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(54) Method of delaying reflective cracking propagation in asphalt concrete overlays and prefabricated bituminous sheet to be used therewith.

(57) A method of rehabilitation of roads damaged by reflective cracking is described. The method comprises the welding onto the damaged pavement a prefabricated sheet, having a thickness of at least 0.5 mm, which consists of an upper and lower layer of polymer-modified bitumen. The two layers are separated by a stress relieving reinforced elastic membrane which is characterized by an elongation of between 30% to 70% and tensile strength of at least 5 kg/cm. The polymer used to modify the bitumen is selected from a thermoplastic rubber, such as styrene-butadiene-styrene, polypropylene and polyethylene and the preferred amount is in the range of between 4% to 10% by weight of the bitumen. The welding of the prefabricated sheet onto the damaged road is preferably carried out by torching out. The preferred thickness of the prefabricated sheet is in the range of between 3 to 5 mm.

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The present invention relates to improvements in the methods for repairing roads. More particularly, the invention relates to a method for delaying reflective cracking in asphalt concrete pavements.

BACKGROUND OF THE INVENTION

During recent decades, marked advances in the applied science called soil mechanics has contributed much to understanding soil behaviour and the technological control of soil for use in road construction. The evolution of technique for compacting soils and controlling the density of compacted soils has put the design of embankments and other road components made of soil on a scientific basis.

An important measure to keep the roadbed from losing stability, is to provide and maintain as impervious a pavement surface as possible. The primary function of a pavement as a structure, is to transmit the loads imposed by vehicles to the subgrade under the roadway in such a manner that the soil mass remains stable, i.e. does not exhibit detrimental deformation or does not rupture. Moreover, the wearing surface of the pavement structure must resist the abrasive action of moving traffic and must provide acceptable riding qualities. The pavement structure and its components also must resist the dete riorating influences of temperature and moisture change and various induced chemical reactions.

The term pavement is generally used to include the top layer which provides the riding surface and the layered system comprising the wearing course and the subgrade also known as natural subgrade soil.

Among the many types of pavements, the most widely encountered is that in which the upper layer is made from manufactured materials such as asphaltic concrete or cement concrete with permanent surfaces containing either bituminous materials or cement as a binder. Asphaltic concretes are more frequently used. They consist of mixtures containing the harder grades of asphalt and high quality densely graded aggregates which are processed in a hot-mix plant. The mixtures are used for heavy-duty bituminous pavements and placed by paving machines producing a uniform surface having good riding qualities.

The rehabilitation of cracked roads by overlaying is not considered an adequate solution. This is in view of the fact that the cracks will rapidly propagate through the new asphalt layer. This well-known phenomenon is called reflective cracking and is wide spread over many roads in many countries. The basic factors which lead to reflective cracking are: (a) repeated traffic loading; (b) thermally induced stresses or strains;and (c) a combination of both the above factors. In addition, the temperature dependent stiffness of the materials and flaws in the overly can also have a major effect.

The known solutions to remedy the reflective cracking can be divided in three main groups:

(a) placing a S tress-A bsorbing M embrane I nterlayer (SAMI) between the cracked support and the overlayer;

(b) modifying the overlay composition by the use of a modified bitumen which incorporates a polymer, an elastomer, or fibrous materials;

(c) use of a very thick overlayer.

However, as mentioned in a very recent publication edited from the Conference held in Liege (8-10 March, 1989) on Reflective cracking in pavements:

"In spite of these efforts, it seems that universal crack repair treatment with good durability is still lacking."

There are indeed controversial opinions on the potential of SAMI for minimizing reflective cracking due to traffic loading. Thus, some field trials carried out by the Ontario Ministry of Transportation indicated no significant improvement with respect to reflective cracking.

Reinforced asphalt overlays were suggested for situations where reflective cracking may normally develop. When the crack is initiated by the high strains induced in the overlay, the presence of a tensile reinforcing element, is potentially useful.

The above brief review indicates the importance of the reflective cracking problem which up to now was not successful resolved in spite of ample research and experiments carried out on it.

It is an object of the present invention to provide a simple method for alleviating the problem of reflective cracking in pavements. It is another object of the present invention to provide prefabricated sheets to be applied on the roads suffering from reflective cracking. It is yet another object of the present invention to provide a simple method for repairing reflective cracking in pavements to withstand against future cracking for prolonged periods.

BRIEF DESCRIPTION OF THE INVENTION

The invention consists of a method for rehabilitation of roads suffering from reflective cracking, which comprises the hot welding onto the damaged pavement of a prefabricated sheet having a thickness of at least 0.5 mm, said sheet consisting of an upper and lower layer of polymer-modi-

fied bitumen, said layers being separated by a stress relieving reinforced elastic membrane which is characterized by an elongation of between 30% to 70% and tensile strength of at least 5 kg/cm. The thickness of the sheet is generally up to 10 mm, although a thicker one could also be useful, but of course will be more expensive. The most preferred thickness will be in the range of 3 to 5 mm being most desirable from an economical point of view. The approach on which the present invention concentrates is based on the use of a reinforced membrane possessing an elastic property. In this manner, the reinforced membrane counterbalances the horizontal movements of the two parts of the crack which produce areas of high strain in the bituminous material resulting in cracks which initiate and propagate to the surface. This mode of action is actually contrary to some of the prior state of art, which suggest the use of a lower-modulus material supposed to reduce the stress concentration by acting as a stress attenuator against the vertical movements.

The reinforcement of the membrane may be obtained by any solid material such as woven or non-woven fabric, fiber glass, or even metal wires, to an extent that it will not affect the visco-elastic property of the membrane, which is one of its main characteristics.

According to the present invention, using the modified bitumen stress reinforced membrane, the thermal and the shrinkage effects caused by the surrounding temperature gradient, recognized to be one of the main factors which cause reflective cracking, are substantially eliminated due to the elasticity of said membrane. At the same time, the use of this membrane also avoids the reflective cracking caused by the traffic loading. Tests carried out with prefabricated sheets obtained according to the present invention, show that no reflective cracking appears even after 5 years.

The use of the prefabricated sheets made according to the present invention avoids the use of increased thick layers - upper and lower ones - which were thought that to remedy to a certain extent, the reflective cracking in the existing pavements.

The upper and lower layers, at the two sides of the reinforced membrane consist of bitumen modified by a polymer at an amount of at least 2% by weight of the bitumen and preferably in the range of 4% to 10%. The added polymer, modifies the bitumen by imparting to it visco-elastic properties which enable elongation of the bitumen above 100% and even up to 1500% without cracking. The polymer to be used may be selected from any elastomer and preferably from a thermoplastic rubber such as styrene-butadiene-styrene rubber, styrene-isoprene- styrene rubber, a polyolefin such as polypropylene, polyethylene, or any other common polymer possessing elastomeric properties being suitable for blending with bitumen.

One of the advantages of the method is the use of prefabricated sheets. In this manner, the sheet is laid onto the road on which a rehabilitation due to the reflective cracking is required, and there it is bonded to the damaged pavement. This bonding can be easily obtained by hot welding and most preferably torching-on with an open flame. A strong bonding is obtained in view of the bitumen constituent present on the pavement as well as on the lower layer of the prefabricated sheet.

For a better understanding of the present invention, some theoretical explanations seem to be indicated. As known, crack growth in a pavement layer is generally considered to arise from three distinct stages involving different mechanisms:

(a) crack initiation, caused by an existing defect in the pavement;

(b) slow crack propagation, and

(c) failure, which is the final phase wherein the crack appears on the surface.

In the case of reflective cracking in treated road pavements, crack initiation is assumed to be connected with the crack from the lower layer to the surface layer. The particular construction of the modified bitumen stress relieving reinforced elastic membrane, according to the present invention, is the main factor which causes the rehabilitation of a road damaged by reflective crackings for prolonged periods of time. This membrane in addition to its counterbalancing effect on the changes in temperature, has a significant effect on the influence of traffic loading which causes this damage. When a wheel load passes over a crack of this type in the old pavement, the overlayer will be subjected to a shear stress pulse, followed by a bending stress pulse. The elastic property of said membrane, avoids propagation of this process and this explains why the rehabilitation of a damaged pavement road will last for prolonged periods of time avoiding the reappearance of reflective cracking.

The combination of this particular construction of said membrane, with the polymer modified bitumen of the upper and lower layers, which are characterized by their viscoelastic property, further contributes to the high resistance against reflective cracking. This is achieved by the filling-in of the resulted small crack spacings by the polymer modified bitumen. This will avoid the crack's increase and thereby reduce the stresses and strains in the bitumen covering this region.

The upper layer also consists of a polymer modified bitumen. This layer should behave independently from the lower layer. It should also possess a large flexibility to sustain large horizontal

movements and a high shear resistance.

According to another embodiment of the present invention there are provided prefabricated sheets to be used for repairing pavements suffering from reflective cracking. The prefabricated sheet having a thickness of at least 0.5 mm is made from an upper and lower layer of a polymer modified bitumen, said layers being separated by a stress relieving reinforced elastic membrane which is characterized by an elongation of between 30% to 70% and tensile strength of at least 5 kg/cm. The prefabricated sheet is made by immersing a fabric sheet through a bath heated to about 120 - 190°C containing a polymer-modified-bitumen and also a filler. Generally, the filler is any inert constituent, added in amounts of between 5% to 25% from the bath content, its main purpose being to decrease the costs thereof. Typical examples of such inert fillers are calcium carbonate, dolomite, quartz, etc.

The sheet is conveyed through the hot bath containing the polymer-modified-bitumen through rolls at a velocity of between 10 to 20 m/min. The hot modified bitumen penetrates through the fibers of the fabric imparting to them adhesive property. According to a most preferred embodiment, it is suggested to carry out an impregnation prior to the immersion in the hot bath, which will enchance the adhesiveness of the sheet to the old pavement on the damaged road.

Summing up, the approach of the present invention for rehabilitation of pavement damaged by reflective cracking is based on providing a particular type of modified bitumen stress relieving reinforced elastic membrane, which covers the old deteriorated pavement in such a way that it will not undergo further crackings due to shrinkage, will take advantage of constrained shrinkage stresses and will close existing cracks in the old pavement, thus producing a new bearing layer of even surface on the old structure. The method is very simple and by using the pre-fabricated sheets it contributes to the economy of this treatment.

The invention will be further illustrated by the following Examples for the manufacture of prefabricated sheet, being understood that the Examples are not limiting the scope of the invention being presented only for a better understanding.

Example 1.

A felt sheet, having a thickness of 0.5 mm,was conveyed through a hot bath, maintained at about 150°C,containing Styrene-Butadiene-Styrene (SBS) modified bitumen. The amount of SBS was 6% of the bitumen. The bitumen used had a penetration of 200 according to ASTM D-5. The bath also contains 25% of powdered calcium carbonate.

The sheet was conveyed through the bath at a velocity of about 15 m/min,hus obtaining the prefabricated sheet containing the polymer-modified bitumen astthe upper and lower layers.

The type of bitumen, can be selected according to the particular pavement to be rehabilitated and the climate prevailing thereto.

Example 2.

The felt sheet, as in the previous Example, was conveyed through a hot bath containing polypropylene (a mixture of atactic and isotactic)-modified bitumen. The amount of polypropylene was about 15% of the bitumen. The bitumen used had a penetration of 65 (ASTM, D-5). The bath also contained 15% of powdered quartz as filler.

The sheet was conveyed through the bath at a velocity of about 20 m/min thus obtaining the prefabricated sheet containing the polymer-modified bitumen as the upper and lower layers.

Claims

1. A method of rehabilitation of roads damaged by reflective cracking, which comprises the welding onto the damaged pavement a prefabricated sheet having a thickness of at least 0.5 mm, said sheet consisting of an upper and lower layer of polymer-modified bitumen,said layers being separated by a stress relieving reinforced elastic membrane which is characterized by an elongation of between 30% to 70% and tensile strength of at least 5 kg/cm.
2. A method according to Claim 1, wherein the thickness of said sheet is in the range of 3 to 5 mm.
3. A method according to anyone of Claims 1 or 2, wherein said hot welding is carried out by torching on.
4. A method according to anyone of Claims 1 to 3, wherein the polymer used to modify the bitumen is selected from a thermoplastic rubber, polypropylene and polyethylene.
5. A method according to Claim 4, wherein said thermoplastic rubber is selected from styrene-butadiene-styrene and styrene-isoprene-styrene.
6. A method according to anyone of Claims 4 or 5, wherein said polymer is in the range of 4% to 10% by weight of the bitumen constituent.
7. A prefabricated sheet for rehabilitation of pavements damaged by reflective cracking, having a thickness of at least 0.5 mm, being made from an upper and lower layer of polymer-modified bitumen, said layers being separated by a stress relieving reinforced elastic membrane, being characterized by an elongation of between 30% and

70% and tensile strength of at least 5 kg/cm.

8. A prefabricated sheet according to Claim 7, wherein said membrane is obtained by conveying a sheet through a hot bath containing polymer-modified bitumen at a velocity in the range of between 10 to m/min.

9. A prefabricated sheet according to Claim 8, wherein said hot bath contains also an inert filler.

10. A prefabricated sheet according to Claim 9, wherein said inert filler is selected from powdered calcium carbonate, dolomite and quartz.

11. A prefabricated sheet according to anyone of Claims 8 to 10, wherein said sheet is impregnated with a solution to enhance its adhesiveness property,prior to its conveyence through the hot bath containing the polymer-modified bitumen.

12. A method of delaying reflective cracking in asphalt concrete pavements, according to anyone of Claims 1 to 6.

13. A prefabricated sheet of delaying of pavements damaged by reflective cracking, according to anyone of Claims 7 to 11.

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EUROPEAN SEARCH REPORT

Application Number

EP 90 40 2814

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-4 637 946 (SHAH) * Whole document *	1,4-10	E 01 C 7/18
A	DE-U-8 706 890 (MODZEL) * Whole document *	1,3,4,7	
A	US-A-4 428 698 (MURPHY et al.) * Claims 1,7,8 *	1,7	
A	EP-A-0 318 707 (BAY MILLS LTD) * Page 3, line 7 - page 4, line 47 *	1,7,11	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

E 01 C

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	17 January 91	DIJKSTRA G.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same catagory
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