THE PROBLEM OF RUTTING IN ASPHALTIC PAVEMENT IN BELGIUM : HOW TO RESOLVE THIS PROBLEM WITH STEEL AND SYNTHETIC FIBERS ?

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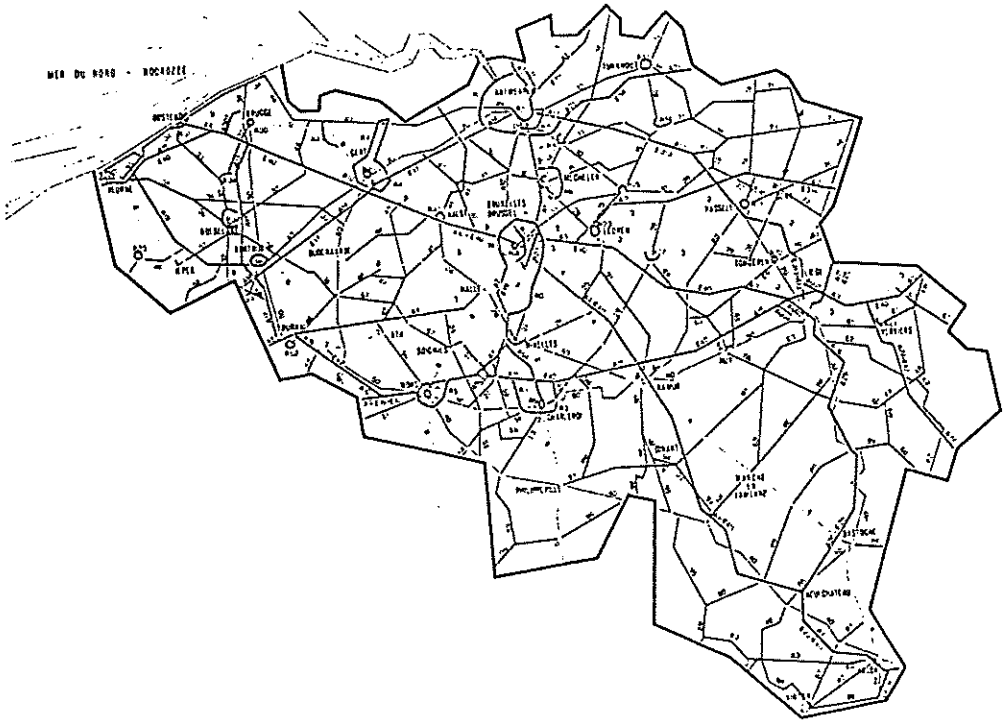
ABSTRACT

The problem of rutting is increasing very hardly because of the amount of trucks and vehicles using the Belgian road network.
The steel and synthetic fibers are presented as a solution to decrease rutting, taking into account their constitutive material, shape, length and percentage : some tests have been realized to analyze the problems of homogeneisation and mixing.
The wheel-tracking simulation test has also been developed to compare the behaviour of different bituminous concrete modified with fibers : the tests conditions were choosen to accelerate the rutting phenomenon and the results permitted to select some types of fibers, some percentages and some constitutive materials.
In-site applications have been realized and showed a decreasing of 50 to 60 % for the rutting of bituminous concrete modified with steel or synthetic fibers.

1. INTRODUCTION

The Belgian network is one of the more dense in the world : 4,91 km/km², in any case, it is very clear on a map.



But now, the administrations are more and more confronted to the repairing of the removing of the roads, essentially the overlay. The requirements of the users are increasing : safer roads, more visibility, mechanical or noise comfort.
It is so necessary to act with precision, rigour and discernment.

2. THE PROBLEM OF RUTTING

2.1. Definition

The rutting is a permanent deformation parallel to the axis of the road; its length is equal to 4 times its width. This deformation can be more than 10 mm deep.
This rutting reduces the users safety when the crack is 15 to 17 mm deep and the road must be repaired or removed when it is 25 mm deep.

2.2. Causes

We have to distinguish internal and external factors.
The external factors means the traffic (overloads, slow speed of circulation, tangential effects) and climatic effects (variation of temperature, variation of water content,...).
The table hereafter permits to estimate the importance of these external factors : this study was realized in 13 different countries.

	D	B	CDN	E	F	IRL	I	J	NL	GB	CH	TR	USA
	○	●	○	●	●	○	●	●	●	○	○	●	○
	○	●	●	●	●	○	●	●	●	●	○	●	○
 (1)	10	13	9	13	13	10	10	10	10	9	10	8	10
°C max	50	50	49	60	55	45	60	60	54	45	55	55	60

Importance : ● grande ○ faible

It concerns :
- the importance of rutting;
- the importance of overloads;
- the maximum authorized weight by axle;
- the maximum temperature of the overlay.

It appears clearly that the most important factors having an effect on rutting are so classified :
1) overloads;
2) maximum weight by axle;
3) temperature.

The degradations of the transversal profile of a road with bituminous concrete can be also produced by irreversible deformations of some layers of the road structure.

For a circulation and climatic environmental conditions, thè resistance to rutting of a road with bituminous concrete is a function of :

- the geometry of the structure (so it is important to take into account the permanent deformation);
- the mechanical properties of the materials.

The mechanical behaviour of these materials is essentially characterized by :

- the deformation modulus (or rigidity modulus);
- the fatigue resistance;
- the resistance to permanent deformations in dynamic compression.

3. EXPERIMENTAL APPROACH

The realization of a bituminous concrete able to resist to rutting needs a binder of high consistency and low thermal susceptibility, a volumic rates between aggregates and binder relatively high and an adapted percentage of voids.

The use of fibers could permit to attempt this way and it is the reason why a lot of types of fibers have been selected. The parameters were :

- the constitutive material;
- the physical and mechanical characteristics;
- the shape and the length;
- the percentage.

Different tests were carried out to select and perform the use of these fibers :

- Marshall test :
  the use of fibers permits an increasing of the Marshall stability and a light decreasing of the Marshall flow;

- Pull-out test :
  the shape of the fiber is very important (for steel, fibers with hooks and gulf; for synthetic fibers, kidney shape);

- Wettability :
  to obtain a good substrate wettability, it is necessary that the surface energy of the substrate is greater than the liquid one. The surface energy of the bitumen is ± 25 mJ/m^2 and for the synthetic fibers we have :
  . Polyprop : ± 32 mJ/m^2
  . Polyamid : ± 41 mJ/m^2
  . Polyacrylonitril : ± 40 mJ/m^2.

But the most important was the realization of a traffic-wheel simulation test.

4. SIMULATION OF TRAFFIC TEST

The most important test to be realized was the rutting test by simulation of traffic. Indeed it was essential to study directly the influence of the fiber on the apparition of rutting into a bituminous concrete.
The results of the tests described hereabove allowed to select a certain number of fibers : it was now necessary to point out some parameters like :

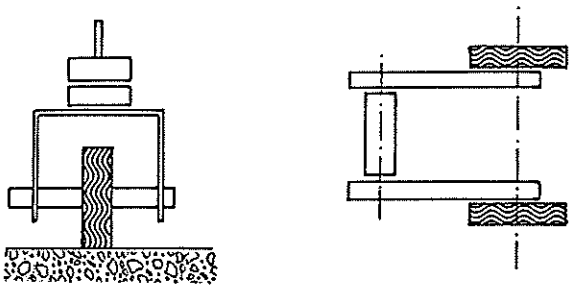
- the constitutive material of the fiber;
- the fiber shape;
- the fiber diameter;
- the fiber length;
- the percentage of fibers.

4.1. Principle of the test

The aim of the test is to estimate, for certain experimental conditions, the susceptibility to rutting of a compacted bituminous concrete and to evaluate the effect of the fibers on this phenomenon. The surface of the samples is loaded by means of two loaded wheels.

4.2. Description and characteristics of the test

A sample of 63 cm diameter and 5 cm thick is laied down in a fixed mould on the rotative part of a traffic simulation testing machine. Two wheels are rotating in a fixed vertical plane, around an horizontal axle.



These wheels are loaded with series of 20 kg weights.

Characteristics :

- maximum circumferencial speed : 1 m/s
- load applied on each wheel : 40 kgf
- type of wheel : VREDESTEIN 260 x 85 - 4 P/R
- air pressure of the wheels : 6 bars (this corresponds to a load of 35 to 40 kg/cm² on the bituminous concrete)
- temperature of the test : 40°C.

4.3. Tests procedure

A recorder allows to determine the number of rotations and the measurement of the rutting is realized on two perpendicular diameters (4 measurements) by means of a dial gauge.

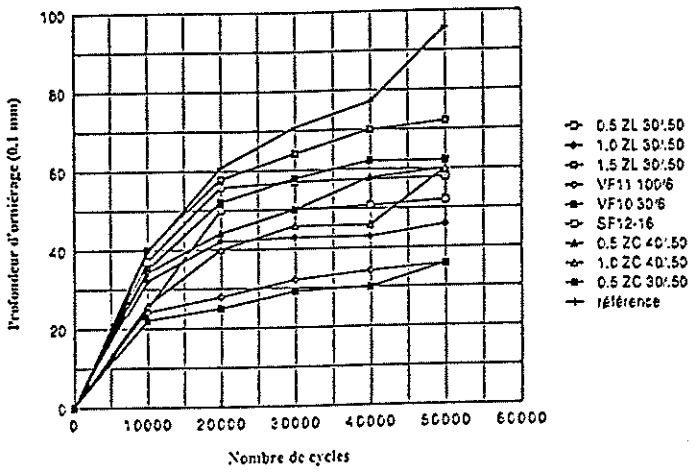
4.4. Tests results

The general table presents hereafter the results for different types fiber and percentages.

Maximum depth of deep cracking (mm)					
Sample	Commercial mark	%	Type	Results	% voids
1	DRAMIX ZL 30/.50	0,5	A	5,8	6,9
2	idem	1	A	4,6	6,4
3	idem	1,5	A	7,2	7,5
4	Reference	-	-	9,6	5,2
5	HOECHST 11 100/6	0,3	AN	3,6	5,3
6	HAREX SF 12-16	1,5	A	5,2	5,3
7	HOECHST 10 30/6	0,3	AN	3,6	5,4
8	DRAMIX ZC 40/.50	0,5	A	6,0	6,5
9	idem	1	A	6,0	6,0
10	idem	1,5	A	6,2	5,3
11	DRAMIX ZC 30/.50	0,5	A	6,2	5,3
12	idem	1	A	4,6	4,5
13	idem	1,5	A	5,4	4,3
14	DACRON D 157-10 mm	0,3	PES	3,8	11,5
15	DRAMIX 30/.50 golf 1,2 mm	0,5	A	4,6	7,3
16	idem	1	A	7,2	10,6
17	idem	1,5	A	6,0	4,2
18	idem, golf 1 mm	0,5	A	4	4,5
19	idem	1	A	3,8	7,0
20	idem	1,5	A	4,8	6,4
21	bicouche 1 % DRAMIX + 0,3 % HOECHST			4,4	7,2
22	bicouche 0,5 % DRAMIX + 0,3 % HOECHST			3,8	8,5

A = steel AN = acrylo-nitryl PES = polyester

It is also possible to present the results in the form of graphics where the values of the rutting measurements are presented versus the number of cycles of loading.
These graphics are established in order to compare the results obtained with different types of fibers and different percentages in relation with a reference sample.



5. CONCLUSIONS

The results given by the theoretical and the experimental approachs permitted to define an interesting solution in order to avoid bituminous concrete rutting along the roads : the incorporation of short steel or synthetic fibers to the mixture.

For steel fibers
The optimum parameters for a Belgian type I bituminous concrete were :

Fiber length (L)	: 1 or 2 times the maximum dimension of the aggregate.
Fiber percentage	: 0,4 to 1,5 % in weight
Ratio fiber length/fiber diameter	: 40 < L/D < 100
Fiber shape	: generalized waves with specific anchorage
Surfacic treatment	: against corrosion.

For synthetic fibers
The optimum parameters for a Belgian type I bituminous concrete were :

Fiber length	: 0,5 to 1 times the maximum dimension of the aggregate
Fiber percentage	: 0,1 to 0,7 % in weight
Fiber shape	: kidney
Fiber raw material	: must resist to temperatures greater than 190°C without any deterioration.

The advantages of these solutions are very clear :

1. increase of the road structure service life (minimum two times);
2. reduction of the repair costs;
3. no recycling problems;
4. possibility of reduction of the road structure thickness (because of increasing of the rigidity modulus);
5. almost no adaptation of the fabrication technics or laying down machineries.

Finally, the solution adopted by the LEGROS S.A., public works society in Anthisnes (Belgium), with the aim to avoid psychological problems due to the possible presence of corroded fibers at the overlay surface, was to use steel fibers in the underlays and synthetic fibers for the overlay.
This system is protected by an international patent.

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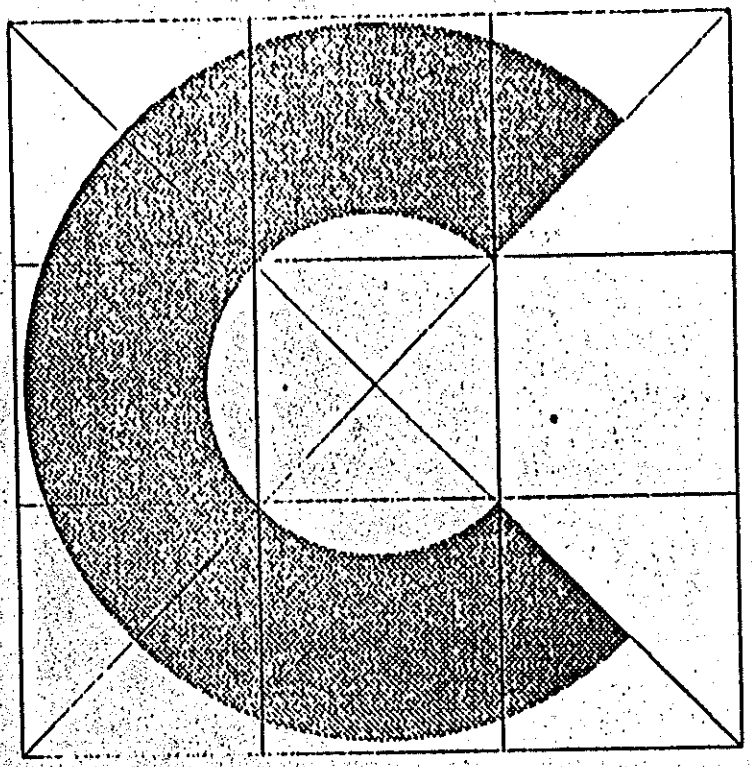

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