Bituminous emulsions

Slurry surfacing with additivated bitumen Increasing the acid index of the bitumen to improve the cohesion of the system

Julien BUISSON[1], Nicolas PICARD[2]
[1]Tech sales - INGEVITY, [2]Lab director Europe - INGEVITY

Abstract

In France like in many others countries, maintenance and preservation of the road is one of key factor for the development and the socio-economic aspect. Thus, one of the most famous technics based on emulsion technology, is the slurry surfacing, technic used and applied since decades with more than 45 million of m2 / year just in France. Ingevity, leader in chemical's additive for road construction and maintenance, has worked since more than 30 years on the development on emulsifiers and bitumen's additive (products based on vegetal's chemical from pine tree) with the aim to obtain the best solution possible. As it, during the fabrication and application of mix asphalt made with emulsion, and especially for slurry seal the key point is the cohesion of the mix. So with a direct and fast break of the emulsion and a good cohesion we obtain a good coating of the aggregates and after the application not any loss of aggregates after opening the traffic. The laboratory study is necessary to choose the good emulsifier for the jobsite (cleaning of the aggregates, temperature of application …). Also the bitumen is one of the key point. The key parameter is the acid index (in mg KOH / g, Norma NFT66-066). So in this paper, we will study the effect of an additive developed by Ingevity to increase the acid index of the bitumen and as a consequence the level of the cohesion (internal and external) of the slurry seal.

This paper was first published in 2020 in version 1.0 of the proceedings of the 7th E&E Congress. This second edition (version 1.1.) of the proceedings is published in June 2021. The content of this paper has not changed, but the author(s) may have provided additional information in the form of an annex.

1. INTRODUCTION

In France as many other countries, the maintenance of road infrastructure represents a key factor at the socio-economic level. Without a regular and adapted investment the results of this lack of conservation are seen very quickly: invisible horizontal signage, gravel rejection, bump formation,... One of the most commonly used maintenance technology in France is the slurry seal, applied every year just in France on more than 45 million m2.

This technique using a bitumen emulsion has always been used with a naphthenic bitumen (origin of Venezuela). These aspects of cohesion rise and rapid opening to traffic have had to be adapted in France as of 2014, due to the difficulties for obtaining Venezuelan bitumen. Thus, it changed for the use of paraffinic bitumen. With its experience in the US, where naphthenic bitumen has been banned many years ago, INGEVITY, a chemical company, has developed, for more than 20 years, high-quality chemicals, obtained from the distillation of vegetable fatty acid from Pine tree that has allowed us to offer a very interesting technical response.

The recommended solution apart from selecting the appropriate emulsifier according to the reactivity and dirtiness of the aggregates and the climate of the area, is adding to the bitumen an additive to increase the acid index of the binder. Thus allowing to approach the values of a naphthenic bitumen increasing aggregate / bitumen adhesiveness and then the cohesion more frank than a classic paraffinic bitumen.

Of course, a laboratory study with standards tests (torqui meter cohesion, WTAT abrasion) are not the only ones necessary. These tests have to be coupled by tests on aggregates (methylene blue value), binders (acid index), cohesion of the mixture, cohesion in the heart of the slurry (HCT test), coefficient of abrasion with TCS test.

2. DESCRIPTION OF THE STUDY

As described above, the objective of the study has been to look at the evolution of the acid index of the binders and the consequences on the technical characteristics of slurry seal. We have compared the characteristics of different bitumens (with and without additive) against a naphthenic bitumen and the consequences on bituminous slurry mixtures.

- Bitumen A = binder 70/100 paraffinic
- Bitumen B = binder 70/100 paraffinic
- Bitumen C = binder 70/100 naphthenic from Venezuela

The additive to play on the acid index of bitumen is an additive derived from pine tall-oil fatty acid, specifically developed for asphalt technics that are very sensitive to bitumen variations. It is called Indulin AD4L and is generally used with a dosage of 0.3% over the bitumen phase (ie 1.8 kg per ton of emulsion for a 60% bitumen emulsion).

The aggregates used for the formulation comes from French Normandy, origin of the quarry of Normandia quarry Vignat type quartzite. The surfactant for the manufacture of the emulsion is part of the range of controlled micro surfacing and called Indulin MFS.

Table 1: Mix design of the slurry seal

	Mix design					
	% bitumen	% emulsifier	% emulsion	% water	% breaking agent	% ciment
bitumen A	60	1	11	10	0,3	0,3
bitumen A + additive	60	1	11	10	0,3	0,3
bitumen B	60	1,1	11	10	1	1
Bitumen B + AD4L	60	1,1	11	10	1	1
Bitumen C	60	1,2	11	10	1	1

The laboratory tests made for this study were :

- Breaking time
- Cohesion instantaneous
- Ball test at 30 minutes
- Benedict cohesion test
- Cohesion HCT
- Abrasion TCS

The breaking time is defined as the break time of the emulsion and when you can no longer work with the slurry inside the laboratory pot.

The golf ball formation test is a test where a ball (golf ball type) is formed handmade, at the time of grouting, leaving the ball for 30 minutes at room temperature. After 30 minutes, the ball is dropped to the ground from a height of 1 meter. You can tell if the ball is destroyed or not. Ok means good cohesion.

The Benedict test or torqui-meter, allows to measure the resistance of the micro surfacing when a constant pressure load is applied at 20, 30, 40 and 60 minutes and at room temperature of the laboratory.

The HCT Cohesion Test (Hilt Cohesion Test), as see pictures 1 and 2, is made by manufacturing a slurry on a 2cm thick plate. In different conditions (time and temperature) half of the plate is left on the table, the other plate being in a vacuum. It shows the seconds before the mix plate is broken. It allows you to notice the cohesion of the grout in your heart.

The TCS test (Cohesion Surface Test), allows to measure the mass of slurry lost after a defined temperature and humidity maturation time of a slurry plate immersed in water and subjected to wheel arches.

Picture 1 and 2: Hilt Cohesion Test (HCT)

Picture 3: Cohesion Surface Test (TCS)

3. RESULTS AND DISCUSSIONS

The first test was to see the evolution of the acid indices of the binders with and without additive (dosage in this case at 0.3% over the bitumen phase) to increase the acid index of the binders. The idea was to approach the results of a Venezuelan naphthenic bitumen, considered the most suitable for the technic of slurry seal due to its good coating of aggregates, quick cohesion and rapid opening to traffic.

First, it is important to note that the addition of fatty acid does not affect the physical characteristics (ring and ball temperature and penetration) of the binders. The modified bitumen stays within its initial range, that is, a 70/100 here.

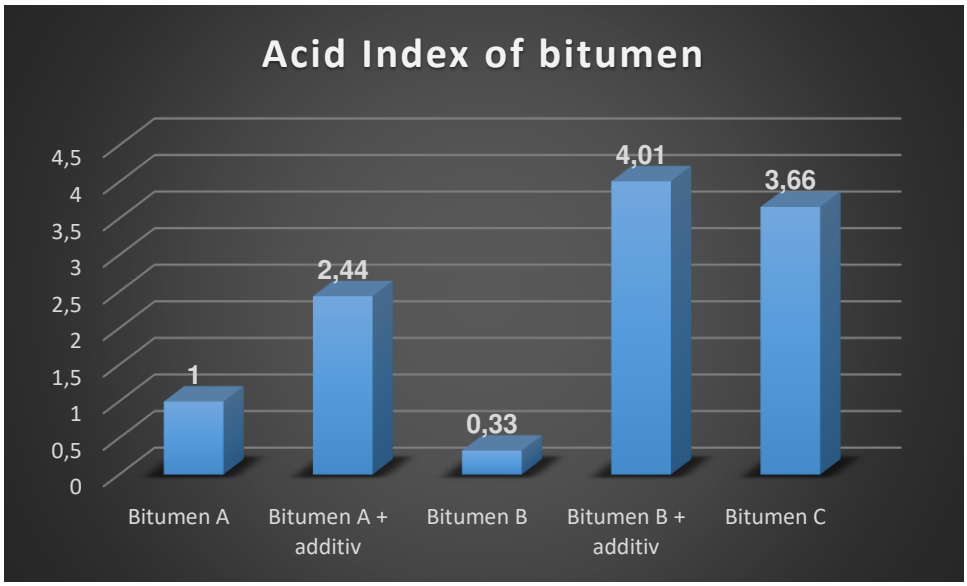

Figure 1 : Acid index of bitumen with and without additiv

The results shown in the figure 1, show that, by adding an acidifying agent to the bitumen, clearly allows to increase the acid index significantly and to be very close or even higher than the level of a naphthenic bitumen.

The different mixtures were manufactured and the physical characteristics of the slurry seal and their cohesion were looked at.

Table 2: Intantaneous cohesion

	Breaking time (in sec)	Ball test at 30 minutes (yes or no)
Bitumen A	185	yes
Bitumen A + AD4L	240	yes
Bitumen B	107	no
Bitumen B + AD4L	137	yes
Bitumen C	129	yes

It can be noted that the systems with acidifying agent additive are slower than the classical formula. Above all, with bitumen B, this breaking time of the slurry seal results in a better formation and cohesion of the mixture (ball test is not destroyed).

Next, the Benedict or Torquimeter cohesion test was done (table 3). Again, it is noted that adding a bitumen agent increases cohesion results and approaches the reference binder (bitumen C, of Venezuelan origin).

Table 3: Results of cohesion – Benedict test

	Cohesion (kg/cm)			
	Min 20	Min 30	Min 40	Min 60
Bitumen A	20	26	25	25
Bitumen A + add	25	28	29	30
Bitumen B	21	21	23	25
Bitumen B + add	24	25	25	26
Bitumen C	35	35	35	35

Table 4: Results of cohesion HCT

	Cohesion HCT (in sec)		
	Min 30	Min 120	Min 120 (60°C in water)
Bitumen A	2	11	21
Bitumen A + add	12	44	27
Bitumen B	0	1	8
Bitumen B + add	7	9	12
Bitumen C	20	20	25

In Table 4, the HCT cohesion for Hilt Cohesion Test, allows to measure the cohesion of the mixture in the heart and not only on the surface of the slurry. Again, the increase in the values of the mixtures bearing a bitumen additive is noted, as a result of better adhesiveness between the aggregates and the binder. The mixture is more rigid and breaks much more slowly when it has in its formula a bitumen additive. Another key point during the study of formulation of slurry, is to see the behavior of the mixture subjected to traffic, looking at the possible losses and rejections of aggregates. Practicing the TCS test (by Test Cohesion Surface).

The results with the use of additive bitumen are similar, we are in the same range, same order of result. It means that the use of bitumen additive has no negative effect.

Table 5: Results of abrasión TCS

	Abrasion TCS 30 min (en g)
Bitumen A	6
Bitumen A + add	5
Bitumen B	5
Bitumen B + add	6
Bitumen C	10

4. CONCLUSION

Through this article, we have been able to see the positive effect of a bitumen additive on its acid index. In fact, an acidifying agent allows to approach the reference values that a naphthenic bitumen can have, recognized as the “Rolls Royce” of the binders for the application of slurry seals. However, this type of additive has no consequences on the technical characteristics of the binders.

After the trials on bitumen, the study on bituminous mixtures was focused. It has been seen that the use of an additive, as an acidifying agent, has a very good consequence on the bituminous mixture. Thus, additivated slurry behaves better, both at the level of rapid breakage of the micro than of cohesion of the mixture on the surface or in its heart. Finally, the loss of material is similar, but it is of the same level as a classic mixture with a naphthenic bitumen, allowing to validate this type of formulation.

In conclusion, the slurry seal technic have the advantage of opening traffic very quickly (between 30 and 45 minutes) due to a frank breakage of the emulsion and a rapid rise in cohesion of the mixture, thus decreasing the disturbances to the end user. Of course, this fact is valid after the selection of a suitable set among aggregates, bitumen, surfactant, working formula etc ...

The recommended solution apart from selecting the appropriate emulsifier is to add the bitumen with a pine talloyl fatty acid derivative to increase the acid index of the binders. Thus allowing to approach the values of a naphthenic bitumen and increasing aggregate / bitumen adhesion then the rise in cohesion more frank than a classic paraffinic bitumen.