Design and industrial application of a microsurfacing pavement based on non-Venezuelan bitumen.

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ABSTRACT

The study presented in the paper focuses on the design of the next generation of microsurfacing pavements. This technique consist of applying in-situ a thin layer of a cold mix in order to regenerate the macro texture and the waterproofing of an aged wearing course. This technique has been getting bigger every year for the last 20 years, especially in France where more than 50 million square meters are applied every year.
This technique relies on the use of asphaltenic bitumen from Venezuela to get fast cohesion built up and minimal impact on traffic.
For years, many alternatives were studied to replace Venezuelan bitumen, with different results, but still Venezuelan bitumen was preferred to get the best quality.
In 2014, Eiffage's central laboratory worked on a brand new microsurfacing design, based on the use of a special chemistry, enabling the use of any type of bitumen to get the same results of the one coming from Venezuela.
To be able to achieve such a performance, a new methodology was set up to characterize in a more effective way properties of the new design.
The same year, first jobsites were laid down using this new technology, covering more than 150 000 square meters of roads.
In 2015, this new design was generalized and more than 800 000 square meters were laid down.

Keywords: Asphalt, Cohesion, Mixture design, Slurry seals, Testing

1. INTRODUCTION

Microsurfacing pavement have been used intensively in Western Europe and especially in France for the last 30 years, where more than 50 million square meters [1] are applied each year.

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The same year, first jobsites were laid down using this new technology, covering more than 150 000 square meters of roads.
In 2015, all microsurfacing applied by EIFFAGE Travaux Publics in France were using this new technology.

2. LABORATORY DESIGN - METHODOLOGY

2.1: Current State of Art:

Microsurfacing products are currently tested according the EN 12274 series of European standards.

One of the difficulties in designing such products is to evaluate the minimum cohesion of the mix to open the traffic. Ideally, because this technique is widely used in urban areas and minimal disturbance is then required, traffic time around 20-30 minutes are often required.

The cohesion test EN 12274-4 [2] relies on the use of the Benedict appliance, which basically measures the torque of a rubber piece on the surface of the product after the desired time (20 or 30 minutes). Minimum values are required to validate the mix design and evaluate the traffic time.

This test is generally combined with the Wet Track Abrasion test (WTAT – EN 12274-5) [3] to evaluate the wearing of the surface of the product under traffic simulation and under water. This test is very useful to validate the compatibility of a given aggregate with the chemical composition of the mixing emulsion used to make the microsurfacing pavement.

Below are photographs of the two tests.

Photos 1 & 2: Benedict and Wet Track Abrasion Tests

However, this methodology can sometimes be misleading as high torque values can be obtained by the result of friction between the piece of rubber on a loose aggregate of the mix.

As the use of napthtenic bitumen was generalized, these variations due to the imperfection of the tests were not so critical as finally the mix was curing quickly on the jobsite. But with the development of a new generation of emulsion using traditional/paraffinic bitumen, this parameter was becoming much more sensitive and our central laboratory developed new testing methods to better and in a more secure way evaluate the cohesion build-up of these types of mixtures.

2.2: New Methodology:

2.2.1: Mixing tests.

Mixing tests are usually the first step necessary to adjust the emulsion design for a microsurfacing pavement. Mixing the emulsion with the aggregates and the different components of the mix (water, retarder, cement etc…) enables to adjust the dosage of the emulsifier into the emulsion so the mix can comfortably applied by the slurry paver on the jobsite. It might differ with the experience of each contractor, but it is generally admitted that a breaking time comprised between 2 and 3 minutes is ideal (Tests are performed at the expected temperature on the jobsite).

In addition to this "breaking" time, we decided to use the basic test to get even more information. We noticed that the faster the curing the better **the stripping** was on the sulfurized paper the mix was applied. By stripping, we mean traces of emulsion or bitumen. The ideal would be to have no traces whatsoever on the paper after the estimated traffic time (20 or 30 minutes). We found that was a good indicator of the curing and the consistency of the mix.

In addition to this observation, we evaluated the cohesion built-up of the mix by performing a ball test with the mix. The time after which a ball could be made without falling apart was also a simple but good indicator of the stiffness and cohesion of the mix. Below is a picture (photo 3) of the stripping and ball test on a mix in the laboratory.

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Photo 3 : Stripping and ball test.

In the process of designing a suitable emulsion based on paraffinic bitumen in a microsurfacing system we evaluated these parameters with our candidate emulsions. Below is an example of results that we obtained during the design of candidate emulsions.

EM	AD	% AD	% DT82	% added water	BT	Stripping	Ball test	Breaking water
EM13145	/	/	1,5	6	300	no stripping	failed	slightly brownish
EM13152	AD3	0,15	1,3	6	195	no stripping	ok	clear
EM13171	AD3	0,3	1,4	6	480	no stripping	ok	brown water
EM13150	AD2	0,15	1,5	6	250	no stripping	ok	v. slightly brownish
EM13160	AD2	0,3	1,5	6	580	no stripping	ok	slightly brownish

Table 1: Results of mixing tests

Note: All names appearing in this table are internally coded in references of laboratory samples and or do not refer to commercial names.

EM 13150 was our reference emulsion based on Venezuelan bitumen.

It is interesting to note that at this stage of the design another candidate emulsion **EM 13152** based on a traditional paraffinic bitumen fulfills also all the required parameters as far as breaking time, stripping and ball tests are concerned.

2.2.1: Hilt Cohesion Test - HCT Test

The Hilt Cohesion Test is a non-standardized method developed by COLAS [4] to better estimate the cohesion built-up of a mix. As already mentioned, the Benedict Test described in the EN 12274-4 standard can really be misleading, even though the different evaluations described above during the mixing tests already give important information on the speed of cohesion of the mix.

Samples of 10 x 10 x 1 cm are manufactured in the lab and tested after 30 minutes.

The idea is to estimate the time necessary (in seconds) for a sample to break under its own weight (see picture 4 below).

Photo 4: Hilt Cohesion Test

A poor performing sample will break nearly immediately with only a few seconds before falling apart, whereas it will take nearly one minute for a good candidate before failing the test.

The table below (table 2) shows the results obtained with different designs based on paraffinic bitumen compared to the reference one made with Venezuelan bitumen (EM 13 350).

Emulsion	Chemical	% chemical	% added water	% retarder	Breaking time (s)	Benedict test		HCT (s)	Comments
						20 min	40 min		
EM13550	Emulsifier A	1.5	2	1	95	**25**	**30**	**51**	**Reference Emulsion With naphthenic bitumen**
EM13516	Emulsifier A	1,5	3	0	95-100	18	20	**6**	Same emulsion as reference but with paraffinic bitumen
EM13534	Emulsifier A	1,5	2	1	95	21	25	26	**Improved Emulsion with paraffinic asphalt**
EM13551	Emulsifier B	1	3	0	90	**25**	**30**	**32**	
EM13552	Emulsifier D	1	3	0	90	**27**	**32**	**32**	
EM13556	Emulsifier E	1	2	1	55	**24**	**30**	**36**	
EM13555	Emulsifier C	0,7	2	1	85	23		19	

Table 2: Results from Hilt Cohesion Test

The EM 13350 represents our reference emulsion designs based on traditional naphthenic bitumen used for microsurfacing.

The EM 13516 is the same emulsion but made this time with traditional paraffinic bitumen.

The difference speaks for itself with 51 seconds for our reference emulsion and 6 seconds for the one base on paraffinic bitumen before failing the test.

All the other candidate emulsions show the improvement made in the emulsion design with for certain samples values reaching 30-40 seconds, very close to the reference EM 13350.

We settled our choice on the **EM 13352** design as both the mixing time and the Hilt Cohesion Test were giving satisfactory results. This is also the same design that previously passed successfully the stripping and ball tests.

3. APPLICATION- Industrial production and first jobsites,

3.1: Initial trial: Importance of the particle size of the emulsion.

The very first trial took place in Normandy during the 2014 season. Though all the emulsion designs were satisfactory in the laboratory, the first trial did not prove as successful as expected, as the mix was very slow to cure, with a traffic time estimated around two hours.

The two photos below illustrate this phenomenon, with still unbroken emulsions after more than 90 minutes after laying-down.


Photo 5 and 6: Unbroken emulsion on jobsite

Several investigations were made to try to understand what happened. Designs were made in our laboratory with the same raw materials that the ones manufactured in the emulsion plant and excellent results were obtained.

Emulsion	Chemical	% chemical	% added water	% retarder	Breaking time (s)	Benedict test		HCT (s)	Comments
						20 min	40 min		
EM 14 524	Emulsifier D	1.0	3	1	85	**26**	**30**	**34**	**Emulsion manufactured in laboratory**
EM 14 525	Emulsifier D	1.0	3	1	➢ 400	**8**	**12**	**1**	**Emulsion manufactured in plant**

Table 3: Evaluation of the same emulsion design manufactured in laboratory or plant

It seemed obvious that the process of the plan t was interfering with the quality of the emulsion manufactured but so far our methodology was not able to really focus on the parameter that caused the problem.

Quality control tests based on Breaking Index (EN 13075-1), water content (EN 1428) or pH (EN 12850) did not show any differences on the properties of the emulsion.

Further investigations showed that the particle size of both emulsions was different and that this could be the main reason of what was observed on the jobsite. Indeed, to get an even breaking and curing of the mix, small and uniform particles are necessary (unimodal curve – gauss type – photo 7). On the contrary, a multimodal, distribution, with bigger particles (photo 8) could lead to partial and delayed curing, similar to what was observed on the jobsite.

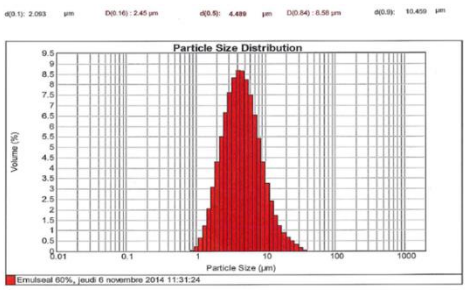

Photo 7: Gaussian curve – Lab production

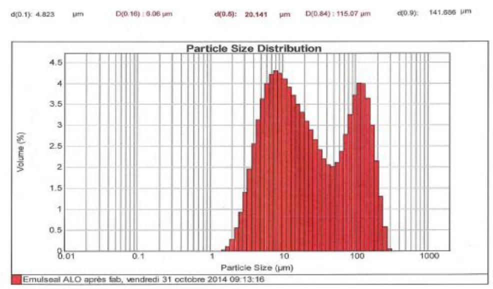

Photo 8: Multimodal curve – Plant production

After maintenance of the plant's mill and fine tuning of its gap, we were able to produce again very fine emulsions giving excellent and satisfactory results on the jobsite, as shown on the photos below (photos 9 and 10).

Photo 9: View of the jobsite during application

Photo 10: Surface texture

It is interesting to note the fast curing of the mix on photo 9, comparing the lane on the right that has already become black while the second one is being laid down. The final rendering of the microsurfacing on photo 10 is perfect.

In addition to all the methodology that we specially implemented for the design of this new generation of micro surfacing (described in the § 2 of the paper) we specified also specific values on the particle size of the emulsion:

D0.5 < 5 µm
D0.9 < 10 µm

3.2: 2015 Micro surfacing campaign.

Following the excellent results obtained in Normandy at the end of 2014, we decided to generalize the use of our new emulsion in 2015.

Therefore, this new micro surfacing was applied in various regions of France, such as the departments of Seine-Maritime (76), Eure (27), Vendée (85), Dordogne (24), Gironde (33), Charente (16), Vienne (86) and Rhône (69) for a total of more **than 800 000 square meters**.

Below are a few pictures of the different jobsites:

Photo 11 : Gironde (33)

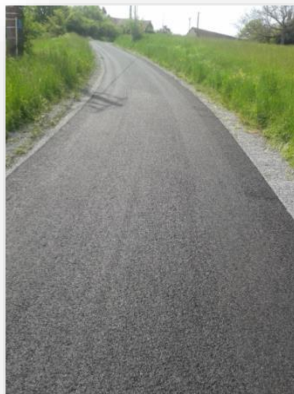

photo 12: Dordogne (24)

photo 13 : Vienne (86)

We even took the opportunity of one jobsite to compare our new emulsion with the traditional one based on Venezuelan bitumen. No differences were observed between the two sections (cf photo 14 below).

Photo 14: Venezuelan bitumen on the left – Paraffinic bitumen on the right

4. CONCLUSION - PERSPECTIVES

The development of this new emulsion design and its implementation took nearly 18 months within the research teams of Eiffage Infrastructures. All this body of work was also the opportunity for us to redesign completely our methodology and to better approach the cohesion built-up of the mix.

Importance of the emulsion production was also highlighted, showing the importance of team work during the development of new products between the different departments of the Company, from Research to Industry and Production. This is certainly a key parameter in the quick and successful implementation of a new product/process in any organization. Networks and relationships were strengthened during this project and no doubt that this will be the success of our further developments to come.

Finally, this generation of new microsurfacing pavements are also an opportunity for Eiffage Infrastructures to be more competitive in Europe and be able to introduce this technology in countries where the availability of Venezuelan bitumen is impossible.
This is in total concordance with the international Development of the Eiffage Group.

5. REFERENCES

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