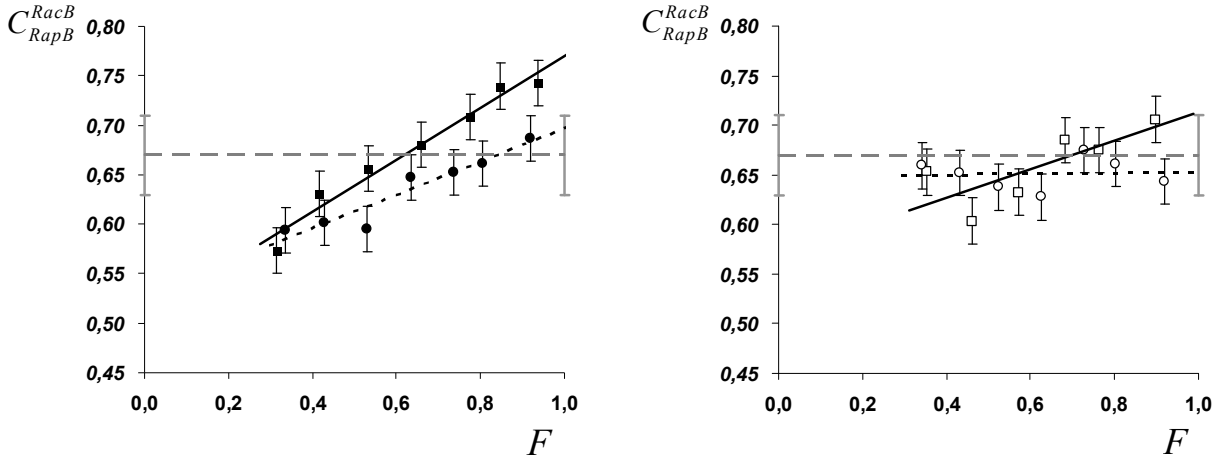
Concerning the *RAC*[2] sample (figure 8), there is significant modification of the slope. This fact indicates that first 30% of the collected reclaimed asphalt concrete can not be taken

into account in HMA parallel drum plant process. The homogeneity level indicated by the slope is good but looks inferior to the previous one.

3.3. Laboratory correction

According to plant produced sample consideration, same correction had been done on previously presented sample and corresponding slopes had been calculated. These results are presented on figures 9 and 10 respectively for the 110°C and 160°C temperature (same keys as previously used on figures 5 and 6).

Concerning $RAC^{0/14}_{110,40}$, $RAC^{0/14}_{110,240}$ and $RAC^{0/14}_{160,240}$ samples, the correction leads into no modification of slopes. Concerning, $RAC^{0/14}_{160,40}$ sample the correction leads into a modification of the slope from 0 ± 0.05 to 0.14 ± 0.07, indicating that the homogeneity level is not as good as previously supposed on figure 5.



$RAC^{0/14}_{110,40}$: slope equals 0.26 ± 0.08

$RAC^{0/14}_{110,240}$: slope equals 0.17 ± 0.07

$RAC^{0/14}_{160,40}$: slope equals 0.14 ± 0.07

$RAC^{0/14}_{160,240}$: slope equals 0.00 ± 0.05

Figure 9 - Corrected figures corresponding to $RAC^{0/14}_{110,40}$ / $RAC^{0/14}_{110,240}$ samples (left side) and $RAC^{0/14}_{160,40}$ / $RAC^{0/14}_{160,240}$ samples (right side)

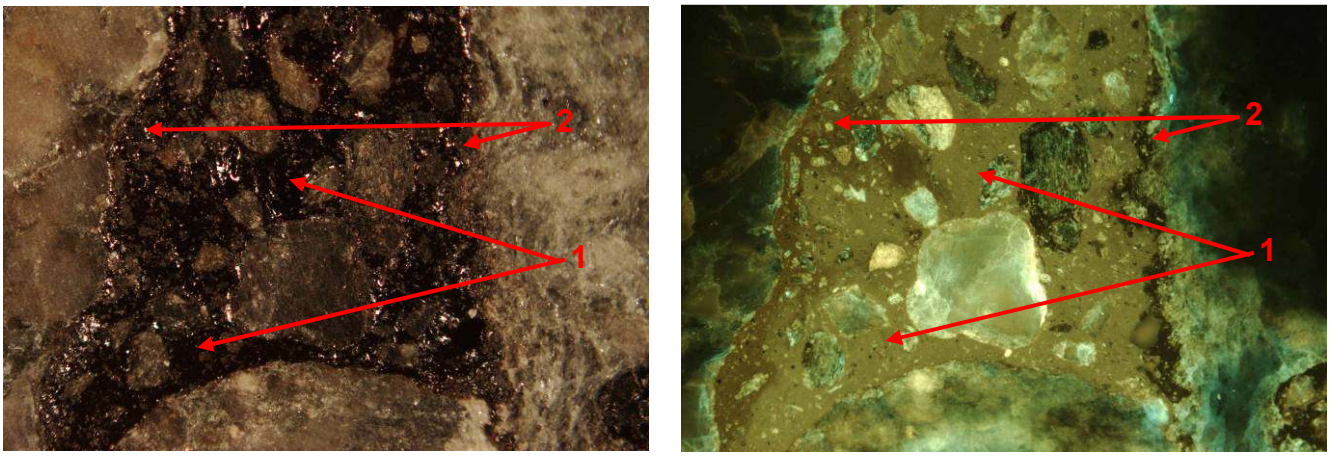
3.4. Visual characterization of Rap in Reclaimed asphalt concrete

In order to ensure visually that the slope modification was related to a difference in terms of homogeneity level, a microscopic observation technique was used.

To differentiate virgin binder and Rap binder, a UV fluorescent binder had been used as virgin binder. Samples of reclaimed asphalt concrete with a 70% Rap content were made for two mixing temperature 160°C and 110°C.

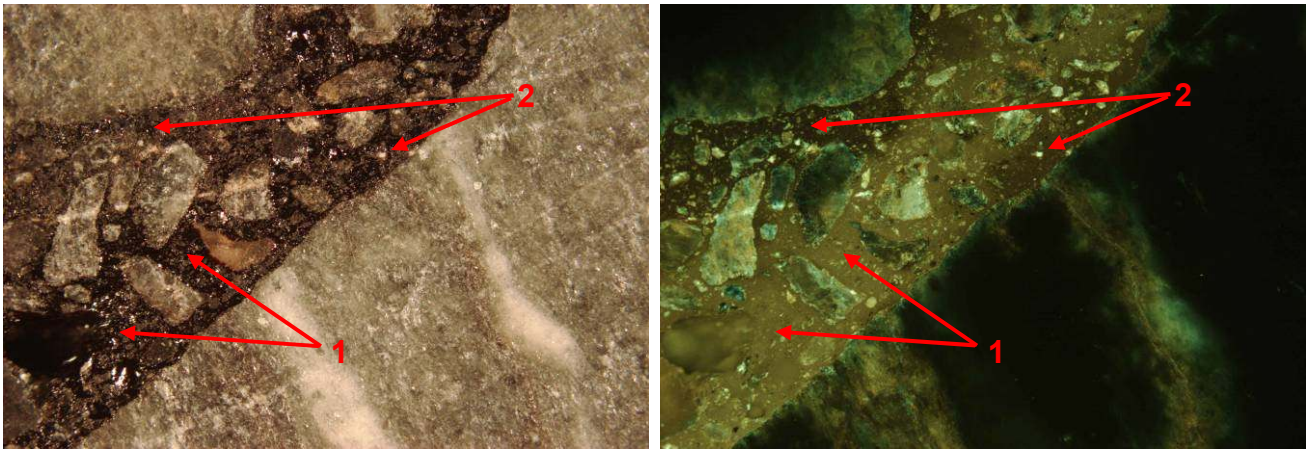
Mixing times were 34 s for the 160°C mixing temperature (figure 11) and 2 mn 26 s for the 110°C mixing temperature (figure 10). In each compacted cold sample, a slab of asphalt concrete was cut down with a circular saw. The two slabs were polished under a water flow at 2°C.

Each slab was pictured under natural light (A) and UV (B) light. Under natural light, the distinction between granular in gray and black bitumen coming from the mix of virgin and Rap binder can be done. Under UV light, we can see that the black zone in the A picture is composed of two colors: a yellow area (1) witch corresponds to the mix of virgin fluorescent binder and Rap and darker zone (2). These two zones correspond to less mixed Rac binder than in the yellow area (1).
. Pictures for each reclaimed asphalt concrete sample are presented in figures 10 and 11. This observation technique has been used to measure homogeneity level dependence to mixing time and mixing temperature. Corresponding results are not presented here.



A B

Figure 10 - Microscopic picture under natural and UV light of a reclaimed asphalt concrete sampled mixed 2 mn 26 s at 110°C



A B

Figure 11 - Microscopic picture under natural and UV light of a reclaimed asphalt concrete sample mixed 34 s at 160°C

We can see that these clusters are located on the surface of aggregates without being able to know if they are reclaimed or virgin aggregates. On figure 10, area 2 has two different colors witch could be the results of the presence of different type of binder in Rap. The identical slope for the two samples $RAC^{0/14}_{110,240}$ and $RAC^{0/14}_{160,40}$ could be the result of an identical presence of Rap clusters on the surface of they aggregates.

4. CONCLUSION

A system was developed to gradually extract binder from reclaimed asphalt concrete, based on lixiviating a sample of reclaimed asphalt concrete. The lixiviation process was carried out by spraying solvent over the sample. Next infrared spectrometry was used to measure the concentration of reclaimed asphalt pavement binder in the lixiviated binder and the reliability of this method was verified against model samples.

Asphalt samples with a high proportion of added reclaimed asphalt (70%), corresponding to production conditions at different temperatures (110°C and 160°C) and different durations (mixing times of 40 seconds and 240 seconds) were studied using our experimental system. Analysis of the results revealed that mixing time and temperature had an influence on the homogeneity of the Rac binder.

Manufacturing temperature was identified as the main factor affecting the homogeneity of the reclaimed asphalt binder, while mixing time had a much less marked effect at low production temperatures.

Pictures of samples for manufacture at 110°C and 160°C suggests the existence of Rap clusters in the asphalt produced which do not participate to reclaimed asphalt concrete binder.

A study of the mechanical performances of reclaimed asphalt concrete samples, produced under the same conditions as those studied in this article, is underway. This will enable us to assess the influence of the heterogeneity of the Rac binder on the mechanical performances of the reclaimed asphalt.

These first plant tests are encouraging results. They will be used to change the collecting time of lixiviates. The proposed method is the first one to measure the quality of the blending process. More plant test including hot and warm mix process must be carried out to develop the method.

This method can contribute to a controlled development of warm mix asphalt containing high rap contents. This method is a way to measure limits of blending process in terms of homogeneity level between virgin binders and Rap binders.

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