STRESS RELIEVING FUNCTION OF PAVING FABRICS WHEN USED IN NEW ROAD CONSTRUCTION

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Abstract
In order to increase the bearing capacity of roadbases constructed on weak or unstable subgrades, many methods of stabilisation of the base courses have been investigated over the years. Without stabilisation, heavy trafficking on the final asphalt overlay will without question result in rutting. Consequently, improvements of the stiffness of the roadbase and by this increasing of the support of the asphalt overlay have been essential in new road constructions.

This paper focuses on the use of stress relieving inlays of nonwoven paving fabrics, sufficiently saturated with bituminous tack-coat and placed between rigid bearing capacity improved cement or lime stabilized base courses and new asphalt overlays. The paving fabric interlayer system allows for slight differential movements between any unintentionally arisen cracks or pre-cracked pattern of the cement or lime stabilized layers. The pre-cracking often done in order to reduce the damaging stresses which emerges from large sections. The method has been utilized over many years, and the inclusion of the stress relieving paving fabric significantly improves the performance period (i.e., time to rehabilitation) of the entire construction due to the retarding of reflective cracking caused by thermal movements and shrink and swell due to moisture variations in the rigid stabilized base course, even when pre-cracked.

Keywords: Stress relieving function, paving fabric, new road construction, stabilization of base courses.

1. Introduction

Through the years, many methods of stabilization of base courses have being investigated in order to increase the bearing capacity of roadbases, especially over weak subgrades, and by this provide improved support for the roadway. Personally, before graduating as bachelor in Science of Engineering in Denmark back in 1973, one of my final main reports was an analysis of a running road project concerning a lime stabilization of the subbase over a weak subgrade course.
Whether the stabilization of a base course is done by the use of additives as lime or cement, a risk for unintentional and accidental cracking in the stabilized layer is predictable. Cement treated base courses act like sheets of concrete. If these are too wide and the mix is too strong, the courses are likely to crack due to the rigidity of the structure, and consequently followed by destructive reflective cracking reflecting up through the entire asphalt overlay.

This paper will focus on the needs and advantageous obtained when using stress relieving paving fabrics in combination with cement treating of base courses.

2. Background

To secure sufficient driving comfort, without rutting, when constructing new road constructions over weak subgrades, we all know that the most stable platform without any settlements is a concrete deck constructed on piles. However, due to heavy construction costs such constructions are limited to very special areas. Pure concrete roads are also stable platforms. However, all joints must be maintained in order to prevent intrusion of water and loss of fines from the supporting roadbase. The lack of possibilities for carrying out suitable smaller repairs and the heavy costs for changing or adding new wearing courses often result in the desire for an asphalt concrete overlay, unfortunately followed by successive reflective cracking. The joints and cracks will normally reflect up through the new asphalt overlay after a period of time, regardless the thickness or the number of asphalt overlays. Constructing the roadway from the beginning with pure asphalt concrete layers over a weak subgrade, however, often result in rutting. Therefore, pre-cracked cement treated base courses and successive paving with asphalt concrete have been more and more commonly used as reliable platforms satisfying the need for increased bearing capacity to withstand loads from heavy traffic. The pre-cracking of the cement treated base courses is done in order to reduce the crack building stresses created by the influence of the thermal coefficients of the aggregates and due to shrink and swell due to moisture changes.

The use of geosynthetics has – when properly designed and installed – proved to be a worthwhile solution in both new road constructions and road maintenance. The nonwoven paving fabrics, sufficiently saturated with bituminous tack-coat, have been utilized in asphalt overlays for more than three decades. The inclusion of a nonwoven paving fabric interlayer system significantly improves the performance of asphalt concrete overlays. The paving fabric system gives additional overlay performance equivalent to increased overlay thickness of 20 to 40% or with other words; savings of up to 51 mm of asphalt overlay thickness is achievable according to GMA [1]. The minimum thickness of the asphalt overlay, however, should still be more than 2½ times largest grain size of the asphalt mixture or as stated by GMA [1] the minimum compacted thickness of the first lift of the asphalt overlay at its thinnest point should be at least 38 mm. The structural improvement is due to the waterproofing function of the paving fabric system and due to the stress relieving interlayer function. The paving fabric interlayer system allows for slight differential movements between the slabs, essential in rigid pavements. Stopping the moisture infiltration achieves the same result as effective base drainage. By maintaining lower moisture content in the roadbase materials, the effective strength or support is improved and provides up to 2½ times the
pavement support of poorly drained pavement bases and provides from 25 to 50% increase in service life according to GMA [1].

3. Examples of site constructions

This section will put into focus the results of experiences drawn together from site constructions, and the know-how based on site constructions where stress relieving paving fabrics have been used. Especially, three large projects with different design will be highlighted and discussed.

This section will also bear the impress of the author’s own personal experiences over the years with the behaviour of cement treated base courses. Experiences, which basically are based on previous 10 years employment in the Danish paving industry, where paving on top of sections reinforced with cement treating of the base courses nearly always brought about problems with undesirable cracking after a period of time. Much effort was diverted into solving these destructive reflective cracking, and many attempt for finding new reliable methods for the repairmen’s of the cracks were brought up.

3.1 Tabuk Military Airport, Saudi-Arabia, 1994
As a part of a main military air base project in Tabuk, Saudi-Arabia back in 1993-1994, the existing runway and taxiways were to be extended with approximately 300,000 m². The demand from the Royal Saudi Air Force Department was to obtain very high bearing capacity for the pavement project. Consequently, a rigid base of cement treated base course was chosen, and the following precautions included in anticipation of the occurrence of reflection cracks, respectively, pre-cracking of the cement treated base courses into a panel size of 4 x 4 m and extra thickness of the asphalt overlay.

The cement treated base was constructed in two layers, each of 13 cm thickness and separately cut to a depth of 4-5 cm while the layers were still green. See Fig. 1. The pre-cutting executed of a cutting device mounted on a pneumatic wheeled roller.

![Fig. 1 – The pre-cracked surface of the cement treated base course.](image)

Already during construction, reflective cracking appeared in the asphalt layers. An investigation into material properties and crack movements took place, and it was concluded by the Airport consulting Engineer Nataraj [2] that the large thermal coefficient of the aggregate in the rigid base in combination with the extreme diurnal
temperature variations were the main cause for the early crack development. Although these reflection cracks would not influence the structural integrity of the pavement, it would increase the maintenance effort from the user. Therefore, a remedy had to be found that would be effective in the long run. See Fig. 2 below:

![Image of reflective cracking in asphalt layers](image)

**Fig. 2 – Already during construction, reflective cracking appeared in the asphalt layers.**

Immediately, improvements to the material mixes and procedures were not sufficient, as reflective cracking continued to develop, and even penetrated up through the second layer of asphalt base course. It became obvious that a stress relieving interlayer had to be incorporated in the construction.

To allow incorporation of works already completed, the choice was made to install a stress relieving paving fabric in between the already paved one and two layers of asphalt base courses and two new finishing layers of asphalt wearing courses. The concept consisted of 160-170 °C hot 60/70 pen bitumen tack-coat spread on top of the last paved layer of asphalt concrete base course in a rate of 1.0-1.2 kg/m² before unrolling a suitable paving fabric. The technical data of the paving fabric according to the American Task Force 25, which today is replaced by the American Association of State Highway and Transportation Officials (AASHTO) in their Geotextile Specification for Highway Applications AASHTO M 288 unchanged.

The chosen paving fabric was mechanically unrolled by means of un-rolling equipment mounted on an adjustable agricultural tractor, and carried out by a well-trained crew educated for the installation of paving fabrics. The crew and supervisors were always following the contents of a suitable working procedure very genuinely. A larger part of this working procedure was due to its overall importance included in the author’s paper presentation at the Fifth IGS conference in Singapore 1994 [3].
3.2 Barbezieux, by-pass road, N-10, France, 1996

The main road (Route Nationale) N-10 in France is heavily loaded with traffic. Many people take this route going north/south and all the cars passing the many small towns situated along the route cause problems. For this reason, the awarding Road Administration in Charente, Direction Départementale de L’Équipement, decided to enlarge the road section and include a by-pass road of 8 km length near Barbezieux.

As the by-pass roadway construction happens to be planned to pass above an extremely soft and unstable area with far too low bearing capacity for withstanding the designed and expected high-expected traffic loads, improvement and stabilisation of the roadbase was decisive. In order to find appropriate and cost beneficial alternative approaches for obtaining the required bearing capacity, the use of local occurrences of lime and limestone materials were investigated for stabilisation purposes, and constructively found acceptable. It gave sufficient support for the foundation and subbase stabilisation, and after general digging and excavating, the general roadwork took place from September 1995 with functional finishing June 1996.

The final 22-25 cm thick lime stabilized base course layer was sealed with bitumen emulsion and sprinkled with bituminised sand. The sealing done in order to protect against evaporation of the essential optimum water content in the lime stabilized layers needed during the hardening process and done in order to protect the whole roadbase construction against wash out of fines caused by unintentional overflowing or intrusion of surface water from heavy rainy showers. Furthermore, the sealing was also functioning as a workable platform for the incorporation of a stress relieving paving fabric installed between the sealed base course layer and the first 6 cm thick asphalt base course. See Fig. 3 below:

Fig. 3 – Spraying of hot melted bituminous tack-coat and installation of the stress relieving paving fabric. Furthermore, paving with the hot asphalt overlay on top of the unrolled paving fabric.

The installed bitumen saturated nonwoven paving fabric allows for slight differential movements between the top of the rigid base course layer and the bottom of the asphalt concrete overlay and counteracts cracks. Furthermore, if failures in the lime stabilisation for some reason should occur in the future, the cracks, which normally would generate up through the entire asphalt overlay due to heavy traffic load induced failures, would
now thus be absorbed by the presence of the paving fabric interlayer, as this will allows many times the amount of traffic loading flexures before pavement cracking occurs.

The asphalt overlay was carried out as a traditional standard structure consisting of three layers of respectively, 6 cm asphalt base course, 6 cm asphalt binder course and 3 cm asphalt wearing course.

### 3.3 Pier Extension, Port of Barcelona, Spain, 2003

Approximately 100,000 m² new land reclamation situated on the southern part of the Barcelona Port, just behind the area with the breakwater, was to be incorporated in the spring of 2003 as new logistic area. Consequently, an asphalt pavement where vehicles could move around without problems was required. However, as the soil had a very low elasticity modulus it was not appropriate to apply asphalt layers directly on top of the new area.

Therefore, a solution was taken to utilize different layers with rising elasticity modulus on top of the new land reclamation. Two layers of cement stabilized gravel courses, of respectively, 30 and 20 cm thickness and with different elasticity modulus were constructed and the last layer sealed with a bituminous tack-coat, performed with the spraying of bitumen emulsion to an amount of 500 g/m² retention bitumen. The goal with the sealing was to improve the adhesion between the superficial particles and to improve the water resistance of the construction. This included also the installation of a bitumen saturated paving fabric. A paving fabric incorporated in between the sealed cement stabilized gravel courses and the two layers of asphalt overlay of together 8 cm thickness. There were two purposes with the paving fabric, as to be a water proofing barrier and by this prevent the penetration of surface water or other liquids to the lower layers resulting in loss of bearing capacity, and to act as a stress relieving interlayer membrane and prevent the reflection of cracks from the pre-cracked layers of cement stabilized gravel courses to the new asphalt layers. See Fig. 4 below:

![Fig. 4 – The installation of paving fabric on top of the pre-cracked and sealed upper layer of cement treated gravel course.](image-url)
4. Alternatives

The use of stress relieving inlays, consisting of a thick layer of open graded asphalt material, has often been considered and consequently used instead of the paving fabric.

The author’s research on several constructions over cement treated base courses, even when pre-cracked, shows that the most used alternative solution equivalent to the stress relieving paving fabric has been an open graded asphalt layer of approximately 10 cm of thickness. E.g. recommended by Mr. A. R. Nataraj, from Netherlands Airport Consultants [4]. However, the author of this paper needs to draw attention to the risk for water intrusion in such open graded asphalt layers, with successive risk for frost failures, in case the project site is located in frost sensitive areas. Furthermore, that rutting might be the possibility as alternative to reflective cracking.

5. Design considerations

A major difference in the case stories is where the stress relieving paving fabric should be incorporated in the overlay construction, placement directly on top of the cement treated base course or in between the layers of asphalt overlay. Due to field experience from the author, the most optimal location will be between the two lowest layers of asphalt overlay (if three layers are available), as this will give the most uniform base for the spraying of tack-coat prior to the installation of paving fabric. The sealing of the upper layer of the cement treated base courses might be worn-away and only sporadically present due to heavy trafficking during the construction face or due to rainy weather, and will therefore not always be suitable as platform for the spraying of tack-coat for the paving fabric. Fig. 5 below:

![Fig. 5 – Inadequate sealing is not recommended as platform for the installation of paving fabrics.](image)

The three major case stories described in section 3 are with the use of different stabilizer for the establishment of sufficient bearing capacity, respectively, cement and lime. The main issue in this paper is not which stabilizer to use, but how to solve the successive reflective cracking performed by the produced rigid base courses.
The discussion whether or not the cement treated base course should be pre-cracked or not, and in which sizes. However, it is obvious, that the smaller the fractions/slabs are, the less stresses have to be relieved in the stress relieving interlayer. Furthermore, as the pre-cracking action is both easy and inexpensive to carry out, the author cannot see any reasons for not taking this precaution against the risk of reflective cracking. Furthermore, the author finds that panel sizes of 3 by 3 meters would be the most advantageous suggestion.

I have, as author, not included case stories from construction sites where the use of thick liquid bitumen emulsion as tack coat, prior to the installation of paving fabrics, has been used. The use of bitumen emulsion as tack-coat is time-consuming as the water has to evaporate before paving, and the heavy trafficking with paving equipment and vehicles carrying asphalt materials might stick to the fabric and cause a more time-consuming working procedure from the crew. The function and quality of the finish installation will be the same, using hot melted bitumen or thick liquid bitumen emulsion. However, in large projects, the waiting time when using bitumen emulsion has to be taken into consideration as a major issue for concern.

Asphalt overlays, are in general, quite permeable. Therefore, when paving fabrics are installed as stress relieving inlays, a water proofing function is automatic included in the construction. Hence, the road base will thus be protected against intrusion of surface water and successively reduce risk for wash out of fines and weakening of the road base courses, which is important in case that surface related cracks or deterioration of the asphalt overlays for some reason should occur in the future.

6. Conclusions

Reflective cracking, normally generated in new road constructions based on stiff rigid roadbases, e.g. base course layers stabilised with cement or lime in order to create high structural bearing capacity, are successfully retarded and counteracted by the inlay of stress relieving interlayer membranes, among which paving fabrics has shown to be a very cost beneficial solution. As a rule of thumb, when calculating the investment costs of stress relieving inlays, the cost of the stress relieving paving fabric – all included – is found to correspond to approximately 1 cm of asphalt overlay. Consequently, far more cost beneficial solution compared to the incorporation of a 10 cm thick layer of asphalt.

7. References