Bituminous emulsions

Enlargement of the field of use of asphalt mixes with ultra-thin emulsion asphalt concrete

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Abstract

Bituminous mixes with emulsion in wearing course have been developed since the 1990s in France. Appropriate manufacturing processes have allowed the constitution of a wide range from very thin to thick mixes. The main area of employment is the low and medium traffic roads which represent 80% of the network in France. A complete overhaul of the French standard was published in 2016 to take into account the latest developments. Colas has developed a new concept of ultra-thin asphalt concrete with emulsion in order to widen the field of use framed by the standard. The thickness of this new generation of emulsion asphalt mix is 1.5cm. It restores the surface characteristics and impermeability of the roadway. Its particle size is 0/6mm or 0/10mm. It is manufactured using a sequential coating process that make the sand hydrophobic before final coating in a cold mix plant. This ultra-thin emulsified asphalt mix shares its field of application with surface dressing and microsurfacing. Its main advantage is the absence of stripping and the reduction of rolling noise generated at tire and road contact. This ultra-thin mix contributes to a high environmental performance thanks to a partial or total cold production, the use of emulsion and undried chippings and vegetal flux. Several projects have already been completed and are currently being monitored. This mix is layed with a conventional application workshop. It is recirculated immediately after the end of compaction. The final cohesion is reached after a curing period quite short because favored by the small thickness of the asphalt. The levels of sand patch test obtained are generally between 0.6mm and 0.9mm which guarantees a surface drainability and a suitable level of adhesion.

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1. INTRODUCTION

Emulsions have been used in paving technology since the 1900s in France, and mean that bitumen can be used without being heated. In its emulsified state, bitumen is less viscous and can therefore be mixed with aggregate, laid and compacted in the cold state.

In the early 1950s, cold grave emulsion was developed. This consists of a mixture of aggregate with emulsion and water. It is suitable for pavements with high deflections. In addition, its long-term properties are outstanding (no rutting). However, the quality of coating is mediocre and leads to a fragile surface which is prone to segregation. To deal with this issue, cold grave emulsions need to be covered with a wearing course.

In recent years, environmental concerns have led to greater interest in cold mix technologies. Since the 1990s, Colas has been developing bitumen emulsion mixes for wearing courses. The objective was to create a product offering both high quality coating and good ride comfort. The first mixes had poor resistance to traffic and low density. Several new technologies were therefore developed to address this problem. In 1992, we developed a patented double coating process. This consists of a sequential coating process that makes the sand hydrophobic before final coating in a cold mix plant. This solution provides a dense cold mix (about 30% passing through a 2mm sieve), with good coating and without segregation.

This process led to the development of storable cold-mix surfacings and thin bitumen emulsion concrete for use as a wearing course.

The resurgence of interest in cold-process mixing techniques has enlarged the field of use of asphalt mixes with the launch of EUROMAC, which is an ultra-thin emulsion asphalt concrete.

The thickness of this new generation of emulsion asphalt mix is 1.5 cm. Its particle size is 0/6mm or 0/10mm. It restores the surface characteristics and water resistance of the roadway. The main area of application is on low and medium traffic roads, which represent 80% of the network in France. It corrects deformations and is therefore similar to a surface dressing or microsurfacing . Its main advantage is the absence of stripping and the reduction of rolling noise which offers improved ride comfort for the users.

This presentation sets out and explains the manufacturing process, laying operations as well as the benefits of this asphalt concrete.

2. MANUFACTURING PROCESS

Ultra-thin emulsion asphalt concrete is laid as a wearing course for road maintenance works. It is a highly efficient way of restoring a road's grip characteristics and a pavement's impermeability. It is exclusively a surface technique, playing no structural role.
The thickness of the asphalt concrete is 1.5 cm with a particle size of 0/6mm or 0/10mm.
It is suitable for use on pavements with high deflections (flexible pavement).

Figure 1: Thickness of Euromac

The first step of the process is coating of the sand with hot bitumen (the grade should be chosen according to the traffic or the site constraints).

The second step is blending the sand and the aggregate with the bitumen emulsion. The viscosity of the emulsion should be matched to the specific features of the site, both in terms of transport time and the weather conditions. This final step takes place in a cold mix plant.

3. MIX DESIGN

The formulation is continuously graded with a 0/6 or 0/10 grain size.
The laboratory mix design process involves identifying the right aggregate, the right emulsion and the optimum ratio between the two. These objectives are met by determining the compatibility between the aggregate and the emulsion, hence making sure the aggregate remains coated. The quality of coating is then checked: all the aggregate particles must be coated by bitumen. Next, the moisture damage resistance is tested via the Duriez test and the workability is tested by means of the gyratory shear compactor test. Finally, the breaking time of the emulsion is determined.
The reference standard NF P 98-139 does not deal with the ultra-thin emulsion asphalt concrete. However, this asphalt must meet the following specifications:

Table 1. Specification for an ultra-thin emulsion asphalt concrete

Theoretical minimum anhydrous binder content (%) (real density = 2.66 Mg/m^3)	**5.0**
Duriez test procedure Moisture damage resistance (i/C, in %)	(NF P 98-251-4 compaction procedure n°1) **≥ 75**

4. LAYING

Ultra-thin emulsion asphalt concrete is manufactured and laid when the ambient temperature is above 15°C and in dry weather.
Depending on the state of the substrate, pavement re-profiling can be considered. In this case, a curing period is necessary if cold mix asphalt is used for reprofiling.

Before laying the asphalt, a tack coat must be laid with a mechanical spreader. According to the state of the substrate, the spread rate should be between 250 and 400 g/m² of residual bitumen.
The lorries must be covered in all kinds of weather. The transport time must not exceed 90 mins.

The asphalt cannot be stored for later use. Laying must be performed on the same day as production.

The mix is laid with conventional laying equipment with a paver according to the standard NF P 98-150-2. Compaction is performed by a smooth drum non-vibrating roller (4 to 8 passes). During laying, the emulsion breaks and water is released. The road can be re-opened to traffic immediately after compaction.

Figure 2: Compaction of Euromac

Cohesion of the product is not instantaneous. A few days of curing are required for it to achieve its final strength. The curing period is quite short because the mix is laid in a thin layer.

Mild weather after laying permits cohesion build-up and reduces the period of fragility. The mean texture depth (with the sand patch test) is between 0.6 and 0.9 mm which guarantees surface drainability and a suitable level of skidding resistance.
The usual thickness is as follows:

Table 2. Thickness of application

Euromac	Granular class	Thickness (in cm)
Ultra-thin asphalt concrete	0/6 or 0/10	1 to 2

5. BENEFITS OF THE TECHNIQUE

5.1. Environment

From the environmental perspective, this ultra-thin mix performs well because of the use of partial or total cold production. This is a significant advantage because it eliminates the emission of fumes, VOC and greenhouse gases during manufacture and the power consumption is far lower than for a hot asphalt. The emulsion is fluxed with a plant-based flux and the aggregates are not dried.

Since it is flexible, it is laid in a thin layer. Less aggregate is used, which preserves natural resources. In addition, the use of less asphalt means that the amount of transport prior to laying is reduced, which also reduces emissions.

The CoTITA (Conférences Techniques Interdepartementales des Transports et de l'Aménagement) made an environmental comparison between a hot and a cold asphalt with the same thickness. The results below show that the cold asphalt consumes 24% less energy and releases 34% less greenhouse gases than a hot mix asphalt.

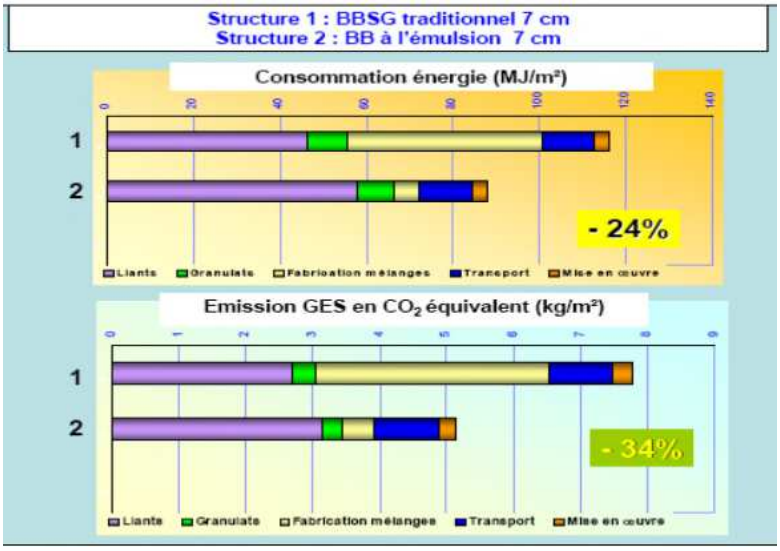

Figure 3: Environmental comparison between hot and cold asphalt (Buquet, et al., 2016)

Finally, at the end of its service life, the pavement can be 100% recycled.

5.2. Comfort and acoustic properties

This technique has clear benefits for road users. In aesthetic terms, it is comparable to a hot asphalt pavement. Coating is of good quality and there is no free gravel as is the case with a chip seal. The acoustic properties of this asphalt concrete are outstanding. Indeed, the noise level was measured on a 0/6 ultra-thin emulsion asphalt concrete, with a spread rate of 30 kg/m² on a 2km medium traffic road, the RD 724 at Beignon, France. The pavement was laid in October 2014. The noise level was measured in September 2015 and the results at 90km/h were ISO = 96.7 and LREP (dB) = 94.1. This is approximately 3dB(A) lower than a cold micro-asphalt or a 0/14 asphalt concrete wearing course and corresponds to a noise reduction of 50%.

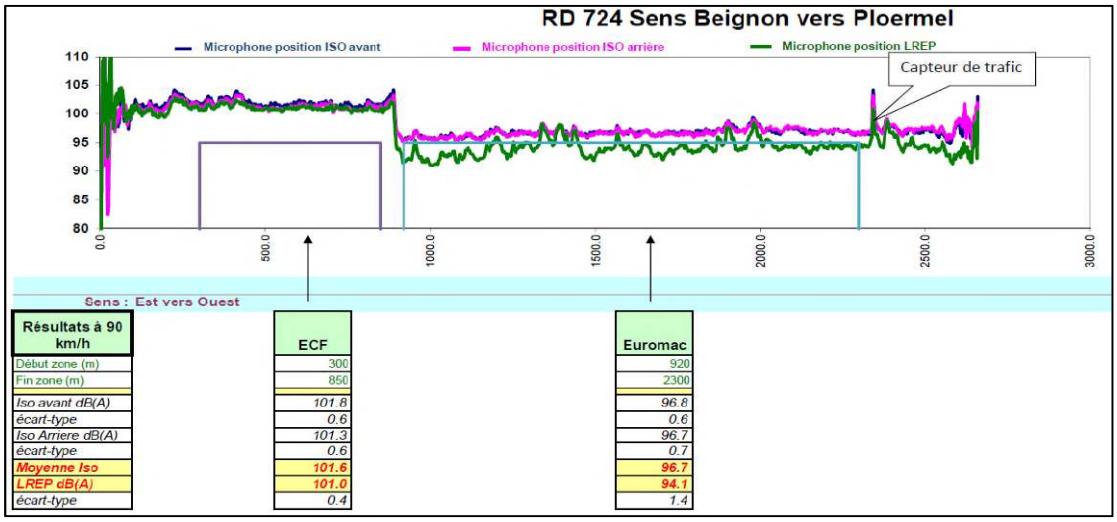

Figure 4: Noise measurements for Euromac and a cold micro-asphalt

In addition to reducing tyre-road contact noise for road users, this is also an advantage for residents.

Working with cold asphalt improves both the safety and comfort of laying gangs, removing the risk of burns and the inhalation of malodorous and poisonous fumes.

6. RETURN OF OPERATING EXPERIENCE

Ultra-thin emulsion asphalt concrete was laid on the 4th of July 2018 on the RN710 at Chancelade, France.

6.1. Technical characteristics

Table 3. Composition of the mixture

0/2 pre-coated sand from Thiviers	23%
2/4 aggregate from Dussac	36%
4/6 aggregate from Dussac	41%
C 67 emulsion	61% ext.
Anhydrous binder content	4.8% ext.
Total water content	4%

Table 4. Grading curve

Screen	0.063	0.125	0.250	0.5	1	2	4	6.3	8
Passing fraction	4.1	5.5	7	10	14	26	61	92	100

Compaction gyratory shear compactor test:

- Voids after 25 gyrations: 25.5%
- Voids after 40 gyrations: 24.1%

Duriez moisture damage resistance test:

- Voids 12%
- Compressive strength = 3.1 MPa
- Ratio between dry and wet compressive strength = 0.82 (specification > 0.80)

Site localization: Municipality of Chancelade in France, RN 710 from the km 28+900 to 30+500.
Length 1600m – width 7m – surface area 11,700m².
Traffic: 10,400 veh/day including 340 trucks.

6.2. Laying

Before laying the asphalt, a tack coat was laid with a spread rate of 400 g/m² of residual bitumen. The mix was laid with a conventional laying equipment including a VOGELE paver and a HAMM HD 110 compactor. Compaction was performed by a smooth non-vibrating drum (6 to 8 passes). Laying was performed on one half of the carriageway at a time and the road was closed to traffic throughout the day.

Figure 5: Laying equipment

6.3. Results

Occasionally, during laying some sand pellets were found and had to be removed. The sides of the road tends to peel off due to the thinness of the layer. Visually, the final result is satisfactory. The residents noticed the noise reduction.

Figure 6: Results of laying on the RN 710

The mean texture depth (MTD) obtained with the sand patch test 1 month after laying was between 0.66 and 0.78 mm which guarantees surface drainability and an appropriate level of grip.

Table 5. Mean texture depth (MTD) by sand patch test)

	Position	Number of profiles	Max. MTD	Min. MTD	Average
Lane 1	**Centreline**	12	0.96	0.67	0.78
	Right wheel side	12	0.82	0.67	0.75
Lane 2	**Centreline**	12	0.87	0.49	0.69
	Right wheel side	12	0.73	0.55	0.66

7. CONCLUSION

Ultra-thin emulsion asphalt concrete reinvents the ultra-thin surfacing technique. Its originality comes from the manufacturing process in which the sand is pre-coated before the final coating in a cold mix plant.
This asphalt can restore the surface characteristics and impermeability of medium traffic roads. It offers several advantages including the correction of deformations, a reduction in rolling noise and an improvement in working conditions. Use of an emulsion binder makes it more environmentally friendly.

This technique is well-mastered with good results from monitoring in the field. Ultra-thin emulsion asphalt concrete provides a durable solution for pavement maintenance, combining strength with comfort.

REFERENCES

Buquet, Arnault, Tallieu, Jean Denis et Robin, Pascal. 2016. cotita. [En ligne] 09 12 2016. http://www.cotita.fr/IMG/pdf/7_PRobinABuquetJDTallieu_GE_BBF.pdf.