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STRENGTHENING OF ROAD IN BLACK COTTON SOIL REGION AND IMPROVEMENT OF OVERLAY AGAINST REFLECTIVE AND FATIGUE CRACKING USING GEOSYNTHETICS

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ABSTRACT

Most state highways in Maharastra state have problems of foundation with highly compressible clay locally known as Black Cotton soil. Large scale deformation, pavement failure etc. results in repeated renewal of pavement. Whereas the existing roads are of inadequate design , based on increasing traffic load and intensity, most of these areas are prone to heavy rainfall. Pore pressure dissipation is difficult in most terrain, where ground is rolling with abutting fields being in higher elevation and are much irrigated due to Sugar cane cultivation.

This paper deals with two case histories in Maharastra State where the pavement renewal program is supplemented with modern analysis, strengthening solutions and crack retardation design using Geosynthetics.

The remedial measures are designed to improve and strengthen the road section including subsurface drainage facility for the road subgrade to reduce the hydrostatic pressure at the base of the road crust and strengthen the road structure with suitable system to reduce the vertical stresses over the subgrade soil in both these sites. Whereas in one site Geogrids were used to strengthen as well as to prevent reflective cracking of pavement, the other site used Geogrids as reinforcement followed by Nonwoven Geotextile for effective sealing against water percolation, improving bonding of surface wearing against water percolation, improving bonding of surface wearing course to the pavement and provide adequate camber in the road pavement in the leveling/correction course for improved surface drainage.

INTRODUCTION

Despite the development in paving techniques, modified bituminous binders, and improvements in paving techniques, modified bituminous binders, and improvements in mix design methods to produce better, longer lasting road surfaces, roads around the world continue with the problems of cracking, rutting and potholes. This has resulted in the development of new technologies in asphalt road-surfacing of the combination of bituminous road surfacing materials with Geosynthetics, i.e. Geogrids and Geotextiles etc.

One of the common problem of renewal of an existing deteriorated pavement is to deal with the progression of cracks from the existing pavement into the new overlay. When a new pavement is constructed on old cracked road surface, as a result of stress concentration at the existing cracked portion, it continues to propagate over a period of time through the new pavement and this process of propagation of cracks is known as reflective cracking.

The reason for the cracking in particular in soil foundation like Black Cotton compressible clay is mainly poor shear strength with ingress of water in the foundation and pavement structure, giving rise to increase in pore pressure. Differential settlement caused by pavement failure is shown in Fig - 1 a & b, where the action of wheel load is shown to create an oscillatory pulse of sway in the bottom of pavement inducing tensile forces. This lateral sway allows pumping of fines from the compressible clayey subgrade, thereby slowly loosing aggregates sinking into the void created by the passage of fines. The pavement thickness reduces slowly and deformation increases, heterogenously depending on subgrade strength and loading conditions. Ruts and potholes appear on surface apart from cracks etc. The solution in such a state is by providing a Tensile inclusion of a plastic grid or fabric/textile separator.

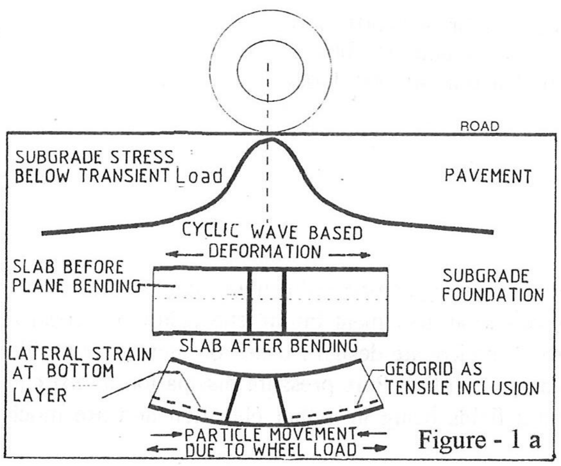


Figure - 1 a

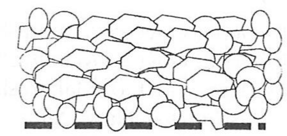
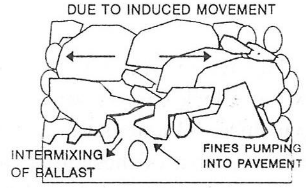


Figure - 1 b



Geosynthetics for pavement renewal

In case of existing pavement however it is not always possible to replace the entire pavement thickness, but it can be strengthened by using a stress absorbing restraint layer. Presence of an intermediate Geogrid provides a stable base, where vertical crack propagation can be restricted and over which a new overlay can be laid

Geogrid is described as an open mesh structure which allows interlocking with surrounding materials mobilization of its inherent high tensile strength even at low deformation. For deformation correction in Black Cotton soil area, Geogrid may provide important strengthening required in pavement foundation stiffness, by interlocking the lower strata with reinforcing action with a tensile inclusion, thereby reducing differential settlement.

Geogrids are chemically inert having high modulus even at elevated temperature and are therefore suitable for reinforcing bitumen bound aggregate layers as well. Like bitumen, stress-strain behavior of Geogrids shows that they are also non-linear visco elastic material. Thereby, the stress-strain characteristics of Geogrids with the bitumen bound aggregates can be designed with compatibility. Because of presence of binder in bitumen based aggregates, movement between layers of aggregate is relatively restricted. It prevents propagation of cracks through new constructed pavements by uniformly distributing the concentrated stress over the surface.

Non woven Geotextile is found highly suitable for repairing all cracked road surfaces with stable subbase. For example, under asphaltic concrete surfaces or in surface treatments, in asphalt overlay Geogrid reinforced stable roads which are to be sealed. Geotextile is laid over the uniformly sprayed bituminous tack coat. Over which surface dressing is carried out. The main three functions of Geotextile are explained below:

Sealing

The Non woven Geotextile prevents penetration of rainwater into the lower lying road structure. Geotextile itself is permeable but when laid over the melted bitumen with a concentration of 1.1 kg/sq.m (ref 1), the pores of the Geotextile is filled with bitumen as a reservoir and makes it impermeable.

Retarding of reflective cracking

The stress reduction at the interface between layers retards or prevents the propagation of cracks in the pavement. With the use of Geotextile the stress is uniformly distributed over the surface as a result of which the stress is not concentrated at a particular point and hence prevents crack propagation and reflective cracking

Surface adhesion

The reservoir of higher quantity of bitumen from impregnated Geotextiles and the interlayer adaptation of Geotextile to uneven surfaces ensures excellent uniform adhesion between layers (old pavement and new surface layer).

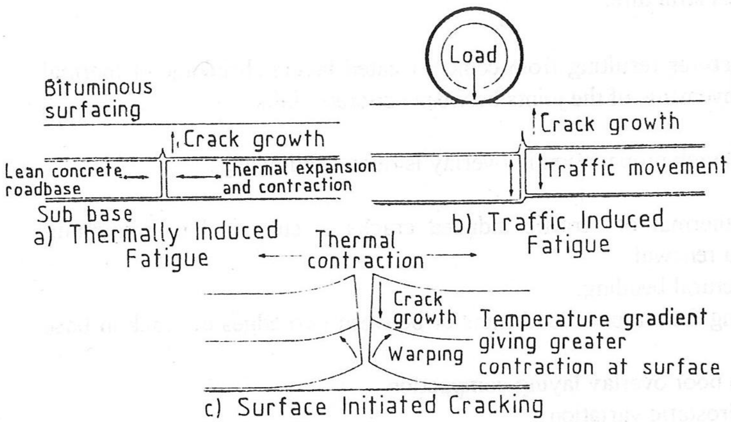
CRACK CONTROL USING GEOSYNTHETIC MATERIAL

Types of Cracking of Pavements

Cracking of pavements can be due to a very large number of reasons. The phenomenon is adequately described in the paper by Molenaar,1989 (2). The cracking of pavement is analysed into four main crack categories, which are shown as :

- Transverse cracking
- Block cracking
- Longitudinal cracking
- Alligator cracking

While the first two types are predominant in overlay over rigid or semi rigid pavement, the later are mostly seen in flexible pavements (also in the rigid/semi rigid based overlays).



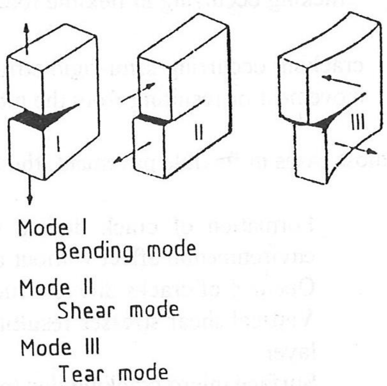


Figure 3: Modes of Cracking

Figure-2a, b & c: Mechanisms of Reflective Cracking

In Figure 2, it is shown that the primary fracture mode of a layer above a rigid or semi-rigid cement treated base is the so called 'mode' I cracking (shown in Figure-3). Crack growth is generated through forces which are acting perpendicular to the crack face; these are forces which are generated due to shrinkage of base because of a drop in temperature.
Block cracking again develops in an overlay with rigid or semi-rigid base when the environmental effects and the characteristics of the pavement are such that block cracking develops. In those cases the influence of the traffic loads will become increasingly important because of the reduction in bending stiffness of the entire structure due to the block cracking.

In areas with Black cotton soil, excessive or uncontrolled deformation of pavement structure is a predominant failure mode. This is induced by high intensity of uncontrolled traffic coupled with trapped pore pressure within the immediate subgrade, giving rise to pumping of fines and loss of pavement thickness. In such cases again overlay deterioration is even more aggravated due to induced crack in base propagating through the overlay due to traffic induced stresses.

Longitudinal cracking in the wheelpaths is influenced by traffic. It is clearly indicated by Molenaar, 1983 (3), Gerritsen et. al., 1987 (4) and Jacobs et.al., 1992 (5) that the horizontal shear forces occurring under wheels are responsible for very high tensile stresses and strains at the pavement surface acting perpendicular to the direction of travel.

Alligator cracking, transverse in nature is related to fatigue of the pavement and according to the latest research findings is related to the tensile strain at the bottom of the asphalt layer. These transverse cracks develop over a limited length, since the width of the loaded area is limited to the tracks of wheelpaths. These cracks propagate by the bending (mode I) and shearing (mode II) action of the traffic loads. Also fatigue cracks will propagate through layers which will be placed on top of the cracked layer.

Cracks Origin and Propagation

To understand the crack origin, it is necessary to make a distinction between two different types of pavement problems [Bonnot, 1989(6)] :

- cracking occurring in flexible roads structure;

- cracking occurring semi-rigid structures resulting from cement treated layers shrinkage or thermal movement or resulting from the movements of the joints between concrete slabs.

In most cases in flexible pavement, the crack propagation in overlay is due to following :

1. Formation of crack due to thermal or traffic induced cracks is subjected to continuing environmental effect without a renewal
2. Opening of cracks due to structural bending,
3. Vertical shear stresses resulting from a poor load transfer between two edges of crack in base layer
4. Surface micro cracking due to poor overlay laying compaction
5. Deformation of subgrade, hydrostatic variation
6. External change in boundary, such as road widening, faulty local repair etc. are all crack originators.

Anti-reflective Cracking Measures & Remediation Technics :

Remediation technics for the above described phenomenon are numerous and may be classified in three main classes :

- Remediation by modifications of the overlay characteristics in order to improve its ability to resist to the strains or stresses imposed by the crack movements.

  while traditionally this is obtained by the use of modified bitumen without reinforcement as a binder for the overlay with increase of the overlay thickness as a solution, this may best be obtained economically by the reinforcement of the overlay by means of fibers and Geogrids [Collumbiar,1989 (7)];

- Remediation by the placement of a stress or strain-absorbing membrane interlayer adhering to the old structure and the new overlay, called "S.A.M.I.", (conventionally with bituminous mortars) by bitumen impregnated Geotextiles or plastic Geogrids [Colombier, 1989(7)];

- Remediation by providing action on the origin of the cracks, for example in black cotton soil based subgrade, by reducing pore pressure with lowering of water table using subsurface drainage and/or reducing deformation and differential settlement by using Geogrid reinforced pavement.

Modifications of the Overlay Characteristics by using Geogrid reinforcement

One effective way to resist to crack propagation is to ensure sufficient :
- deformability or
- tensile resistance in the overlay.

Reinforcement, understood on the classical way, requires that the modulus of elasticity of the reinforcing material be higher than the one of the material to be reinforced. Comparing the E modulus, it may be observed that an effective reinforcement by means of fabrics or grids is to be expected mostly for thermal solicitations. Glass fibers and steel wires have higher moduli. Reinforcement of the overlay may also be obtained by means of "reinforcing" fabrics, grids or meshes in the lower part of the overlay. Orthotropic behavior is to be expected from the reinforced overlay and accordingly the reinforcement should be chosen. It also means that diagonal directions are weaker and more subjected to failure.

Finally, the placement conditions are very important. No wrinkles may occur. This is why these reinforcing elements are placed under tension (by nailing for instance). Geosynthetics may also be used as a reinforcement of microsurfacing layers (fabric/grid reinforced chip seal).

Interlayer between the old pavement and a new overlay using Geotextiles

The interlayer functions are as follow :

Stress release : Basal and/or overlay differential movements of thermal origin may be absorbed by the interlayer, having an important stress release effect on the structure. On the other hand, traffic stresses must be transmitted correctly between the pavement layers. All the interlayer actually developed are base on bitumen or modified bitumen. The visco-elasto-plastic behavior of this material fits very well to the above mentioned requirements.

waterproofing : in case of cracks, one must avoid any intrusion of water in the soil underneath the pavement. Else, soil bearing capacity will decrease and some pumping effect is to be expected under traffic loads, inducing extra stresses into the pavement and additional distress. Bitumen is the basic interlayer component in such application. In order to decrease the interlayer thermal susceptibility, important modifications based on elastomers or plastomers are done.

The interlayer bitumen is mechanically stabilized by means of fabrics acting as a container. These may be presented as manufactured fabrics on the structure to be repaired. Rigo et al. 1989 (8) reported that the majority (about 2/3) of the mechanical effect of the stress release function is insured by the interlayer bitumen. The remaining part is due to the fabric structure.

It is evident that the interlayer mechanical effectiveness is highly dependent on its adhesion to the old pavement and the new overlay [Fock, 1989 (9)]. The adhesion must be permanent and uniform. It is essential to the bearing capacity, stability and durability of the new road structure. The use of a paving fabric as a bitumen carrier offers the possibility of applying a defined and regular bitumen film as the bonding agent or bonding bridge between the individual composite strata.

The waterproofing function may be obtained by the complete saturation of the interlayer fabric mass. It is why this requirement is fulfilled in case of nonwoven (like needle punched, mechanically bonded) fabrics. Open structures like grids are not able to fulfill this requirement.

THE CASE HISTORIES : PROBLEMS

Several experiment has proved that the use of Geosynthetic material as a reinforcement significantly improve the quality of road and increase the life of the structure by increasing the tensile strength of pavement, making it impermeable and reducing the differential stresses between the substrate and the new surface layers. To illustrate these effects this paper describes application in two locations in Maharastra State, with different design approach. In one application strengthening and crack prevention using two layers of Geogrid is attempted. The other location uses strengthening measure using Geogrids, coupled with Sealing and adhesion improvement with a Nonwoven Geotextiles.

This paper deals with two sites in Maharastra State. The first site is located in Km-6/200 & Km-27-28 on State Highway SH-78, Malharpeth - Pandharpur Road. The second site is situated on the State Highway SH-141, Nagar Karmala - Tembhurni - Pandharpur - Bijapur Road, near Karmala town. Both the sites are located in Eastern Maharastra State.

MALHARPETH - PANDHARPUR ROAD SITE

This site is locationally passing through black cotton soil subgrade with adjoining Sugarcane cultivation land being at higher elevation than the road, although the pavement thickness here were initially of adequate design. However the Black Cotton soil foundation in this area is at most extremely critical condition here, the whole stretch failing and twisting like a ribbon with very high differential settlements, large-scale surface disintegration, cracks and sinking.

This area falls into the high rainfall zone. The adjoining land gets inundated/over inundated due to stagnant water during rains. The inundation results into increasing high ground water table during rains. After the rains, the water present in the subgrade immediately below the pavement crust does not drain out easily. There are stagnant pools of water in many locations in adjoining borrow area. The traffic in this road is very heavy and design of the pavement inadequate for such increase in traffic.

The buoyant hydrostatic ingress/excess of high water table and low permeability of the black-cotton soil under the pavement causes alternate swelling and shrinkage of the subgrade black-cotton soil. This results into erratic deformation pattern of the subgrade soil and subsequently failure of the base and sub-base courses. Large pot holes, sunk portions and undulating road surface are common features over the affected road stretch under consideration. Again road side drainage is almost non-existent allowing borrow water to stagnate and percolate in to the pavement.

The heavy traffic (estimated 37000 MT/day) coupled with overloaded vehicles moving over the weak pavement structure on black-cotton subgrade soil is causing heavy damages in the form of large potholes, cracked surface, damaged pavement edges, highlighting that the road is in state of distress which cannot be tackled easily by conventional methods of repair and maintenance in a techno-economically viable manner.

This site deals with road renewal using Geosynthetic materials mainly as a reinforcement, for both road foundation underlayer and asphaltic overlay.

Remedial Scheme

The Remediation involved raising and rebuilding this section with a leveling course with 80 mm trap metal, followed by a Bi-Oriented Polypropylene Geogrid (TENAX LBO 270 variety). Over this Geogrid a layer of LBM is laid and compacted. Further a layer of 50 mm thick Bituminous Macadam is laid, over which a layer of special paving grade Polypropylene Geogrid (TENAX RA 201) is installed. A Surface dressing with 25 mm thick premix carpeting is followed. The remedial scheme is shown in Figure - 4

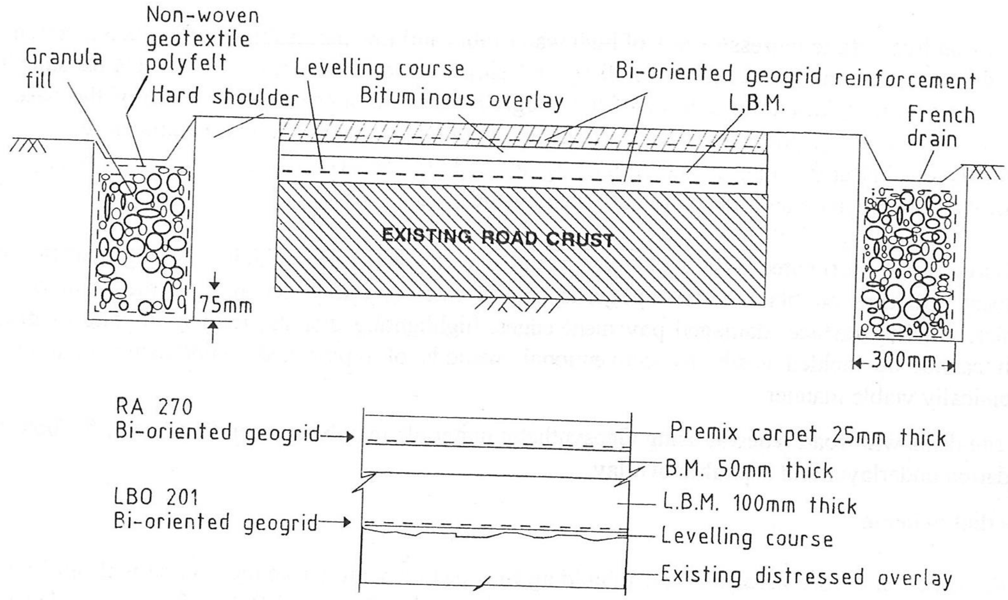
The road section is designed with Longitudinal subsurface drainage below a open surface drains on both sides at an invert 200mm lower than the road existing subbase, followed by cross subsurface drainage at 15m intervals dug into their existing road crust, which needed complete rebuilding.

The installation of this stretch has been completed before onset of the monsoon 1997. After the monsoon the road is reported to have performed well without any distress or deformation. Installation process for this site are shown in Plates-1 and installation sequence shown in Annexure-1. The fresh laying of leveling course and soling/subbase was done after installation of longitudinal and cross drainage , compacted to achieve a flatform using a 10ton Roller. Before placement of Geogrids, the surface of the leveling course is thoroughly cleaned before placement of the Geogrid. The grid is stretched at one end with a tensioning beam attached to a moving vehicle to remove all kinks and bends, the other end stapled into the pavement. The Geogrid is laid, it's surface hugging the road surface closely. The overlaying followed immediately at an operating laying temperature of 125-130°C. Once the first layer is completely installed the Bituminous Macadam layer is laid, further laying of the paving grade Geogrid were laid followed by a premix carpet course. The special paving grade Geogrids used were designed to withstand a laying temperature upto 165°C.

NAGAR KARMALA - TEMBHURNI SITE

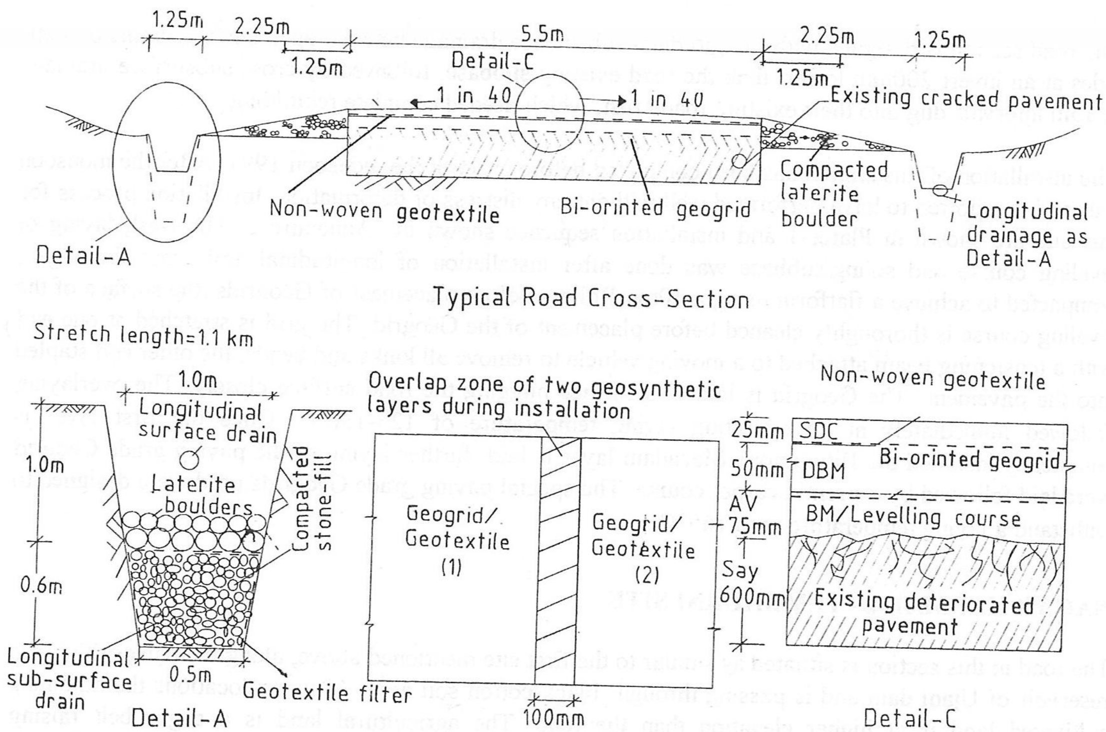
The road in this section is situated as similar to the first site mentioned above, along the bank of the vast reservoir of Ujani dam and is passing through black cotton soil area. At many locations the adjoining cultivated land is at higher elevation than the road. The agricultural land is a sugar belt raising sugarcane crop right through the year. Compressible black cotton soil in foundation and absence of functional side drains are causing damages to pavement.

This state highway is an important link for the movement of industrial as well as agricultural produce which has resulted into heavy increase in traffic intensity which at present has reached the order of



STRENGTHENING OF M.P. ROAD KM 6/200 USING GEOSYNTHETICS IN HIGH WATER-TABLE CONDITION

Figure-4



STRENTHENING THE EXISTING ROAD PAVEMENT AT KM 130/0 OF SH 141 OVER BLACK-COTTON SOIL IN SOLAPUR DISTRICT, MAHARASTRA

Figure-5

Not to scale

cumulative 30,000 MT/day, which includes two axle, three and four axles vehicles playing over the road. The problem is further aggravated due to overloading of the vehicles much more than the standard axle loads. The existing road pavement has been severely damaged and has become a major traffic hazard and is in urgent need of repairs and strengthening using Geosynthetic material.

Although the area experiences rainfall of medium intensity, the water logging from sugarcane cultivation deteriorates it's foundation throughout the year, due to absence of proper drainage facilities. The road surface is severely distressed with reflection cracks, innumerable local patch repairs (inducing further fatigue) and sinking. The road width is narrow compared to the heavy traffic, forcing vehicular load to hard shoulders, causing edge failure in many locations. The camber in the major part of the present road is almost non-existent and therefore, surface water also does not clear off the road pavement.

The remedial measures for this major road renewal program for a stretch length of 1.1 km road section uses strengthening measure in two layers by using Geosynthetic reinforcement asphalt binder treatment. The two types of Geosynthetic material used for renewal of road are Polypropylene high strength Bi-oriented Geogrid and Endless Polypropylene fiber Non woven Needle punched Geotextile.

The major function of Nonwoven Geotextiles in engineering application have been identified as separation, reinforcement, drainage and filtration. Of this, separation is governed by the pore size of Geotextile and grain size distribution of soil, drainage and filtration is governed by the hydraulic properties while the reinforcement function is determined by the strength and deformation characteristics and mechanical properties of Geotextile. Geogrid is used mainly as a reinforcement and to strengthen the road.

Cracks formed due to differential settlement of subgrade soil result in a quick degradation of the road way, caused by the intrusion of water and oxygen. As a result of stress concentration the lifetime of the concrete pavement is further reduced. The process of crack elongation due to stress concentration is known as reflective cracking. Using Geogrid as reinforcement and Geotextile to form a impervious layer on the site with a sprayed bituminous coat which enables it to perform four essential functions: Strengthening, sealing, stress reduction and surface adhesion.

Remedial Scheme

Longitudinal subsurface drains on both sides along the road is needed to catch subsurface water flow seeping out from soil subgrade below the road. A subsurface drain is designed below an open surface drain on both sides of the road with Non woven Geotextile (from Polyfelt, Austria) of 140gm/sq. variety is used to construct a wrap-around subsurface drainage as shown in Figure-5 encapsulating a drainage bay with a granular fill. Longitudinally this drainage is connected to a graded allowing free dissipation of accumulated ground and at the same time it will maintain the integrity of the surrounding soil by preventing the migration of soil fines into the granular drain and thus effectively dissipate the hydrostatic pressure.

The damaged road pavement is designed to be repaved with two layers of Geosynthetics - one layer of a high strength Bi-oriented Geogrid reinforcement (TENAX LBO 270 or LBO 201) laid within a 75mm thick Bituminous Macadam leveling course on the existing road surface. This is followed by a layer of 50 mm thick Dense Bituminous Macadam. Further, a layer of Paving Grade non-woven Geotextile, of Polypropylene continuous filaments bonded by needle punching (Polyfelt PGM14) is followed by 50 mm thick asphaltic concrete overlay.

The installation of this site has been taken up recently. The results shall be assessed by following September after the monsoon period.

Plate -1

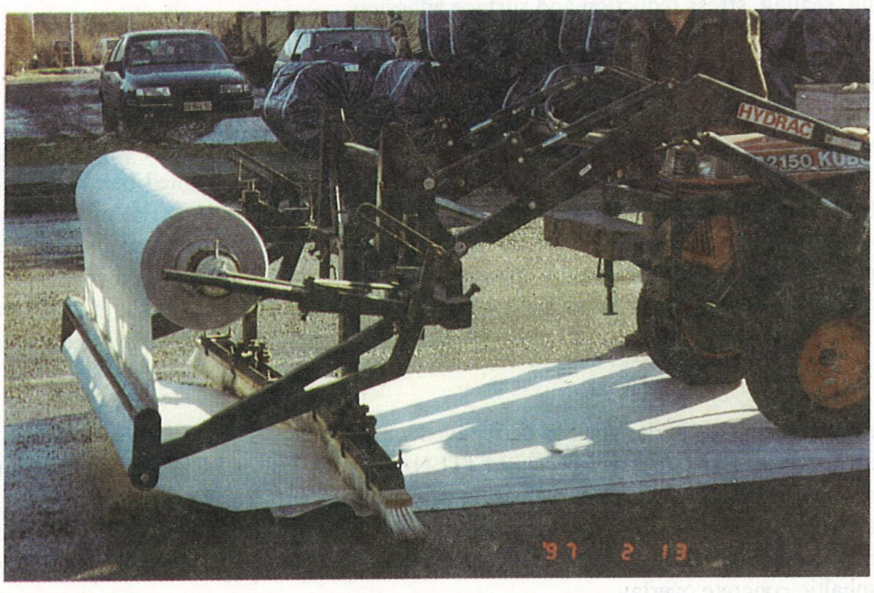


Plate-2

Salient points on Paving fabric Installation

The principal factors contributing to a longer road life consist in the sealing function performed by the bitumen-impregnated paving textile, the considerably improved evenness of the bonding, and the resulting resistance to flexural fatigue of the resurfaced asphalt concrete layer.

Paving fabric Geotextile

Paving fabric used in this application met all the requirements of paving felt materials used in asphalt road construction as specified in "Task Force No. 25/FHW - Specifications for Paving fabrics, Jan 85" as well as Specification for Roads and Bridges by Ministry of Surface Transport, which are used as existing guideline for asphalt \overlays.

Laying Paving grade Geotextile

Nonwoven Geotextile is laid partly manually and partly by machine (shown in Plate-2), taking into account that:

- when using pure bitumen as tack coat, the textile may be laid immediately after coating
- wrinkles were certainly avoided;
- edges lengthway and across overlaped by 5-10 cm; and additional pure bitumen binder of 0.9 kg/m were applied on the overlapping seams;
- transverse overlapping was carried out with reference to the direction in which the asphalt finisher will proceed i.e. each successive length of fabric is tucked under the previous one so that the fabric does not shift out of place when the asphalt concrete is applied;
- when one half of the road is made (leaving the other open to traffic) at least 25 cm of the lengthwise fabric edge must remain uncovered to allow overlapping when laying the other half of the road;
- during short term stoppages of construction work,, the road under construction was opened to slow traffic without detriment to Geotextile.
- rain water on the Geotextile surface was not allowed to evaporate before applying a top layer.

Applying the asphalt concrete surface.

The asphalt concrete surfacing was applied immediately after laying Geotextile using a Paver/finisher, material mix having a temperature of between 145° and 155° C. To avoid tyres of the finisher or truck sticking to the fabric (which usually happen in hot climate or when too much tack coat has been applied) some of the mix were spread ,manually in the pathway of the vehicles.

CONCLUSIONS

The use of Geosynthetic materials as reinforcement instead of traditional solution would provide the following advantages:-

Geogrid-Geogrid combination :

- Increase the tensile stiffness of the pavement and life and of the road by about 3 times.

- Reduces traffic induced stresses, subgrade deformation and eliminates vertical crack propagation

Geogrid-Geotextile combination :

Helps achieve following apart from the above mentioned advantage of using Geogrid ;

- Use of Geotextiles prevents intrusion of rain water and atmospheric oxygen into the road body
- Reduction in differential stresses between the substrate and the new surface layers provide excellent, uniform bonding between the layers.
- improves the quality of the road and
- The entire operation can be laid very easily and economically.

Use of Subsurface Drainage :

- Construction of side drains with Geotextile will reduce the dissipation of hydrostatic pore pressure

Saving in pavement thickness :

- Although the use of Geosynthetics can reduce the pavement thickness appreciably, it was decided to use the full pavement thickness to achieve a longer life, reducing the life cycle cost including repetitive maintenance.

REFERENCES

1. Technical Design manual of Polyfelt, Ges.m.b.H., Austria
2. Molenaar,A.A.A. (1989) Effects of mix modifications, membrane interlayers and reinforcements on the prevention of reflective cracking of asphalt layers, in Proceedings of Conference on Reflective Cracking in Pavements, Liege, pp. 225-232
3. Molenaar, A.A.A. (1983) Structural performance and design of flexible road constructions and asphalt concrete overlays, Dissertation, Delft University of Technology, Delft.
4. Gerritsen, A.H, van Gurp, C.A.P.M>, van der Heide, J.P.J., Molenaar, A.A.A., Pronk, A.C. (1987) Prediction and Prevention of surface cracking in asphalt concrete pavements, in Proceedings Sixth International Conference Structural Design of Asphalt Pavements, Ann Arbor, Vol. I pp. 378-391.
5. Jacobs, M.J.J., Bondt, A.H. de, Molenaar, A.A.A., Hopman, P.C. (1992) Cracking in asphalt concrete pavements, in proceedings Seventh International Conference on Asphalt Pavements, Nottingham, Vol. I pp. 190-198.
6. Bonnot., Oral presentation as reporter of the session on laboratory and full scale experiments. Proc. of Reflective cracking in pavements. Assessment and control. Liege, March 1993.
7. Colombier G., Fissuration des chaussees : nature et origine des fissures; moyens pour maitriser leur remontee. Proc. of Reflective Cracking in Pavements. Assessment and Controle. Liege, March 1989.
8. Rigo et al., Laboratory testing and design methods for the prevention of reflective cracking interlayers. Proc. of Reflective cracking in pavements. Assessment and Control. Liege, March 1989.
9. Fock G. The use of paving felts to influence the life expectancy and permanent adhesion of asphalt road surfaces. Proc. of Reflective Cracking in Pavements. Assessment and Control. Liege, March 1989.

GEOGRID INSTALLATION PROCEDURE

Equipment/Material Required

- Metered distributor for pure bitumen.
- Cutting tools.
- Rubber tired roller.
- Equipment for fixing geogrid with nails and clips.
- Equipment for mechanical laydown and compacting of asphalt surface.

Sub-base preparation

1. The sub-base will be carefully cleaned, by removing the dirt, dust and vegetation. Irregularities deeper than 10 mm cracks being more than 6 mm wide will be filled; if sub-base is excessively cracked, it could be appropriate to apply a thick asphalt leveling layer.

Laying of the Geogrids and of the asphalted surface

2. Measurement of the surface on which the Geogrids will be laid; The Geogrids could be cut with a disc-saw.
3. The Geogrids will be unrolled; if available , it is possible to use an auxiliary mechanical equipment (Plate-2). To ensure a correct impregnation of the Geogrids a brush can be used. A rubber tired roller will pass on the Geogrids. Particular care should be taken during Geogrids laydown, to avoid folds and wrinkles and the geogrid will be fixed to the road surface using clips and nails.
4. First 2 m of Geogrids will be unrolled and fixed, with the Geogrids face down, to ensure a correct positioning.. On one end the grid shall be held with a tensioning beam to stretch the wrinkles by applying a pull of about 2 Kn/m, while the other end is stappled to the road surface.
5. A quantity of about 0.80 to 1.2 l/sqm. of pure bitumen will be sprayed on the prepared surface; the spraying temperature should be 140° on a surface at least 15 cm wider than the Geogrids dimension.
6. When the Geogrid is correctly impregnated, mechanical lay down of asphalt surface will begin. Acceleration, deceleration and steering of any vehicle that needs to pass upon the Geogrids prior to paving must be reduced as possible. During this phase, temperature should not exceed 150°.

NON-WOVEN GEOTEXTILE INSTALLATION PROCEDURE

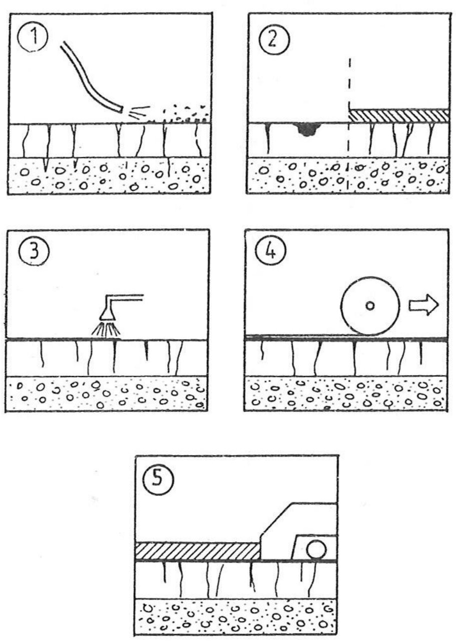


Fig. 6: Construction stages

1. Clean the road surface.

2. Fill cracks (>4 mm) and potholes or apply a levelling layer.

3. Uniform spray application of bituminous tack coat (approx. 1.1 kg/m^2 of residual bitumen when laying asphalt concrete; and approx. 0,7 kg/m^2 in surface treatments). The required quality of the tack coat material depends on climatic conditions and the type of the new surface.

4. Geotextile is laid by rolling on to the tack coat. A pretensioning or nailing is not necessary.

5. The application of the asphalt overlay can proceed immediately after the installation of Geotextile , additional bitumen is not necessary. The temperature of the overlay should not exceed 160° C on contact with Geotextile (i.e. max. 185° C mixing temperature). In surface treatments, the quantity of residual tack coat for the first stone chip layer should be increased by approx. 0,3 kg/m^2.