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THE DEVELOPMENT OF A GEOTEXTILE SYSTEM TO RETARD PAVEMENT CRACKING

ENTWICKLUNG EINES GEOTEXTIL-SYSTEMS ZUR VERZÖGERUNG VON RISSBILDUNGEN IM STRASSENBELAG

DEVELOPPEMENT D'UN SYSTEME GEOTEXTILE POUR RETARDER LA FISSURATION DES CHAUSSEES

The use of geotextile to combat the rise of cracks in pavements is an old-established idea. Numerous solutions have been proposed, and the results obtained do not seem, a priori, to have convinced European specialists. We therefore analysed various types of cracking in order to understand the mechanisms involved. Following this examination, we concluded that fatigue cracking was unavoidable and could be remedied only by renovating the pavement structure. In this case of shrinkage cracks of thermal origin, a textile-bitumen system makes it possible to delay the initiation of cracking in the bituminous concrete course and hence to retard its appearance on the surface. Test methods were specially developed to demonstrate the reliability of this system.
The textile-bitumen system is patented.

1 - INTRODUCTION

The earliest utilization of textiles in the upper structures of pavements dates back to the 1930's, when cotton fabrics were used in the Southern United States to stregthen asphaltic courses. Employing the same approach a European producer of man-made textiles developed a polyester grid possessing impressive characteristics to increase the tensile strength of bituminous concrete surface courses. In both cases, the results did not come up to expectations. Despite these setbacks, for which there was a logical explanation, certain manufacturers persevered along these lines.

Another approach, again with the basic idea of strengthening bituminous concrete courses to prevent cracking, was developped in the U.S.A about 1970. The use of needled polypropylene nonwoven fabrics in combination with various forms of bituminous binders (emulsions, cutbacks etc...) laid underneath the bituminous course seemed to give encouraging results. It may be noted that the use of nonwoven polypropylene fabrics requires the application of bituminous binders at a temperature below 150°C. With hindsight, and despite numerous publications -often of commercial origin - it is not easy to make an accurate assessment of such a procedure to combat rising cracks. But it appears that in the American highway context (axle load, level of service, use of soft bitumen) this system provides a solution to the problem of cracking only in the Southern States, where temperature variations are slight.

In 1973 it was observed on an experimental section in Belgium that a needled polyester nonwoven laid on a cracked concrete pavement (shrinkage cracking + fatigue cracking) and covered with a layer of 5 cms of bituminous concrete significantly delayed the rise of cracks by comparison with reference sections. Core sampling showed that the interface formed by the geotextile presented a poorly impregnated fibrous zone which had most certainly loosened the courses and hence stopped the rise of the crack towards the surface. Though the results were encouraging, it was risky to incorporate in a pavement structure a zone in which adhesion was limited (the mix being liable to detachment) and in which the compression of the fibrous part of the nonwoven fabric could cause excessive flexion of the wearing course, thereby prematurely fatiguing the bituminous concrete and generating fatigue cracks.

After this initial experiment we constructed many other experimental sections both on roads and on airport runways, using the same geotextile in various grades. After a thorough examination of the observations recorded, we were convinced that a textile interface produced positive results in certain cases. But the results were not sufficient for such a system to be proposed on the European market, whose technical requirements are so strict.

2 - THE CRACKING OF PAVEMENTS

The principal, if not the only, field of application of geotextiles is that of soil mechanics and geotechnics. Thus we have to pinpoint the problem of cracking in order that our approach may be clearly understood.

2.1. Statement of the problem

We shall distinguish between two types of cracking, which differ markedly in their origin and configuration.

2.11. Cracks due to the accumulation of normal or abnormal stresses, which we shall call "fatigue cracks". These cracks are generally longitudinal, and lie near the wheel-tracks of heavy vehicles. Sōme of them are transverse, near to and in combination with the longitudinal ones, cutting up the surface into a multitude of slabs and giving it the appearance of a crocodile skin when the pavement is very fatigued.

To limit this cracking, it suffices for the pavement to be correctly structurally designed ; that is to say for each course (foundation, base, wearing) to be thick enough to function in the elastic field. Note that any structure subjected to mechanical stress will weaken in the long term, and when it does so symptoms of fatigue will occur.

2.12. Cracks due to thermal shrinkage are linked with the physical characteristics of concrete and aggregates incorporating hydraulic binders (cement, slag, lime, fly-ash, etc...) ; such materials are frequently used in France as base courses for roads carrying heavy traffic. These cracks usually occur regularly and transversely in relation to the centre-line of the pavement. Though these shrinkage phenomena are well know and occur unavoidably, this technique of road-building, despite this drawback, is widely employed in Europe, and especially in France by reason of a favourable relationship between technical and economic factors;

2.2. The effect of cracking on the functioning of pavements

Even though in the initial stage cracking is very fine and appears in the form of micro-cracks, the latter destroy the continuity of the slab. We then have a succession of slabs and when traffic loads are transferred deflexions at the point of cracking are increased if the structure is under-designed.

If the crack rises to the surface after passing though the bituminous concrete wearing course (BC), considerable damage to the structure may occur as a result of penetration of water into the base courses (erosion, pumping, flexion of slabs, etc...). There may also be deterioration of the BC, chipping of the edges of the cracks, ramification, and detachment of the BC.

Faced with these harmful effects of cracking, either under or on the surface, have we any means of remedying such processes of deterioration ?

2.3. Remedies and treatment for rising cracks in BC courses

As already mentioned, cracking of thermal origin is unavoidable. To counteract the risks it involves, we must:

- Either prevent the appearance of cracks on the surface by acting upon the properties and characteristics of BC courses and tackling the problems of adhesion of the cracked or crackable underlay.

- Or allow cracks to appear on the surface and carry out appropriate maintenance of the wearing course.

2.31. Curative treatment

This consists of making the crack impervious by sealing and/or bridging with bituminous compounds (modified or not), or even resin. Depending on the level of service of the pavement, it is always possible to improve this treatment by means of a thick or thin surface dressing, or even a thin bituminous mat.

2.32. Preventive treatment

This approach is more elegant than the foregoing one, and deserves a more thorough consideration, because as pointed out in par. 2.11/ all pavements age, so it suffices for preventive treatment to be effective during the interval between two successive renovations of the pavement.

23.21 Reinforcement of the BC

As mentioned in the introduction, this idea which dates back a considerable time has been the subject of experiments, and it has been shown that textiles do not act as a reinforcement. It is mechanically inconceivable that materials with a modulus of elasticity of around 5 GPa can reinforce BC's with a modulus of 40 GPa. In the present state of our knowledge of textile materials, we consider that this line of approach must be abandoned.

23.22. Retarding the rate of rise of cracking

We allow cracking to reach the lower part of the BC and do our best to slow down its advance so as to delay its appearance on the surface.

The efficacity of this treatment depends on a substantial increase in the thickness of the BC despite the economic consequences, because we know that the time cracking takes to rise depends on the distance it has to traverse. Note that for a given thickness, a BC course is much more effective if it is laid in a single operation.

23.23. Retarding the commencement of cracking at the base of the BC course

Unlike the foregoing treatment, here we try to prevent the cracking of the base course from initiating cracking of the BC course for as long as possible.
Several operational scenarios may be envisaged :

- Deviating the path of the cracks, directing it into a horizontal plane at the interface between the courses.

- Blocking the crack at the level of the interface and preventing its vertical advance, using a suitable material possessing viscoelastic properties.

Tests on experimental sections show that the interface seems to be the best point to apply a treatment to prevent the commencement of cracking. Traditional geotextiles, membranes incorporating polymer-blended bitumen or rubber-blended bitumen, (thickness = 3 to 6 mm) appear to produce positive results but too often give rise to secondary effects (fatigue, delactment) which require the system to be redesigned.

3. "ANTICRACKING" GEOTEXTILE INTERFACE

This system invloves two main constituents a matrix (geotextile) and a binder (bitumen). It must play a preventive rather than a curative role, and must necessarily meet functional, operational and economic requirements.

3.1 Requirements

3.11. Functional

The system must ;

31.12. Delay the initiation of cracking by deviating the advance of the crack horizontally, through limited localized loosening.

31.13. Create a thin viscoelastic interface allowing of slow relative displacements between the courses caused by temperature variations.

31.14. Adhere to the two adjacent courses to ensure perfect transmission of stresses under the effect of variations of loads due to heavy traffic.

31.15. Store and hold a sufficient quality of bituminous binders to take advantage of its viscoelastic behaviour.

31.16. Withstand settlements and not cause flexion in the BC course so as not to fatigue the latter.

31.17. Despite deformations, preserve a continuity ensuring the imperviousness of the structure.

31.18. Be comparatively insensitive to tempature variations, in order that full advantage may be taken of the viscoelastic properties of the binder.

3.12. Operational

The system must :

31.21. Be sufficiently flexible in its plane to limit the formation of creases and allow of the the unrolling of the textile even on very sharp bends.

31.22. Withstand high temperatures above 170°C, the temperature at which BC courses are commonly laid.

31.23. Withstand attacks by solvents which may be present in the bituminous compounds;

31.24. Be able to restrain the migration of the bitumen course so as to avoid problems of trafficability during the laying of the BC course.

3.13. Economic

31.31. The matrix, and consequently the geotextile, must be of low overall cost, and hence have a low mass per unit surface. In addition, it must be compact so as not to give rise to high transport costs. This compactness is also an asset because it means a minimal consumption of bituminous binders.

31.32. The binder must be of bituminous origin, thereby possessing valuable viscoelastic properties at perfectly admissible cost for highway engineering purposes.

All the above requirements can be summed up in one sentence :

Under rapid traffic stresses, the system must have a rigid behaviour, while under slow stresses (temperature variations) it must have a plastic behaviour.

3.2. The system

There are two components ;

- A polyester nonwoven geotextile matrix whose characteristics and properties are specific to this application.

- A binder whose properties are chosen in function of the functional requirements of the system.

This combination of textile matrix + binder was the subject of various applications for patents.

3.3. The results

To establish and evaluate the advantage of such a system, it was necessary either to construct experimental sections, involving numerous drawbacks such as time and cost, or to develop tests making it possible to establish a comparative rating of the efficacity of such procedures.

The latter approach, involving laboratory experiments, was adopted and was the subject of a publication in which the phenomenon of cission (i.e. plane shearing) which appears to be one of the major factors in the functioning of the process, was studied.

4. CONCLUSION

The "anticracking" geotextile interface system is patented. It comprises two complementary components, a textile matrix and a bituminous binder.

This system is effective and applicable only in the case of structures whose main cause of deterioration is of thermal origin (shrinkage). It is indeed illusory to imagine that textile-based systems can remedy deteriorations of structural origin such as deflexions, flexion of slabs, etc...

The behaviour of the system, and hence of the interface, can be equated with an "anisotropic bitumen sponge", where adavantage is taken of the viscoelastic properties of bitumen.

Our investigation, which was of long duration, was the result of an overall approach to the problems of cracking from both the technical and the economic angles.

In conjunction with French pavement experts, we were led to the establishment of a comparative rating of the different solutions that could be envisaged, and to the development of laboratory tests representative of these cracking phenomena.

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