Contribution of Cellulose Fibers to the Performance of Porous Asphalts

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Observations on Belgian roads have not yet demonstrated any significant effect on polymer additives on the peformance of porous asphalts, also known as open-graded asphaltic concrete or open-graded friction course. Nevertheless, they have shown that there may be local problems with pure bitumen draining by gravity through the bituminous material during mixing, transport, and laying. This occasionally happens. SCREG Belgium has developed porous asphalt mixes containing pure bitumen and organic fibers. Numerous test carried out on its initiative, both in the laboratory and on roads, have confirmed the anti-draining action of cellulose fibers, which makes it possible to lay low-cost, high performance porous asphalt with an eventual higher bitumen content, while solving the occasional problem of binder drainage.

The use of porous asphalt mixes in Belgium and other Western countries has greatly increased the past few years, mainly because of the well-known advantages they present regarding skid resistance, aquaplaning, splash and spray, visibility, rolling noise, and resistance to permanent deformation (*1*).

Observations made on Belgian roads have shown the good performance of those mixes, even with pure bitumens. With the latter, it is possible, although they are less expensive than polymer-modified bitumens, to obtain pervious and high performance surfacings. However, it has been found (*2*) that local problems may occur with pure bitumen draining by gravity through the material during mixing, transport, and laying. As a result, aggregates are worn away by traffic on local spots where the bitumen content is too low.

To solve this problem and enable porous asphalt mixes to be laid with higher contents of bituminous mastic, SCREG Routes has been successfully using (*3,4*) a small amount of asbestos fibers in its porous asphalts. Because the use of these mineral fibers is prohibited by law in Belgium, SCREG Belgium has been investigating the possibility of working with cellulose fibers in its porous asphalt mixes. This investigation, intended to determine whether those fibers prevent bitumen drainage and make it possible to work with higher bituminous mastic contents, is the subject of this paper.

ORGANIC FIBERS USED

The organic fibers used are gray fibers with a cellulose content of at least 75 percent and a pH of 6 to 8.5. The maximum length of the fibers used is 1.2 mm, and their density is about 1.5 g/cm^3. The fibers generally have a temperature-resistance of more than 180°C during 1 hr.

This type of fiber has already been used in chip mastic asphalt in the Federal Republic of Germany (*5*), The Netherlands (*6*), and elsewhere, and in the thin surfacings (*7*) of SCREG Routes and SCREG Belgium.

The celluose fibers are wrapped in sealed polyethylene packs with a sufficiently low melting point, to be dissolved in the hot mixture. There are also precoated fibers containing 50 percent fibers and 50 percent hard (20/30 or 40/50 penetration) bitumen. They are specially intended for drier drum mixers.

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LABORATORY TESTS ON MIXES

Basket Drainage Tests

Seven porous asphalt mixes, with or without fibers (Table 1), were subjected to a basket drainage test. The operational procedure was as follows:

1. The mixes were manufactured and compacted in great Duriez molds (*8*) under a pressure of 30 bars,
2. These molds were laid on a grid and the set was then placed in an oven at 180°C for 7½ hr; these severe conditions were choosen to simulate occasional cases when the bitumen is draining through the aggregates, and
3. The bitumen drained through the mix to the grid was recovered and the loss of bitumen was calculated with respect to the initial binder content.

The bitumen used for these tests was an 80/100 pen bitumen doped with 3 ‰ of adhesion agent.

The amounts of bitumen drainage obtained, as percentages, are given in Table 1 and represented in Figure 1. From these results, it can be concluded that:

- Porous asphalt without fibers lost 13.5 percent of its binder during the test, even at low binder content (4.7 percent),
- In the mixes composed with fibers, the latter play an important role as an anti-draining agent. Indeed, compared with the mixes without fibers, little bitumen is lost (maximum 4 percent), even at binder contents higher than 5.5 percent. It is thus possible to use a great deal of binder if organic fibers are added, and
- There is very little difference in drainage behavior between the porous asphalts with 0.3 and 0.5 percent of fibers. Consequently, it does not seem necessary to use more than 0.3 percent.

TABLE 1 BASKET DRAINAGE TESTS

Mix	A	B	C	D	E	F	G
Composition (%)							
Diorite 10/14	55.5	55.5	55.5	55.5	55.5	55.5	55.5
Diorite 6/10	30	30	30	30	30	30	30
Sand 0/2	13	12	12	12	12	12	12
Filler	1.5	2.2	2.2	2.2	2.0	2.0	2.0
Organic fibres	0	0.3	0.3	0.3	0.5	0.5	0.5
Bitumen 80/100	4.7	5.5	5.7	5.9	5.5	5.7	5.9
Loss of bitumen (%)	13.5	1.5	2.9	3.4	0.3	1.3	1.2

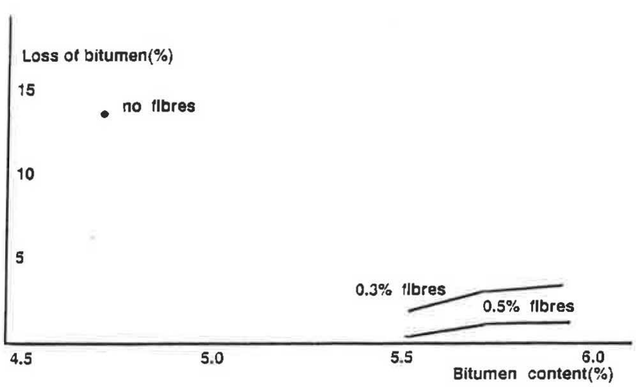

FIGURE 1 Influence of the bitumen and the fibers content on the loss of bitumen by the basket drainage tests.

Schellenberger Drainage Tests

Drainage tests done according to the Schellenberger method (*9*) were conducted on porous asphalts the composition of which is given in Table 2.

In short, 1,000- to 1,100-g samples of asphalt were put in 800 ml glass receivers and then placed in an oven at 170°C for 60 min. Here, too, the amount of binder drainage was determined with respect to the initial amount of bitumen during mixing. The bitumens used for these tests were not doped. The conclusions from the results of these tests (Table 2) are similar to those from the basket drainage tests: the mixes without fibers lost 15 to 21 percent of their binder and the fibers are effective in preventing bitumen drainage (Figures 2 and 3). Again, no significant difference was found between the results according to the amount of fibers (0.3 or 0.5 percent), so that the lowest of these contents should be sufficient.

Moreover, the loss of binder from the porous asphalts with fibers was found to be smaller than in the basket tests; on the other hand, it was slightly greater for the mixes without fibers. In making this comparison, one should nevertheless consider the difference between the bitumens used.

Finally, the cellulose fibers used all gave similar results.

Voids Content and Cantabrian Abrasion Test

For the mix design of porous asphalts, the Belgian Road Research Centre has suggested a procedure which consists of determining the voids ratio on Marshall samples and then performing the Cantabrian abrasion test on those samples, to determine the percentage of wear of the material after 300 revolutions in a Los Angeles cylinder without abrasive charge (*1,2*).

These tests, carried out on 4 porous asphalt mixes with or without fibers (Table 3) produced the following findings:

- A slight reduction (1 percent) of the voids in the porous asphalt without fibers with the 1 percent increase in bitumen content,

TABLE 2 SCHELLENBERGER DRAINAGE TESTS

MIX	A	B	C	D	E	F	G	H	I	J	K	L
Composition (%)												
Durite 10/14	55.5	55.5	55.5	55.5	55.5	55.5	55.5	55.5	55.5	55.5	55.5	55.5
Durite 6/10	30	30	30	30	30	30	30	30	30	30	30	30
Sand 0/2	12	12	12	12	12	12	12	12	12	12	12	12
Filler	2.5	2.5	2.5	2.5	2.2	2.2	2.2	2.0	2.2	2.2	2.5	2.2
Fibres a	0	0	0	0	0.3	0.3	0	0	0	0	0	0.3
Fibres b	0	0	0	0	0	0	0.3	0.5	0	0	0	0
Fibres c	0	0	0	0	0	0	0	0	0.3	0	0	0
Fibres d	0	0	0	0	0	0	0	0	0	0.3	0	0
Bitumen 60/70	4.5	4.7	4.9	4.9	5.9	6.1	5.9	5.9	5.9	5.9	0	0
Bitumen 80/100	0	0	0	0	0	0	0	0	0	0	4.7	5.9
Loss of bitumen (%)	15	16	21	17	0.1	1.1	1.1	0.3	0.6	1.1	18	0.5

FIGURE 2 View of the glass receivers after the Schellenberger drainage test. (Porous asphalt with 4.7 percent bitumen and without fibers.)

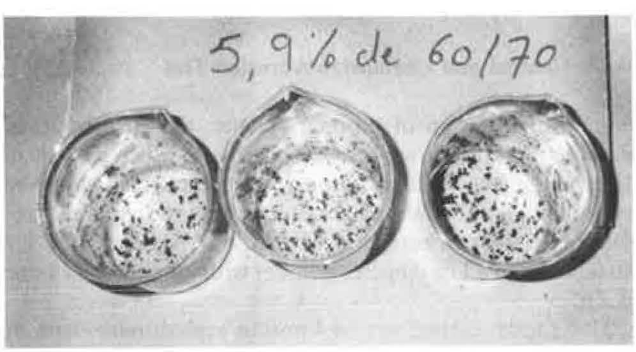

FIGURE 3 View of the glass receivers after the Schellenberger drainage test. (Porous asphalt with 5.9 percent bitumen and 0.3 percent fibers.)

TABLE 3 VOIDS CONTENT AND CANTABRIAN ABRASION TEST

Mix	A	B	C	D
Composition (%)				
Porphyry 7/14	85	85	85	85
Sand 0/2	12	12	12	12
Filler	3.0	2.7	2.5	3.0
Fibres	0	0.3	0.5	0
Bitumen 80/100	4.5	5.5	5.5	5.5
Voids (%)	22.5	20.3	21.3	21.1
Wear of material (%)	15.9	16.6	18.0	20.0

- No significant difference in voids content between the porous asphalts with 5.5 percent of 80/100 pen bitumen, according to whether they contained fibers, and
- A very good resistance of all the porous asphalt mixes—with or without fibers—to attrition, whatever their binder content. There is little difference between the mixes tested, but the wear of their material is well below the maximum value of 30 percent which is generally suggested.

One of the conclusions to be made from all those tests is that the voids of porous asphalts with 5.5 percent of pure bitumen and with the addition of 0.3 or 0.5 percent of fibers is equivalent to those of "conventional" porous asphalts with about 4.5 percent of pure bitumen and without fibers; the addition of fibers allows an increase of the bitumen content and the durability, and avoids problems with binder drainage through the material. Working with binder content higher than 5.5 percent is not considered because observations and experiments on roads in Belgium have shown that 0/14 mixes that meet the Belgian grading standards, but contain more than 5.5 percent of binder with polymer additives, present less drainability and generate more rolling noise (*1*,*2*).

FULL SCALE TESTS ON ROADS

In April 1988, three porous asphalt mixes with cellulose fibers (Table 4) were laid on the N 56 Ath–Ostriches state road in Ath, Belgium (Figure 4), with a thickness of 4 cm. This road experiment is being monitored by the Belgian Ministry of Public Works. Using a falling head permeameter (*10*), drainability tests were carried out after two weeks and six months of rather dusty traffic. Although such traffic often causes local spot clogging of porous surfacings, the Belgian Ministry of Public Works found the drainability to be excellent: the drainage time is always less than the maximum average figure of 60 sec, which is stipulated after laying. It should be noted that, even with 6 percent of binder, no bitumen drainage has been observed.

In 1989, new applications were made in Belgium, more particularly at Kuurne (Figure 5) and in the center of the town of Ath.

All the coating plants of SCREG Belgium are equipped to work with fibers. The sealed polyethylene packs are poured into the mixer while the aggregates are being introduced. Dry mixing of the combination of aggregates (stone and sand) and fibers takes place before the bitumen and the filler are added. In the patented double mixing procedure used, for example, in the experiment at Ath, the fibers are added to the sand

TABLE 4 POROUS ASPHALTS ON N 56 AT ATH

Mix	A	B	C
Composition (%)			
Porphyry 7/14	85	85	85
Sand 0/2	11	11	11
Filler	3.85	3.7	3.5
Fibers	0.15	0.3	0.5
Bitumen 80/100	5.0	5.5	6.0
Drainage time (sec)			
- after 2 weeks	15	12	15
- after 6 months	32	14	16

FIGURE 4 Porous asphalt sections on N 56 Ath–Ostriches at Ath.

FIGURE 5 Porous asphalt sections on city streets at Kuurne.

before the bitumen and the filler are introduced; after this bituminous mortar has been mixed, the stones are added and thus coated with homogenous mortar.

COMPARISON OF COSTS

Belgian studies (*11*) have shown that, at equal binder content, the use of modified binders in porous asphalt surfacings entails an extra cost of about 40 percent as compared with pure bitumen. With respect to porous asphalts containing 4.5 percent of pure bitumen and no fibers, the extra cost of products with 5.5 percent of pure bitumen and 0.3 percent of cellulose fibers is about 10 percent. This means that these products not only perform well, but are also relatively cheap.

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REFERENCES

1. Y. Decoene. Knowledge Acquired After 10 Years of Research on Porous Asphalt in Belgium. Presented at 4th Eurobitime Symposium, Madrid, Oct. 1989.
2. *Les enrobés drainants: Demi-journée d'études*. Belgian Road Research Centre, Brussels, Oct. 1988.
3. J. P. Serfass and J. Samanos. Hot mix Asphalt with Fibers; Their Contribution to Comfort and Safety. Presented at Roads and Traffic 2000, International Road and Traffic Conference, Berlin, Sept. 1988.
4. A. Bauduin, B. Chambon, B. Darrieumerlou, B. Durand, H. Tessonneau, and B. Thirriot. Trois grands chantiers d'enrobés drainants Drainoflex. *Revue Générale des Routes at Aérodromes*, No. 664, June 1989.
5. Der Bundesminister für Verkehr, Abteilung Strassenbau. *Zusätzliche Technische Vorschriften und Richtlinien für den Bau bituminöser Fahrbahndecken*. ZTVbit-StB84, Bonn, 1984.
6. G. J. V. Jansen and J. H. G. Rietmulder. Steenmastiekasfalt in Drenthe. *Asfalt*, No. 1, March 1989.
7. J. P. Serfass, P. Chazal and H. Tessonneau. Enrobés à chaud avec fibres; le revêtement très mince Mediflex. *Revue Générale des Routes et Aérodromes*, No. 631, June 1986.
8. M. Duriez and J. Arrambide. *Nouveau traité de matériaux de construction*. Paris, 1962.
9. K. Schellenberger and W. von der Weppen. Verfahren zur Bestimmung der Homogenitäts–Stabilität von Splittmastixasphalt. *Bitumen*, No. 1, Jan. 1986.
10. Administration des Routes. *Enrobés drainants*. Circulaire A-169—86/04000, Belgian Ministry of Public Works, Brussels, April 1986.
11. Association Royale Permanente des Congrès Belges de la Route. *Revêtements bitumineux: nouvelles techniques*. Question I.A.2. Presented at XVIe Congrès Belges de la Route, Mons, May 1985.