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COLOMBIER, G., LARTAUT, M. and MACHET, J.-M., Laboratoire Central des Ponts et Chaussées, France

REFLECTIVE CRACKING: A NEW TEST FOR SAMI

RISSSCHUTZFOLIE: EINE NEUE PRÜFUNGSMETHODE

MEMBRANES ANTIFISSURES: UNE NOUVELLE METHODE D'ESSAI

After having recalled semi-rigid pavement structure and functions, the paper describes the origin of road-base cracking and the mechanisms of reflection cracking, qualities of an efficient interlayer, ability to delay reflection cracking and, at leat, to keep impervious the pavement, are then deduced. A textile used together with asphalt cement seems to be a good solution. For testing such a solution, a new device is developped by the Laboratoire Central des Ponts et Chaussées in France (Public works Research Laboratory). It is a shearing test - shearing in the plane of the interlayer -, carried out at successively two speeds and two températures. The test at low speed and temperature simulates the thermal shrinkage effects. In these conditions, interlayer has to be as deformable as possible. The test at high speed and medium temperature simulates traffic loading effects. Interface has them to be rigid as possible, for ensuring closery bound layers. These tests carried out on specially studied and manufactured textiles and with various bitumen qualities and contents lead to select the best solutions.

Après avoir rappelé la structure et le principe de fonctionnement d'une chaussée semi-rigide, on indique l'origine de la fissuration, le processus de remontée des fissures, et les qualités que devrait donc posséder une interface pour retarder significativement la remontée des fissures ou, du moins, maintenir l'étanchéité vis-à-vis du support après remontée des fissures. Pour tester ces solutions, un matériel d'essai a été récemment mis au point par le Laboratoire Central des Ponts et Chaussées. A vitesse lente et température basse, l'essai simule les efforts exercés sur l'interface par l'effet du retrait thermique. Dans ces conditions, l'interface doit être la plus déformable possible. A vitesse rapide et température moyenne, l'essai simule les réactions de l'interface au passage d'un véhicule. Son comportement doit être alors le plus rigide possible, pour assurer un bon report des contraintes entre les deux couches. Ces tests combinés appliqués à des géotextiles spécialement étudiés et pour différents paramètres du liant (qualités, dosages) permettent de sélectionner les solutions les mieux adaptées.

INTRODUCTION

Hydraulic binders (cement, slag, flying, ashes, etc) are widely used in road construction in France, for base course and subbase.

Mixes are given a high stiffness modulus, and moreover a low cost.

But, because of shrinkage, these materials crack. The deformation due to thermal shrinkage transmits cracks into the wearing course. Water and various pollutions can then go inside the pavement, producing damages.

At Las Vegas Meeting, COLOMBIER, ASTESAN and GOACOLOU, as others authors, have emphazised how interesting an interface made of a fabric together with asphalt cement could be. In situ experiments carried out in France were likely to prove it.

Since, a new laboratory test has been developped for improving the interface design (quality and quantity of binder), quality and thikness of fabric, etc).

I - REFLECTION CRACKING MECHANISM

The pavement is usually made of various layers as indicated fig. 1.

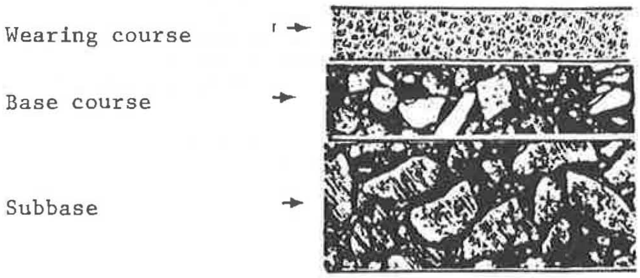

Figure 1 - Pavement cross-section

The base course is cracked because of contraction due to the setting shrinkage. Then tensile and compression strengths due to thermal variations produce a beginning of cracking at the botton of the bituminous concrete (wearing course), as indicated fig. 2.

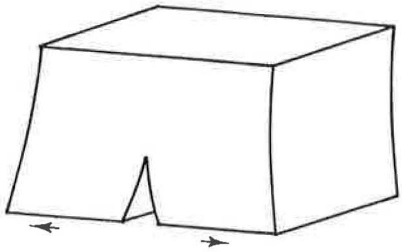

Figure 2 - Beginning of the crack

As a matter of fact, as soon as the cracking begins, stresses at the crack tip increase by concentration effect. Then overstresses due to traffic make the crack come up to the surface. fig. 3.

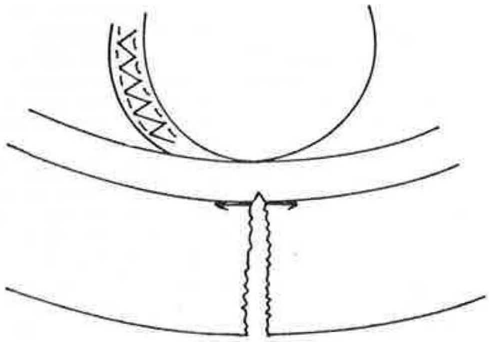

Figure 3 - Reflexion cracking process

Two solutions are available :

- First, to held up the crack beginning by deconnecting the wearing course and the lower part. Only weak stresses are then transmitted. However, this deconnection shouldn't be a detachment in the meaming of the pavement design. Otherwise, a fast fatigue will occur in the bituminous concrete.
- To held up the crack coming up by increasing the thickness of bituminous concrete.

The test described in this paper deals only with the first solution.

II - THE EXPERIMENT

Under traffic loads, an interface has to ensure a good connection between the layers, for increasing the pavement inertia. To ensure both a good connection in bending due to traffic loads, and a sort of separation in shearing due to shrinkage motions is the aim of the interface.

Traffic loads stresses vary fast, but those due to thermal shrinkage slowly. It's why it's taken advantage of visco-elastic properties of materials such as asphalt cement in the interface.

Description of the device

The interface shearing test is schematized. fig. 4.

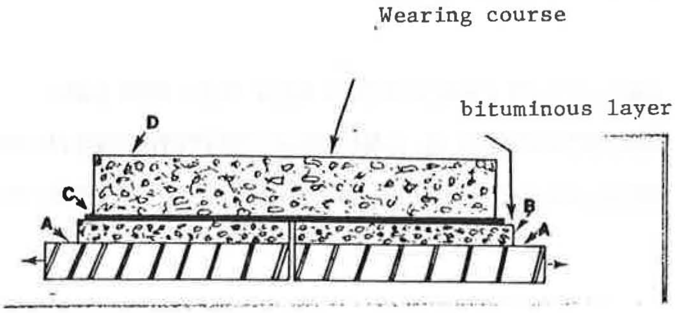

Figure 4 - Test cross-section

A poured material is set upon the two metallic plates (A), on this material (B), precracked, the interface (textile and asphalt) is spread. Above is the wearing course. The two metallic plates can be acted by a jack with a system of jaws. Opening and closing the gap (simulating a crack) make shearing deformations in the interface (C).

The whole device (fig. 5) is set in a temperature controlled cupboard, because of asphalt susceptibility to temperature.

The displacement speed of the jaws may be chosen in a range from 1 to 10.

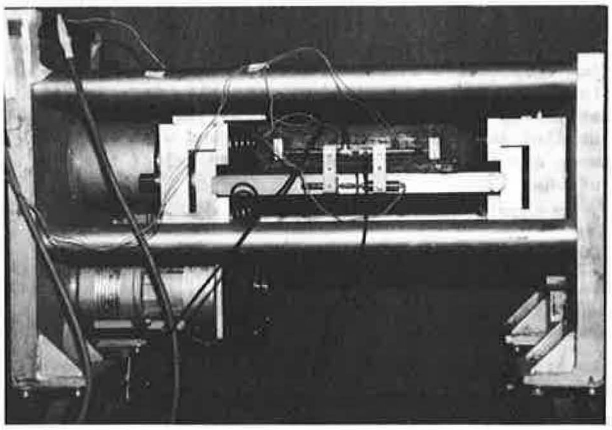

Figure 5 - View of the device

Tess process

Two tests have to be carried out :

1 - High speed and middle temperature test

The aim is to simulate fast sollicitations due to traffic loading. The temperature is about the same as the "equivalent temperature" used for bituminous layers design.

2 - Low speed and low temperature test

Daily variations due to thermal shrinkage is simulated here. The largest opening of cracks occurs in the deep winter. So, this test is carried out at a low temperature.

It is done as beneath :

a - The initial gap is opened upto 0.6 mm or 0.7 mm at a temperature of 20°C. The interface flows by shearing. So, when the force is loosen, the gap decreases just a little. The residual opening has to be at least of 0.5 mm (see fig. 6).

b - Then, at the same temperature of 20°C and a horizontal relative motion speed of 30 mm per hour, the gap is opened to 0.3 mm (tensile force). Afterwards, the motion is reversed in order to make cycles as described fig. 6.

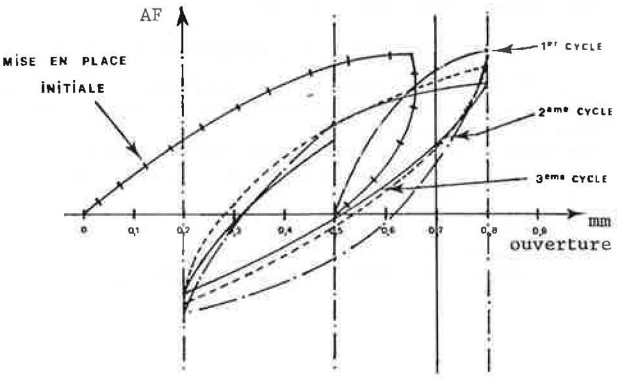

Figure 6 - Loading cycles

c - After a few cycles, the jack force is released. One decreases the temperature to 5°C, and kees it for a time long enough for obtaining a stable and homogeneous temperature in the material. Then, the same cycles as described above are made, but at a lower speed, of 3 mm per hour.

In each case, the force applied, the gap opening and the deformation of the upper layer are continuously measured.

The force amplitude is calculated by adding the two maximal forces (positive and négative), and the opening amplitude is the total opening of the gap (0.6 mm).

The ratio $\frac{\text{Force amplitude}}{\text{opening amplitude}}$ is called shearing pseudo - stiffness.

Utilization of results

For each test, we get a value of the shearing pseudo-stiffness at 5°C and 3 mm per hour (noted G5) and another one at 20°C and 30 mm par hour (G20).

The best interface will have a high value of G20 and a low value of G5 ; such a material ensures two layers well connected under traffic loading, but relatively disconnected for stresses due to thermal schrinkage.

So, it's not a failure test -failure tests results are broken up-, but a shearing deformability test.

III - CASE OF ASPHALT FILLED FABRICS

Behaviour of the interface

Visco-elastic properties of the asphalt cement have to be used. But the efficiency of these properties depends on the thickness of the interface ; a sufficient thickness is needed. But :

1 - To realise a thick film (a few mm) of pure asphalt cement is technically difficult.

2 - Such a film increases the flowing risk.

A fabric, working as a bolster, can get rid of these inconveniences. So, a textile has to work as a tank, vertically uncompressible.None of the fabrics we used coud work as a mechanical reinforcement, because of the low stiffness of any fabric.

A lot of in situ experiments using fabrics have been carried out in France for some years, sometimes successfully. But in some cases, a too fast fatigue of the wearing course has occured. An analysis of theses cases has proved that an anti-cracking interface has to be uncompressible, perpendicularly to the interface plane.

Experiments carried out and main results obtained

In the exemple given here, two fabrics A - B have been compared. The textile A is very anisotropic (low shearing stiffness in the plane, high compression modulus perpendicularly), and specially made as anti reflection-cracking interface. This fabric has a voids content lower than the classical fabric B (needle-punched) : a filling asphalt content is three times less. Then, the cost of this new solution is quite lower.

A common asphalt cement has been used, at various contents. For one content, a modified binder has been used (propylène/bitumen).

Résults are recorded table I and table II.

Bitumen content g/m^2	Test temperature °C	Strength amplitude daN	Opening amplitude mm	Shearing pseudo-stiffness G x 10^{-3} MNm-1
235	5	408	0,441	9,3
	20	111	0,518	2,15
337	5	467	0,423	11,2
	20	144	0,507	2,9
378	5	529	0,416	12,8
	20	161	0,510	3,2
637	5	518	0,416	12,6
	20	141	0,507	2,8

Table I - Fabric A

Bitumen content /m^2	Test temperature °C	Strength amplitude daN	Opening amplitude mm	Shearing pseudo-stiffness G x 10^{-3} MNm-1
816	5	480	0,468	10,3
	20	177	0.52	3,4
1430	5	353	0,462	7,7
	20	94	0,52	1,8
2040	5	440	0,472	9,2
	20	134	0,53	2,5
2650	5	350	0,490	7,1
	20	112	0,53	2,1

Table II - Fabric B

The coefficient of variation (ratio of standard deviation to average value) of force and displacement is about 10 %.

Binder contents depend on the filling capacity of each fabric.

The results of the experiment with the modified binders are recorded table III, and shearing pseudo-stiffness values fig. 7.

Fabric	Test temperature °C	Strength amplitude daN	Opening amplitude mm	Shearing pseudo-stiffness $G \times 10^{-3}$ MNm^{-1}
A	5	243	0,512	4,75
	20	136	0,526	2,60
B	5	98	0,542	1,80
	20	40	0,552	0,73

Table III - Modified binder

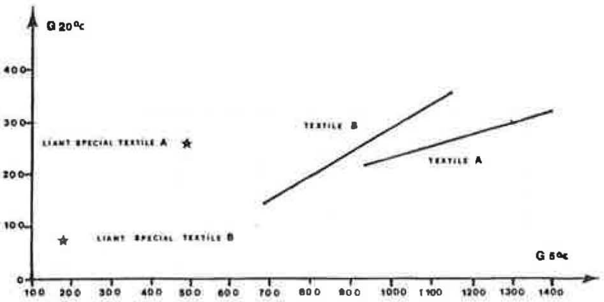

Figure 7 - Results

At 20°C, results are roughly equals, both for fabrics A and B with pure bitumen, and for fabric A with the modified binder. But in this last case, the shearing stiffness at 5°C is very good (very low). So it seems to be the best solution for reflection cracking.

Results obtained with the modified binder with the common fabric are deceiving. As a matter of fact, we can observe that the filling of this fabric by bitumen leads to high bitumen contents, and then excessive deformation under traffic loading.

CONCLUSION

This test allows to select among various fabrics, various bitumen content, and various binders. Before in situ experiments, it makes us able to classify designed solutions, and possibly to eliminate some of them.

This device is aimed to test solutions proposed both with fabric and with any kind of material ; with it, a new fabric could have been developed, specially designed as an interface for reflection cracking.

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