Bituminous emulsions

Reinforced anti-crack complex for protection of fatigued pavements: feedback from a new preservation solution

CHRISTOPHE PRIEZ
COLAS

Abstract

In France, the budgetary limitations of contracting authorities have led to a new perspective on maintenance techniques. A new surface treatment which combines a single under layer of fiber filled surface dressing and a upper layer of microsurfacing have been developed. Adding fibers in the surface treatment, like in the microsurfacing, limits binder run off, slows the spread of cracks and enhances the performance of the complex in dense and heavy traffic. This thin layer mean that no ancillary leveling work is required. The new complex ensures waterproofing for the support, skid resistance and a homogeneous and aesthetically pleasing appearance of the treated section. Thanks to these anti-cracking, sealing and flexibility properties, this new sealing compound makes it possible to correct maintenance defects and to postpone heavy repairs. For 6 years, feedback from low to medium traffic has demonstrated the durability of this process over time. The complex helps to block the damage of a fatigued pavement. From a structural point of view, it has been noted an improvement (decrease) of the deflection of the protected pavement. The service life of highly cracked pavement is increased by several years under good service conditions. This is a major advantage for preserving road assets.

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

The first composite pavement surfacings date back to the 1960s. The technique in question, known as Cape Seal, was invented in South Africa (in Cape Town, hence its name).
Colas's technical department brought this technique into France in the 1990s, and has developed it by carrying out a large number of trials, and, depending on the formulation of the two layers that make up the composite surfacing together with the use of glass fiber filling, this Composite Surfacing, called COLBFIBRE , can now be used with varying qualities of substrates and varying traffic levels.
Monitoring of the first projects over the past 6 years, carried out on very poor quality substrates, highlights the considerable potential of composite surfacings.

2. RESULTS OF MONITORING

2.1. The technique

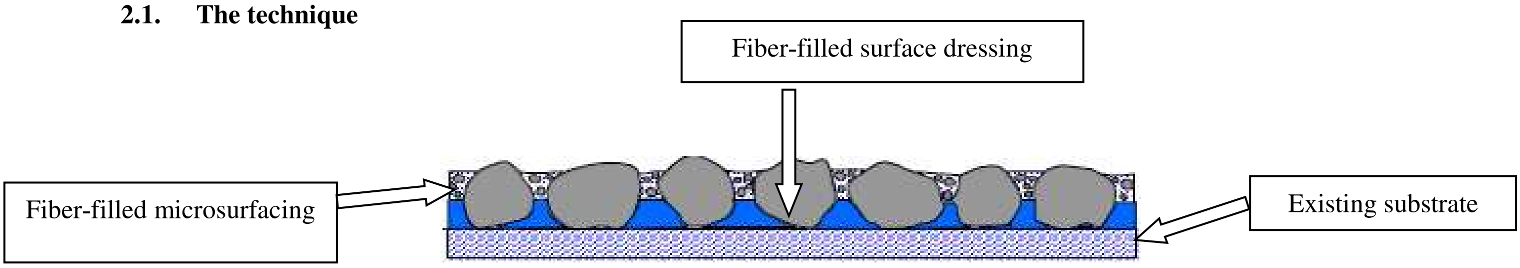


Figure 1: Cross-section showing the technique

- A first layer of fiber-filled surface dressing with a fairly sparse application of 6/10 chippings in order to ensure even distribution of the microsurfacing between the aggregate particles (sealing action).
- A second layer consisting of microsurfacing which is also fiber–filled (occasionally bituminous slurry may be used).
- Elastomer-modified emulsions are used to ensure high deformability of the composite.
- The technique can be modified according to the level of damage to the substrate and the traffic level.

2.2. Laying operations

Fig. 2: Laying operations

Photo 1 & 2: Laying of emulsion + fibers
Photo 3 & 4: Laying of sparsely chipped surface dressing
Photo 5: Laying of the fiber-filled single surface dressing
Photo 6: The finished works

This surfacing combines the advantages of both techniques without their disadvantages, namely excellent pavement impermeability, no whip-off and long-term durability of the macrotexture.
Formulation aside, this technique, like its two components, requires not only technical expertise but also know-how with regard to laying.
One of the most sensitive aspects of construction is synchronizing the surface dressing and cold microsurfacing laying equipment. This is because it is most unadvisable for vehicles to travel on the surface dressing, but the cohesion build-up of the surface dressing must be sufficient to stand up to the equipment that lays the microsurfacing. The timeframe must therefore be as short as possible, but nevertheless sufficient. The construction works are therefore carried out on a lane that is closed to traffic. It is preferable for the microsurfacing to be laid on the same day as the surface dressing, but in some jobsite situations and weather conditions, it may be postponed for a few days.

2.3. Follow-up of projects

It was necessary to use two approaches to evaluate the performance of the pavements on which the fiber-filled composite pavement surfacings had been laid. The first approach assessed the impermeability of the structure after the works and the second assessed the impact of the surface dressing + microsurfacing composite on the mechanical performance of the structure.

Below is a review of the first trials carried out in the Hauts-de-France region, which considers both the effectiveness of impermeability and the performance over time.

2.3.1. Impermeability of the road structure

Water is one of the main threats to pavements: through seepage, it degrades the performance of the road structure. It reduces the bearing capacity of the subgrade. In winter, as a result of frost, water can degrade the materials in the pavement, which then undergoes a long deterioration process (Fig.3/Photo 7).
Visual inspection reveals that the structure no longer absorbs stormwater (Fig.3 /Photo 8), skidding resistance is maintained as the result of a mean texture depth (MTD) that is equivalent to that measured in a semi-course asphalt concrete with a mean macrotexture depth of over 0.6 mm (Fig.3/Photo 9).

Figure 3: Impermeability of the road structure

Photo 7: Structure damaged by frost and road traffic
Photo 8: Surface state of the composite road surfacing after a period of rainfall: the water does not seep into the structure
Photo 9: Surface roughness of the composite road surfacing equivalent to a 0/10 semi-coarse asphalt concrete.

2.3.2. Long term mechanical performance with low to moderate traffic

2.3.2.1. Visual surveys

Below we shall present some follow-up of projects on severely damaged structures:
This is one of the first projects carried out in 2011, the road through Arvillers, a municipality located in the Picardy region. Figure 4 shows the changes in the road structure after three years of use under T3 traffic (50 trucks/day to 150 trucks/day). The structure has retained its integrity in spite of its very poor initial state.

Figure 4: ARVILLERS: State of the pavement before the project and after 3 years of trafficking

Photo 10: Damaged structure before laying of the fiber-filled composite road surfacing
Photo 11: Surface state of the composite road surfacing after 3 years. The structure has retained its integrity.

Figure 5 shows another project, the road through the river port of Lille, capital of the Hauts-de-France region. This road carries heavy traffic, in excess of 500 trucks/day.
The existing structure showed significant deformations (old cobbled pavement Fig5 /Photo 12) and was no longer able to carry truck traffic. An emergency decision was taken to evaluate the new fiber-filled composite road surfacing (Fig 5 /Photo 13) after taking the precautionary measure of reprofiling the entire structure with bituminous products in order to restore not only the longitudinal profile but - in particular - the transverse profile.
The structure's performance after one year with this surfacing (Fig 5 /Photo 14) was quite satisfactory, and a recent inspection carried out in June 2019, i.e. six years after construction, showed its effectiveness. In spite of the need for some localized repairs the product has withstood stresses better than expected.

Figure 5: Port of LILLE: State of the pavement after 1 year of traffic

Photo 12: State of the structure prior to works
Photo 13: Pavement surfaced with fiber-filled composite road surfacing after reshaping works
Photo 14: State of the structure after 1 year of trafficking

2.3.2.2. Long-term mechanical performance.

Colas' technical department wished to monitor the mechanical performance of a pavement with an initial high level of deflection after resurfacing with fiber-filled composite road surfacing. The selected case was rue Conflans St Honorine in the municipality of Béthune in the Nord Pas de Calais département (Fig.6). This pavement was subjected to level T5 truck traffic, carrying almost 25 trucks/day. It was surfaced with fiber-filled composite road surfacing in 2013.
For this purpose, pavement deflection measurements were made before the work was carried out (Fig.6/Photo15), and the values obtained were compared to those measured over a period of more than three years (Fig.6 /Photo16) until 2016.
Analysis of the measurements showed a significant improvement in the deflection level in the first 6 months, with an initial characteristic deflection level of 234/100 mm. After the works, the deflection level remained at 150/100 mm over the three years of testing, i.e. a reduction of about 36% compared to the initial characteristic deflection.
Because the impermeability of the pavement has been maintained, the structural layers of the pavement have been rehabilitated with a reduction in the hydric state of the road foundation; the moduli of the materials have actually improved and improved the structure's performance.

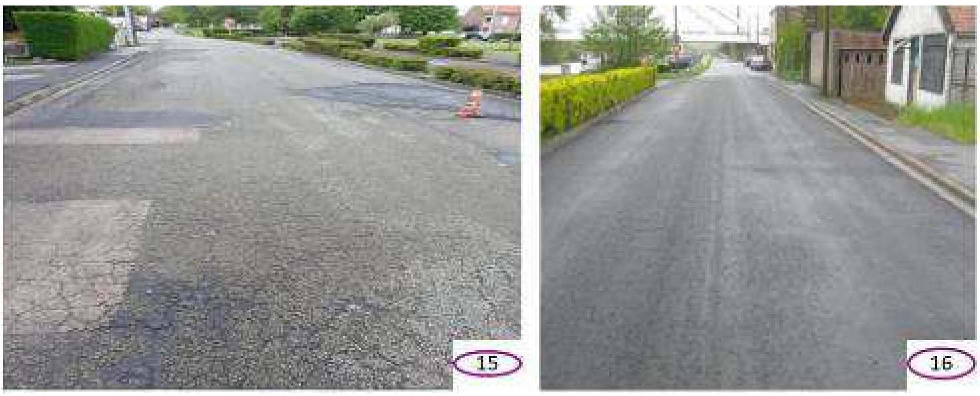


Figure 6: Béthune: Rue Conflans St Honorine. State of the pavement after 1 year of traffic

Photo 15: State of the structure prior to works
Photo 16: Pavement surfaced with fiber-filled composite road surfacing after 1 year

Date	Deflection measurements		
	Existing substrate	Results	Characteristic deflection
16/05/2013 - D+1	Wearing course: Micro surfacing + COLBIFIBRE	Min = 14/100 mm	Cd = 231/100mm
		Mean = 131/100mm	
		Max. = 240/100 mm	
22/11/2013 = D+180		Min = 14/100 mm	Cd = 153/100mm
		Mean = 131/100mm	
		Max. = 240/100 mm	
11/06/2014 = J+360		Min = 14/100 mm	Cd = 135/100mm
		Mean = 131/100mm	
		Max. = 240/100 mm	
15/05/2016 = 3 years		Min = 14/100 mm	Cd = 155/100mm
		Mean = 131/100mm	
		Max. = 240/100 mm	

Figure 7: Deflection measurements over a three-year period

This demonstrates that a fiber-filled composite road surfacing can provide a good level of impermeability on a damaged substrate, which, by an indirect effect, improves the mechanical performance of the structure.

2.3.3. The long-term mechanical performance of a high-traffic road

Since the SETRA call for innovative road projects in 2012, the Colas group has taken part in several experimental programs conducted in partnership with a number of Interdepartmental Roads Directorates (DIR) on high traffic roads.
One of the trial sites that was selected to evaluate COLBIFIBRE was a section of the A23 motorway between Lille and Valenciennes.
The goal was to evaluate the performance of a 900m section of fiber filled composite road surfacing carrying level T0 traffic (7000 vehicles/day with 8.5% of trucks) in comparison with a double surface dressing and a very thin asphalt concrete manufactured with elastomer-modified bitumen.

2.3.3.1. Spotlight on the DIR-Nord's experimental program on the A23 motorway

The A23 consists of a semi-rigid structure made from treated base gravel surfaced by a severely damaged 0/14 high modulus asphalt concrete (Fig.8/Photo 17-Photo 18). It should be explained that when the wearing course was laid it was very common practice to use hard multigrade bitumen.
The damage to the existing surfacing was analyzed with a device that was able to conduct a continuous survey of the condition of the pavement (rutting, cracking, etc.) using laser imagery at a speed of between 70 and 90km/h (Road Eagle: Fig.8/Photo 19).

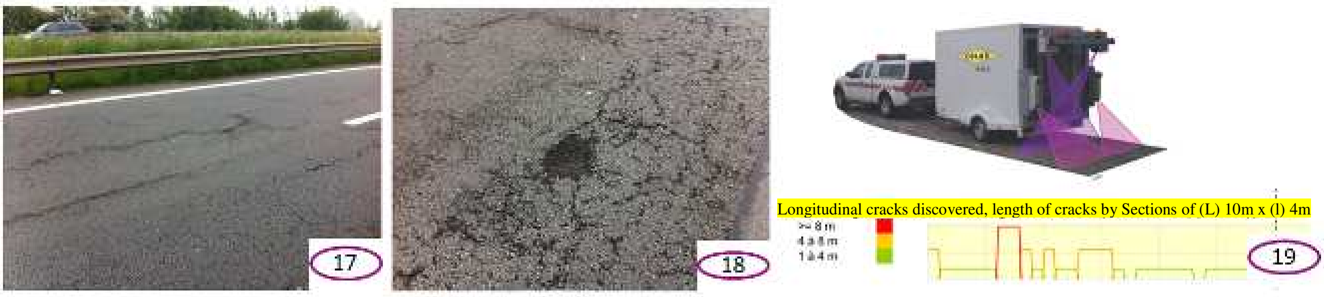


Figure 8: A23 motorway: Damage survey

Photo 17 - Photo 18: State of the surfacing prior to works
Photo 19: The laser scanner (Road Eagle)

The appearance of the surface was extremely varied with old zones exhibiting crazing and zones where the wearing courses has been partly replaced, and a large number of cracks (both thermal and fatigue), particularly in the outer lane.

Three 300-metre-long strips in which the wearing course was renewed were constructed.
A follow-up program was organized to monitor the pavement after 3 months, 1 year, 3 years and 5 years. This included visual inspections, macrotexture measurements, skidding resistance measurements - LFC (longitudinal friction coefficient) and SFC (Sideway-force coefficient) -, longitudinal and transverse evenness measurements, as well as near field noise measurements.

2.3.3.2. Strips manufacturing

- Strip No.1: 0/6 fiber-filled micro surfacing as a tack coat + 0/10 very thin asphalt concrete

The fiber-filled microsurfacing tack coat was on the entire section at a spread rate of 8 to 10 kg/m² depending on the appearance of the substrate.
The 0/10 very thin asphalt concrete was laid to a thickness of 2.5 to 3cm and excellent bonding between the layers was achieved.

- Strip No. 2: 6/10 – 0/6 fiber-filled composite road surfacing:

Table 1. Spread rates of the different components

	Product	Dosage
6/10 Fiber-filled surface dressing	69% modified emulsion	2 kg/m²
	6/10 P	9 kg/m²
Fiber-filled microsurfacing	60% modified emulsion	1.5 kg/m²
	Sand	13 kg/m²

- Strip No.3: 10/14 – 4/6 Double surface dressing: Fiber-filled surface dressing

The 1st layer of the double surface dressing was made with modified emulsion and fibers. The second consisted of NEOCOL®L emulsion with no fibers.
The spread rate was varied between 2.3kg/m² and 2.5kg/m2 depending on the traffic lane
The table below sets out the spread rates of the different components:

Table 2. Spread rates of the different components

	Product	Spread rate
SURFACE DRESSING	69% modified emulsion	1.1 to 1.3 kg/m²
	10/14 P	8 to 9 kg/m²
	4/6 P	7 kg/m²

2.3.3.3. Roughness measurement results (Mean Texture Depth - MTD)

MTD measurements were made on the inside lane three years after laying.

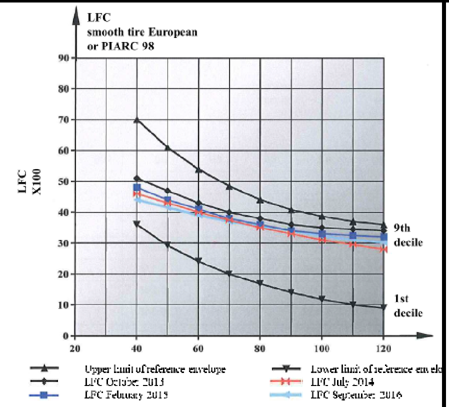
Table 3. Measured MTD after 3 months

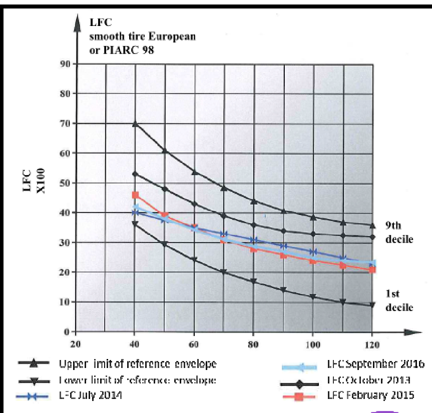
	Very Thin Asphalt Concrete	COLBIFIBRE	DOUBLE SURFACE DRESSING
MTD	Average MTD = 1.32mm Min. MTD = 1.15	Average MTD = 0.75 mm Min. MTD = 0.66 mm	Measurements stopped

The level of roughness obtained with the fiber-filled composite road surfacing meets the thresholds laid down in skidding resistance circular 2002-39 of 16 May 2002: for a 2x2 lane dual carriageway with a speed limit of 130 km/h, the min. MTD should be greater than 0.5 mm and the average MTD should be greater than 0.7 mm.
It was decided to cover the double surface dressing with a 0/6 fiber-filled microsurfacing, because the rolling noise was too high for the residents.

2.3.3.4. LFC measurement results

LFC measurements were made on the inner and outer lanes three years after laying. The figure below shows the measurements made on the Very Thin Asphalt Concrete and the fiber-filled composite road surfacing on the inner lane.





Inner lane		40 km/h	50 km/h	120 km/h
0/10 very thin asphalt concrete	On completion of works	0,51	0,36	0,34
	1-year follow-up	0,48	0,34	0,32
	3-year follow-up	**0,44**	**0,34**	**0,39**
Colbifibre	On completion of works	0,53	0,34	0,32
	1-year follow-up	0,46	0,26	0,21
	3-year follow-up	**0,42**	**0,27**	**0,23**
Outer lane				
0/10 very thin asphalt concrete	1-year follow-up	0,52	0,39	0,38
	3-year follow-up	0,46	0,37	0,33
Colbifibre	1-year follow-up	0,53	0,38	0,37
	3-year follow-up	**0,44**	**0,34**	**0,29**

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Figure 9: LFC measurements

Photo 20: LFC envelope / Measurements on the Very Thin Asphalt Concrete
Photo 21: LFC envelope / Measurements on the fiber-filled composite road surfacing
Photo22: Table summarizing the measurements

For the Very Thin Asphalt Concrete, on the inner lane, a reduction in the LFC at 40 km/h was observed between the values after 1 and 3 years, which did not apply in the case of the fiber-filled composite road surfacing, for which the values were fairly similar at all traffic speeds.
In the outer lane, the LFC measurements on the Very Thin Asphalt Concrete and the composite road surfacing were similar.

2.3.3.5. SCF measurement results

SFC made on the inner and outer lanes years after laying. The table below sets out the measurement results from the Very Thin Asphalt Concrete and the fiber-filled composite road surfacing on the inner and outer lanes.

Inner lane		CFT
0/10 very thin asphalt concrete	**On completion of works**	0,62
	1-year follow-up	0,67
	3-year follow-up	**0,61**
Colbifibre	**On completion of works**	0,63
	1-year follow-up	0,61
	3-year follow-up	**0,58**

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Outer lane		
0/10 very thin asphalt concrete	**1-year follow-up**	0,69
	3-year follow-up	0,64
Colbifibre	**1-year follow-up**	0,76
	3-year follow-up	**0,63**

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Figure 10: SFC measurements

Photo 23: SFC measurements on Very Thin Asphalt Concrete /fiber-filled composite road surfacing on the inner lane
Photo 24: SFC measurements on Very Thin Asphalt Concrete /fiber-filled composite road surfacing on the outer lane

In the case of the Very Thin Asphalt Concrete, on the inner lane, performance was satisfactory with a mean value of 0.61. The results for the outer lane were also good.

In the case of the fiber-filled composite road surfacing, on the inner lane, the measurements were varied because an asphalt joint had been added after the initial construction works. The mean value was good, and the values on the outer lane were considerably better.

2.3.3.6. Noise measurement results

Noise measurements were made at 90 km/h and 110 km/h on all the strips. The table below sets out the continuous and pass-by measurements (Fig 11)

Characteristics (Measurement point + type)	2013 (age 0 years)		2014 (age 1 year, outside strip 3)		2015 (age 2 years, outside strip 3)		2016 (age 3 years, outside strip 3)	
	Pass-by (90 km/h)	Continuous (110 km/h)	Pass-by (90 km/h)	Continuous (110 km/h)	Pass-by (90 km/h)	Continuous (110 km/h)	Pass-by (90 km/h)	Continuous (110 km/h)
PR12+100 to 12+400 BBTM type 1	76,8 dB(A)	101,8 dB(A)	75,8 dB(A)	99,7 dB(A)	76,5 dB(A)	101,4 dB(A)	77,3 dB(A)	102, dB(A)
PR12+400 to 12+740 Colbifibre	76,4 dB(A)	102,4 dB(A)	75,8 dB(A)	98,9 dB(A)	76,5 dB(A)	100,5 dB(A)	75,8 dB(A)	100,3 dB(A)

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Figure 11: Noise emission measurements

Photo 25: Continuous measurements on the Very Thin Asphalt Concrete and the fiber-filled composite road surfacing & Coast-by measurements on the Very Thin Asphalt Concrete and the fiber-filled composite road surfacing

For the 0/10 Very Thin Asphalt Concrete, both the pass-by and the continuous measurements (CPX) showed an increase in noise levels of about 0.5 dB(A) after 3 years.

For the fiber-filled composite road surfacing, both the pass-by and the continuous measurements (CPX) showed a decrease in noise levels of about 0.6 dB(A) for the pass-by measurements and 1.8 dB(A) for the continuous measurements.

The fiber-filled composite road surfacing had better acoustic performance than the Very Thin Asphalt Concrete after 3 years irrespective of the speed at which the measurement was made.

2.3.3.7. Surface state

The Road Eagle enabled us to monitor changes in the state of the surface in the course of three measurement campaigns. The first measure the initial state, the second the state two years after the works and the third the state five years after.

This technique allowed us to observe a low level of rutting on the pavement prior to works, but a large amount of cracking and crazing. Figure 12 shows the state of the pavement before and after data processing. The presence of disorderly cracks is clearly apparent.

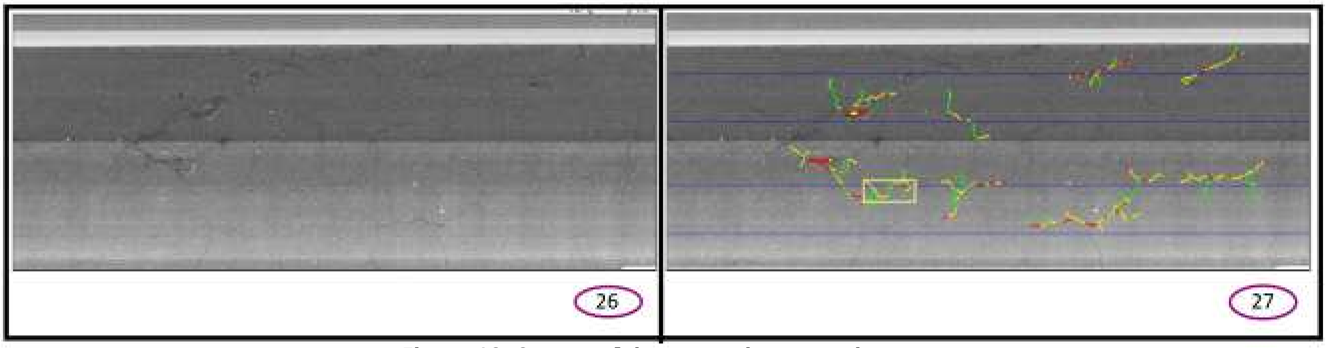

Figure 12: Survey of damage prior to works

Photo 26: Survey before computer processing
Photo 25: Survey after computer processing

The third measurement campaign that was performed after five years showed that the Very Thin Asphalt Concrete strip exhibited a reappearance of cracking which was neither longitudinal nor transverse and whose total length was between 0.3 and 5m.

On the fiber-filled composite surface strip, no cracking was apparent after five years showing its very good ability to limit reflection cracking.

3. CONCLUSIONS

The results of 6 years of follow-up to monitor the performance of a fiber-filled composite surfacing, known as COLBIFIBRE within the COLAS group, has taught us a great deal:

- the composite surfacing withstands heavy traffic well, whether in terms of skidding resistance, noise and ability to limit reflection cracking.
- when laid on a damaged low traffic road, its flexibility and impermeability limit further deterioration, and even in certain cases, by an indirect effect, improve the performance of flexible pavements.

This technique exhibits good durability over time, and its use can optimize the economic management of road assets.
To date the material has been used on more than 1.3 million m² of pavements in the Hauts-de- France region.

References:

RGRA N°926, road maintenance innovation, March-april 2015.

Information note from IDDRIM Number 35, January 2018.