Maintenance and Rehabilitation

Percolated asphalt coating as an anti fuel solution in a heavy traffic motorway

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Abstract

Resistance to fuel of asphalt pavement surfaces is of capital importance in the maintenance of pavements that are exposed to frequent oil spills. It is well known the adverse impacts of hydrocarbons spills on strength and durability of asphalt pavements. Some solutions based on fuel resistant asphalts have been developed in the last years as, for example, highly modified binder combined with a very dense and compactable mix design. However, these kinds of solutions have not been proved sufficiently effective in a special case of a heavy traffic motorway in Spain, with high slope and affected by continuous gasoil spills from trucks. For this special case, a pilot section was constructed in the highway, to test a solution based on a percolated asphalt coating. The study of the pavement behaviour in this pilot section is still not concluded, although during the first year, the performance of this solution has been proved much more effective than the ones previously applied. Practical issues like percolation of the cement slurry on porous asphalt surfaces with high slopes or the treatment for assuring the skid resistance of the surface are also discussed in the paper.

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1 INTRODUCTION

One of the major problems of asphalt pavements that are exposed to frequent oil spills is their disaggregation because oils and fuels dissolve the bitumen that acts as a binder to the mixture, leaving the aggregates loose and, therefore, susceptible to being removed under traffic and atmospheric agents action.

This is an ongoing problem in the Spanish highway AP-7, just before the French border, where fuel spills on the road are constant due to:

- Frequent traffic jams due to borders controls (stop-go traffic)
- High slope, between 4 and 5 per cent
- Petrol is cheaper in Spain, so trucks go with their fuel tanks full. This, combined with the high slope and the continuous stops and starts of the lorries, cause constant fuel discharges

In addition, the reduced speed of heavy vehicles as well as the shear stresses, both due to stop-and-go driving, cause a considerable decrease in the stiffness of the asphalt and a significant creep of bituminous materials, which result in rutting and in a widespread deterioration of the pavement.

Figure 1 shows the affection of oil spills on the pavement. This occurs mainly in the lane for slow-moving vehicles.

Figure 1: Examples of asphalt disaggregation due to oil spills in AP-7

This constant deterioration of the pavement has meant considerable maintenance and reparation costs to the highway concessionaire (ACESA). For this reason, it was very convenient the study and experimentation of anti-fuel solutions to be implemented in the slow lane of AP-7.

2 ANTI-FUEL SOLUTIONS AVAILABLE

Some solutions based on fuel resistant asphalts have been developed in the last years, for example, highly modified bitumen combined with a very dense and compactable mix design or mortars based on synthetic resins applied over the surface layer. These solutions have been tested in the AP-7, but they have not been proved sufficiently effective because the durability was short and the damages due to oil leaks from the trucks soon reappeared (see Figure 2).

Figure 2: Damage in the slow lane, after several rehabilitations

The traditional solution for pavements subjected to frequent hydrocarbon leaks (e.g. gas stations, toll areas, airports) has been concrete pavement because it has a high resistance to fuel and chemical agents attacks. But for the concessionaire of AP-7 Highway, this kind of pavement presents some disadvantages like higher costs, difficult execution with traffic in the rest of the lanes, need of 7 days before opening to traffic, surface performances (smoothness, noise, ...). For tthis reason, ACESA (a company of ABERTIS Group) decided to execute a pilot section of a percolated asphalt coating as anti-fuel solution.

Percolated pavements are asphalt pavements consisting of a porous asphalt layer whose voids (around 25%) are afterwards filled with a slurry of cement and additives [1]. To facilitate the penetration of the cement slurry into the porous asphalt, a vibration system (usually with a steel drum roller) is applied. Percolated pavements are, therefore, a mixed system that, on one hand, has the advantages of resistance against fuels that a concrete pavement would have, thanks to the coating of cement mortar; and, on the other hand, it implies a continuous pavement without joints (like an asphalt pavement) but with anti-fuel characteristics and high puncture resistance. So, this type of solution is intended to obtain a road surface resistant to temperature variations, oil and fuel spillage and puncture; but at the same time is more flexible than a concrete pavement. Moreover, these pavements show an upgraded bearing capacity (achieving dynamic module values twice as much as conventional bituminous mixtures); their execution is quick and simple and can be opened quickly to traffic (from 24 hours after execution, depending on the products used).

All these characteristics and performances of percolated pavements should result in a greater durability of this kind of pavement with respect to other alternative techniques (based on the use of special bitumen and resins), under the specific aggressions occurring in the reference section. This led the concessionaire of AP-7 highway to make a pilot section in order to check its durability. Eiffage Infraestructuras was entrusted to do this work.

3 EXECUTION OF PERCOLATED PAVEMENT IN AP-7

Once the specific problem was analyzed (oil spills on the road caused by the large heavy traffic in the area), in July 2018 a pilot rehabilitation was designed to be implemented in 380 m of the slow lane at the PK 1+000 (milepost) of AP-7 descendent way (direction to France).

The percolated implementation consisted on applying the cement and resins slurry over the porous asphalt causing it to penetrate the layer by applying vibration with a steel drum roller. The slurry must penetrate until the whole thickness of the bituminous mixture is filled. This penetration depends mainly on the design of porous asphalt (% voids) and on the proper fluidity and composition of the slurry. In this case, the high slope of the road (4-5%) introduced an additional uncertainty factor, because it was the first time that this system was applied on surfaces with so much slope, in Spain. Eiffage Infraestructuras had experience on the application of this solution in flat surfaces as parking lots, industrial areas, …but never on slope.

The rehabilitation was performed in three phases during a week:

- Clean up and replacement of bituminous layers affected by oil-contamination
- Percolate of porous asphalt layer

- Hydro-blasting (or hydro-jetting) of road surface for recovering macrotexture

3.1 Preliminary trial

Previously, in order to validate the materials and the execution procedure to be implemented in AP-7, a series of previous studies, formulation and manufacturing tests of the mixtures and a test track were carried out in the asphalt plant. Figures 3, 4 y 5 show different moments of this preliminary trial. The percolated was done one day after the laid of the porous asphalt. The mortar selected to fabricate the cement slurry is specially designed to percolate and to achieve high short-term strength and, therefore, it would allow to open the highway traffic in 24 hours.

Figure 3: Laying the porous asphalt in the preliminary trial

Figure 4: Percolate of the porous asphalt in the preliminary trial

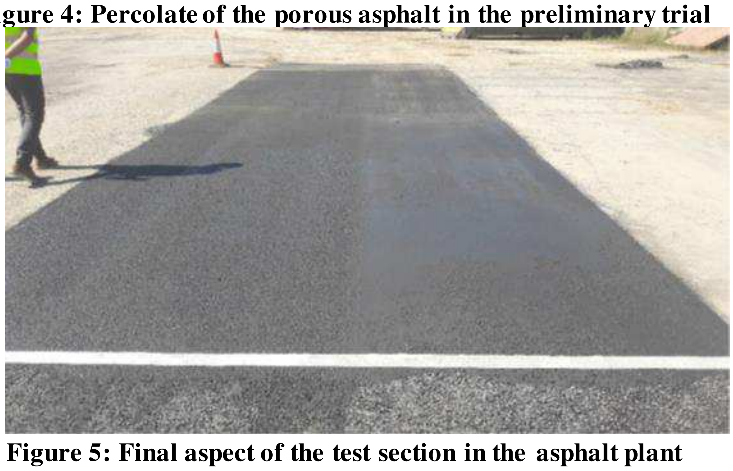

Figure 5: Final aspect of the test section in the asphalt plant

As a result of this initial test, several conclusions were drawn:

- The 25% void content in the porous asphalt was suitable for the percolation of the cement slurry

- To prepare the cement slurry it was needed 1 liter of water for every 4 kg of mortar
- The optimal dosage of cement slurry was determined as 3.4 l/m^2 of porous layer
- To obtain a correct finishing, a final brushing with mechanical sweeper with the mortar still fresh was applied
- The final color of the surface was similar to the one in the highway asphalt, so it was accepted by the client
- Samples cores were extracted to verify the whole penetration of the cement slurry. These cores were also subjected to oil immersion and resistance to hydrocarbons was confirmed

3.2 Clean up and replacement of bituminous layers in AP-7 pilot section

Now we go on to describe the work carried out on the AP-7. First, 14 centimetres depth of oil-contaminated pavement were removed by milling (Figure 6). This depth of milling was necessary to ensure the complete elimination of oil pollution.

This removed pavement was replaced by two asphalt layers: a first layer, 10 cm depth, with a semi-dense asphalt concrete type AC 22 with pure bitumen 35/50 and with 20% of RAP; and a second layer (4 cm depth), with porous asphalt, PA 16, with modified bitumen PMB 45/80-65.

Figure 6: Milling of oil-contaminated pavement

3.3 Percolate of PA layer

After 24 hours of the laying and compacting of the porous asphalt layer, the cement slurry was applied. The formulation and dosage of this slurry were done according to the results of the initial trial in the asphalt plant. The slurry was fabricated in a small mixer (Figure 7), transported in a forklift and poured on the pavement from the highest points, to facilitate the percolate by gravity (that is, it started from the top of the lane and worked downstream). As in the preliminary trial, after pouring the slurry, its penetration into the porous layer was aided by a tandem vibratory steel roller (Figure 8). After the roller, a brushing to remove the excess of the slurry in the surface was done and after that. a cure film was applied (Figure 9). This curing will prevent, or at least reduce, a common problem in this type of application, such as the appearance of surface fissures due to the initial retraction of any mortar with cement.

Figure 7: Left: Pouring the cement slurry. Right: Aspect of the cement slurry in the mixer

Figure 8: Percolating the slurry into the porous layer

Figure 9: Finishing works: brushing and cure film application

3.4 Hydro-blasting of the road surface

The final hydro-blasting performed in the AP-7 pilot section (Figure 10) had the following purposes:

- Removing the surface film of the slurry by applying a high-pressure flow of water
- Recover the macrotexture of the pavement
- Improving the skid resistance

That is, the hydro-blasting was made to ensure the minimum road safety performances prescribed for highway lanes.

Hydro-blasting is a technique that has been used on many roads throughout the Spanish territory, being able to achieve yields of between 1,500 and 2,000 m^2/hour[2]. A suction system is integrated into the hydro-blasting head, so that all the water used during the jetting is absorbed and the road is only slightly wet after the passage of the equipment.

Figure 10: Left: Execution of hydro-blasting. Right: Final aspect of the surface after hydro-blasting

Figure 11 shows in detail the aspect of the surface after the hydro-blasting.

Figure 11: Core extracted from the pilot section after the hydro-blasting

In the end, road markings were painted and this pilot section was opened to the traffic.

4 QUALITY CONTROL AND PERFORMANCE UNDER TRAFFIC

To evaluate the quality of the solution tested in the AP-7 regarding the resistance to oil spills, several tests were performed on cores extracted from the pavement. Samples were tested before and after gasoil immersion to check the effect that oil had in the mechanical characteristics of the percolated. The results are shown in Table 1.Although the wheel tracking test does not make sense to do on percolated pavements, it was performed so that we were able to compare the deterioration after immersion in gasoil.

Table 1: Control tests over percolated pavement cores

Test	Standard	Value	Unity
Particle loss[(1)]	EN 12697-17		
<u>Cores external lab</u> Core 1 Core 2 Core 3		25 18 19	%
<u>Cores Eiffage lab</u> Core 4 Core 5 Core 6		17 24 19	%
Wheel tracking (WTS)	EN 12697-22		

Specimen percolated in situ (2) Not percolated PA 16 Percolated PA 16 Percolated PA 16 after gasoil immersion (1)		0,067 0,033 0,063	$mm/10^3$ cycles
Percolated cores (3) Before gasoil immersion After gasoil immersion (1)		0,014 0,018	$mm/10^3$ cycles
Skid resistance (PTV: British pendulum) (4)	EN 13036-4		
Before hydro-blasting After hydro-blasting		58 55 81 71	
(1) After 72 horas of gasoil immersion (2) Specimen made in lab and percolated in the worksite (3) Percolated cores extracted from the pavement (4) Measured on the pavement surface			

The results presented in Table 1 prompted the following conclusions:

- The particle loss values after gasoil immersion (72 hours) are similar to those obtained for porous asphalt without immersion and fulfill the requirements for Spanish specifications [2].
- The oil spills don't affect the percolated pavement in terms of rutting.
- Hydro-blasting has been shown to be effective in improving skid resistance

Figure 12: 9-month old pavement status (April 2019)

After 9 months with the new pavement under traffic (Figure 12), additional follow-up tests were monitored to evaluate the performance of the pavement. Thus, deflections were measured by falling-weight deflectometer (PRIMAX 2500 HWD) and showed that sections with percolated pavement had better structural capacity than sections with conventional asphalt (see Figure 13).

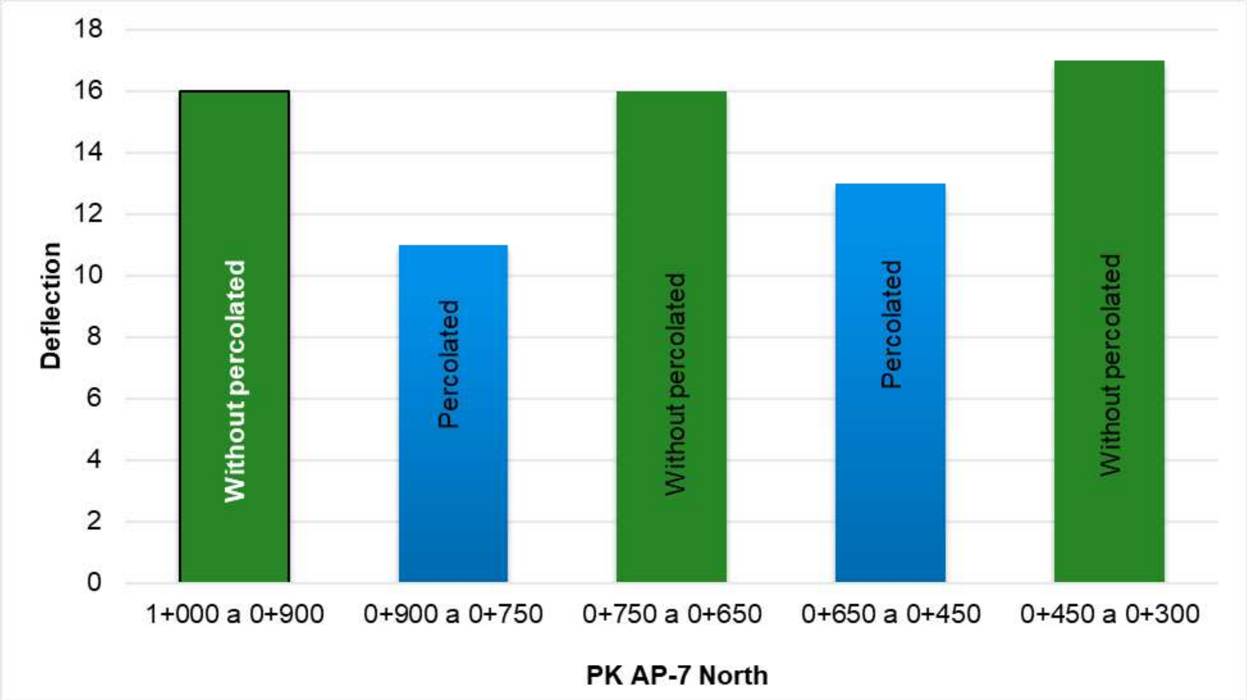

Figure 13: Comparison between sections with and without percolated (deflections)

Also, pendulum and macrotexture tests were carried out both in areas affected by oil spills and in clean areas. The results are presented in Table 2, but they are not conclusive on the effect of oil contamination on the surface features.

Similarly, cores were drawn also from both areas and tested for particle loss. In this case the results reveal that percolated pavement is not affected by oil spills (Table 3).

Table 2: Surface characteristics of the pilot section under traffic

Test	Standard	Value	Unity
Macrotexture (MTD)	EN 13036-1		
Hydro-blasted Clean Percolated asphalt Hydro-blasted Oil-affected Percolated asphalt Oil-affected Conventional asphalt		1,05 0,78 0,83	mm
Skid resistance (PTV)			
Hydro-blasted Oil-affected Percolated asphalt Oil-affected Conventional asphalt		59 59	

Table 3: Particle loss results over cores

Particle loss (%) (EN-12697-17)	
Hydro-blasted Clean Percolated asphalt Hydro-blasted Oil-affected Percolated asphalt	21% 23%

5 CONCLUSIONS

As a result of the execution of this pilot section with percolated pavement in the AP-7 Highway and of the performance evaluation after a year under traffic, the following conclusions can be drawn:

- Visual inspection after one year is completely satisfactory: there is no cracking in the surface, no disaggregation nor holes in the pavement, there have been no rutting.
- The thickness affected by gasoil never exceeds 4 mm, being normal of 1 mm.
- In terms of particle loss, the value is the same with and without oil contamination, so it can be said that the spills do not affect this feature.
- Hydro-blasting treatment as had been done in the pilot section (100 atm of water pressure) is not recommended, because there is no difference in the skid resistance after one year under traffic. To ensure a SFC greater than 55 it is estimated sufficient to apply a mechanical treatment over the percolated in the phase of curing.

- A porous asphalt with a void content higher than 25% must be ensured. This requires a correct formulation study and the execution of a test track to check it.
- It is necessary to ensure that the slurry is evenly distributed throughout the porous layer. For this, it is necessary to use an effective application system and proper compaction.
- The deflection value drops considerably in the percolated sections, improving the structural capacity for heavy traffic.
- As can be seen in the pictures showed in this paper, most of the work described in the percolating phase were carried out manually, being very labour intensive. Therefore, it is advisable, in view of the future development of this technique for highway lanes, to propose its application on the pavement in a more industrial way.

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