PAVEMENT EVALUATION AND APPLICATION OF GEO TEXTILES IN PAVEMENTS

[1] Naragani V V Gopala Rao [2] J.Sowjanya
[1]PG Student,Dept.of CIVIL, MVR College of Engg & Tech. Vijayawada Rural, Paritala, A P, India 5221180.
[2]Assistant Professor, CIVILDept. MVR College of Engg & Tech. Vijayawada Rural, Paritala, A P, India 5221180.

ABSTRACT

Geotextiles have been widely promoted for pavement structure. However, there is a lack of well-instrumented, full-scale experiments to investigate the effect of geotextile reinforcement on the pavement design. In this study, full–scale accelerated tests were conducted on eight lanes of pavement test sections. the lots of indoor and outdoor experiments, several key technical issues in construction of the Desert Highway have been solved satisfactorily, on the basis of great achievements of the studies in respects of dry compaction on sand base, design parameters, structure combination of subgrade and pavement, stabilization analysis of sand base strengthened with geotextile and a complete set of construction techniques. Using geotextiles in secondary roads to stabilize weak subgrades has been a well-accepted practice over the past thirty years.

Two design methods were used to quantify the improvements of using geotextiles in pavements However, from an economical point of view, a complete life cycle cost analysis (LCCA), which includes not only costs to agencies but also costs to users, is urgently needed to assess the benefits of using geotextile in secondary road flexible pavement. Two design methods were used to quantify the improvements of using geotextiles in pavements. In this study, a comprehensive life cycle cost analysis framework was developed and used to quantify the initial and the future cost of 25 representative low volume road design alternatives. The sub grade must be stable, unyielding, properly drained and free from volume changes due to variation in moisture. If not, it leads to failure of pavement. Normally, pavement fails due to the reasons such as structural, functional, or materials failure, or a combination of these. But in the study area, it is observed that, the pavement failure is under the category of structural failure.

1.0 INTRODUCTION

The economic development of a country is closely related to its road transport infrastructure facilities available. Especially in an under developing country, the rural roads connecting agricultural villages is vital in improving the rural economy. It is known that the option of unpaved roads are economical for low traffic volume in such areas, however, when unpaved roads laid on soft sub-grade undergoes large deformations, where the periodical maintenance of the rural road is limited due to cost considerations, which may disrupt the service and affect the function of the road. In such situations, comparing various other methods, geo-synthetics can be utilized to improve not only the performance of the unpaved road by increasing the life time, but also, minimizing the maintenance cost as well as reducing the thickness of the road. India has one of the largest road networks in the world, aggregating to about 33 lakh km at present. However many of the existing roads are becoming structurally inadequate because of the rapid growth in traffic volume and axle loading. At locations with adequate subgrade bearing capacity/CBR value, a layer of suitable granular material can improve the bearing capacity to carry the expected traffic load. But at sites with CBR less than 2% problems of shear failure and excessive rutting are often encountered. The ground improvement alternatives such as excavation and replacement of unsuitable material, deep compaction, chemical stabilization, pre loading and polymeric geo synthetics etc are often used at such sites. The cost of these processes as well as virgin material involved is usually high and as such they are yet to be commonly used in developing nations like India. In this context natural fiber products hold promise for rural road construction over soft clay.

India is the first largest country, producing coir fiber from the husk of coconut fruit. The coir fiber (50 to 150 mm long and 0.2 to 0.6 mm diameter) till recently were spun into coir yarn and then woven to obtain woven nettings. The fibers are now a days being needle punched or adhesive bonded to obtain non-woven products or blankets. Geotextiles are proving to be cost effective alternative to traditional road construction method. Studies have indicated that the biodegradability of coir can be used to advantage and the coir based geotextile have the potential of being used for rural road construction over soft clay. In paved and unpaved road construction, geo-synthetic reinforcement has been applied to improve their overall strength and service life. The stabilization of pavements on soft ground with geotextiles is primarily attributed to the basic functions of separation of base course layer from subgrade soil, reinforcement of composite system etc. But these synthetic products are biodegradable and cause environment problems, whereas natural geotextile like coir is biodegradable.

The report presents the results of CBR and plate load test carried in a model test tank simulating rural roads with coir geotextiles. The results of the test in the laboratory and the construction of road stretches at 3 locations, with each 100m length are encouraging for use in developing countries (like India) in rural roads that are yet to be developed to connect as many as 0.2 million villages as most of these roads happen to be on soft clay.

Geotextiles:

Textiles were first applied to roadways in the days of the Pharaohs. Even they struggled with unstable soils which rutted or washed away. They found that natural fibers, fabrics, or vegetation improved road quality when mixed with soils, particularly unstable soils. The first use of textiles in American roadways was in the 1920s. The state of South Carolina used a cotton textile to reinforce the underlying materials in a road with poor quality soils. Evaluation several years later found that the textile was still in good workable condition. When synthetic fibers become more available in the 1960s, textiles were considered more seriously for roadway construction and maintenance. During the past thirty years, geotextiles have been known to be good for improving the performance of paved or unpaved roads. Both woven and nonwoven geotextiles can be effectively used in the separation/stabilization of primary highway, secondary or low volume roads, unpaved and paved (access roads, forest roads, haul) roads, parking lots, and industrial yards.

2.0 LITERATURE REVIEW

The roadway considered in this study is a secondary road system. It is hypothesized that geotextiles work as a cost effective separator between the granular base layer and the natural subgrade of the pavement. It is reported that geotextiles improve pavement performance by preventing the intermixture of subgrade fines and base layer. If, in the absence of a geotextile at the subgrade/base course interface, aggregate contamination by the subgrade fines occurs, the overall strength of the pavement system will be weakened. As for cost considerations, vehicles keep a uniform speed through the work zone. The vehicle arrival and discharge rate from queue remains constant. The user delay costs must be represented by a constant average per vehicle hour. In addition, the traffic volume for both directions is available; the maintenance or rehabilitation cost is a linear function of the work zone length. The time required to maintain or rehabilitate a work zone is also a linear function of the work zone length. The combined traffic volume from both lanes should be smaller than the capacity of one lane

Hans and Andrew (2001) investigated the reinforcement function of geo synthetics for a typical Minnesota low volume roadways. From the study it was observed that the addition of a geo synthetic does provide reinforcement to the roadway as long as the geo synthetic is stiffer than the subgrade material. The service life of a roadway may also be increased with the addition of geo synthetic reinforcement. It was also observed that the deflection response of roadway is governed by the Young's modulus of the geo synthetic used. Since the deflections were controlled by the Young's modulus of the geo synthetic; the largest modulus geo synthetic produced the largest increase in service life.

Schriver at al. (2002) conducted experimental study on geogrid reinforced lightweight aggregate beds to determine their subgrade modulus and increase in the bearing capacity ratio. From study it was observed that the geogrid reinforcement placed at sub base/aggregate interface effectively increases the service life of paved roads. Geogrid reinforcement provides a more uniform load distribution and a deduction in maximum settlement more at the asphalt-aggregate and aggregate-subgrade interface.

Ranadive (2003) investigated the performance of geotextiles reinforcement in soil other than sand. In this study, model strip footing load tests are conducted on soil with and without single and multi-layers of geotextile at different depths below the footing. Testing was carried out on Universal Testing Machine. From the study it was observed that bearing capacity improved considerably for reinforced soil over unreinforced soil. It was observed that for a single layer system, BCR (Bearing Capacity Ratio) for a depth of layer below footing equal to 0.25B is maximum where B is the width of the footing and BCR decreases as the depth of layer increases and for multilayer system, BCR for a constant d/B ratio and S/B ratio, (where d is the depth of single reinforcing layer below footing and S is spacing between subsequent geotextile reinforcing layers when depth of top layer below footing was kept constant equal to 0.25B). The BCR is maximum for N=4 but the percentage increase in BCR for N=4 over BCR for N=3 is very low. Thus N=3 is recommended as optimum value.

Lyons, C.K. and J. Fannin (2006) conducted plate load test to study the variation of load carrying capacity for both reinforced and unreinforced pavements. It was observed that the bearing capacity improved by providing coir geotextiles as reinforcement. She reported an increase in bearing capacity by 1.83 times for reinforced pavement compared to unreinforced pavement.

Venkatappa and Dutta (2005) conducted monotonic and cyclic load test on Kaolinite with geotextile placed at the interface of the two soils. It was found bearing pressure of the soil improved by about 33% when reinforced with coir geotextiles. Indian Roads Congress also suggest in its Rural Road Manual the use of coir geotextile but no design methodology, construction guidelines and product specifications are mentioned.

Bhosale, S.S. and B.R. Kambale (2008) Review of the information obtained from the various sources in this literature search revealed that some research has been conducted on the use of geotextiles in flexible pavement for road construction. Much of the work has been limited to small laboratory studies with little published information on full-scale field and/or long-term investigations. There are various standard design procedures for flexible and rigid pavements available; however, they do not include the use of geotextiles. This study revealed that there are design guidelines and procedures available where geotextiles are considered for flexible pavement road construction. Some of these procedures will be mentioned; however, details are not given in this report but can be obtained from the respective references. A brief summary on the most comprehensive work to date on geo synthetic (geogrid or geotextile) use in base courses for flexible pavements is given below along with other items related to geotextile usage that are considered to be important.

3.0 Design guidelines and procedures for using geotextiles in flexible pavement road construction can be found in the "Geotextile Engineering Manual" and "Geotextile Design and Construction Guidelines." Design examples for geotextiles used in flexible pavement for roads are also given in the "Geotextile Engineering Manual" and in "Geotextile Engineering Workshop Design In using geotextiles in the design of flexible pavement for roads no structural support is assumed to be provided by the geotextile, and therefore, no reduction is allowed in the aggregate thickness required for structural support Standard design methods are used for the overall pavement system. Aggregate savings can be achieved when using a geotextile through a reduction in the aggregate required in the first lift referred to as the "stabilization lift." Sufficient stabilization of the subgrade (CBR < 3) is provided to allow access of normal construction equipment for the remaining structural lifts. The stabilization lift thickness using a geotextile is determined as that for an aggregate surfaced pavement which will only be subjected to limited number of construction equipment passes. Geotextiles have proven to be among the most versatile and cost-effective ground modification materials. Their use has expanded rapidly into nearly all areas of civil, geotechnical, environmental, coastal, and hydraulic engineering. They form the major component of the field of geosynthetics, the others being geogrids, geomembranes and geocomposites. The ASTM defines geotextiles as permeable textile materials used in contact with soil, rock, earth or any other geotechnical related material as an integral part of civil engineering project, structure, or system. Based on their structure and the manufacturing technique, geotextiles may be broadly classified into woven and nonwoven. Woven geotextiles are manufactured by the interlacement of warp and weft yarns, which may be of spun, multifilament, fibrillated or of slit film. Nonwoven geotextiles are manufactured through a process of mechanical interlocking or thermal bonding of fibers/filaments.

Mechanical interlocking of the fibers/filaments is achieved through a process called "needle punching". Needle-punched nonwoven geotextiles are best suited for a wide variety of civil engineering applications and are the most widely used type of geotextile in the world. Interlocking of the fibers/filaments could also be achieved through "thermal bonding". Heat-bonded geotextiles should be used with caution, as they are not suitable for filtration applications or road stabilization applications over soft soils.

Geotextile:

Geotextiles are polymer fabrics used in the construction of roads, drains, harb our works, and break waters, and for land reclamation and many other civil engineering purposes. Geotextiles, a newly emerging field in the civil engineering and other fields, offer great potential in varied areas of applications globally.

Woven geotextiles:

Consist of monofilament, multifilament, slit-film and/or fibrillated slit-film yarns - often in combinations - that are woven into a geotextile on conventional textile weaving machinery using a wide variety of traditional, as well as proprietary, weaving patterns. The variations are many and most have a direct influence on the physical, mechanical and hydraulic properties of the fabric. The resulting woven geotextiles are typically flexible, exhibit high strength, high modulus, low elongation, and their openings are usually direct and predictable.

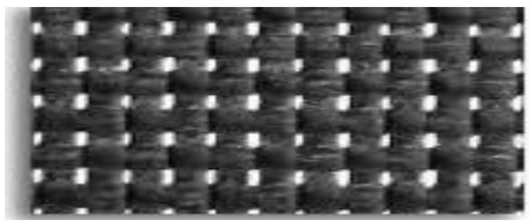


Figure 3.1 Woven geotextiles

Nonwoven geotextiles:

Consist of fibers that are continuous filament or short staple fibers. These fibers are then bonded together by various processes that can include a needling process that intertwines the fibers physically (needle punched), or a chemical / thermal bonding operation that fuses adjacent fibers together. The resulting nonwoven geotextiles have a random fiber orientation with high porosity and permeability, but indirect and unpredictable openings, a thickness ranging from thick felt to a relatively thin fabric, and low modulus and high elongation (needle punched).

RESULTS

In this study two material models were considered for the HMA layer: elastic and creep model. Initially, the HMA layer was modeled based only on its elastic modulus. The elastic model, however, could not show permanent strain in this layer after unloading; the layer rebounded after removal of the load and the vertical plastic strain in this layer was zero. Therefore, the elastic model is not an appropriate model for HMA and other pavement layers. Plastic deformation of aggregate base and subgrade layer has a defining role in determining pavement performance. A majority of rutting in HMA pavements happens due to permanent deformation of the base and/or subgrade layer(s). Therefore, an accurate model should consider plastic behavior of the underlying layers

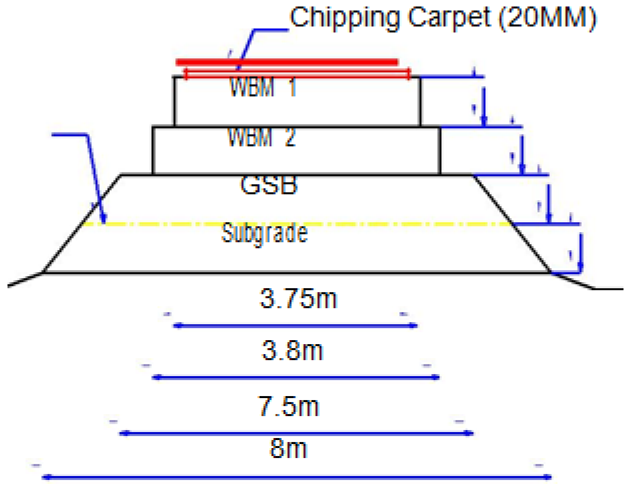
HMA Layer Properties:

Plastic behavior of the HMA layer was modeled using creep properties. The elastic modulus and Poisson's ratio were used to model elastic behavior of the HMA layer. Elastic layer moduli for each section were back calculated from surface deflection data obtained in the FWD test. Poisson's ratios were estimated to be typical values because their effects on the back calculation 63 process were negligible. The creep model was defined by five material parameters which define time-dependent behavior of the HMA material: creep parameters, A, m, and n. In order to obtain these parameters, flow test was conducted on samples compacted by the Super paver Gyratory compactor with loose asphalt samples from CISL test sections. The test was conducted following AMPT Flow Test Protocol developed in the NCHRP study.

The stretches for the 800m to 900m is chosen as the test stretch

Design of Section H1:

Geo textiles are to be placed between sub grade and sub base as shown in Fig

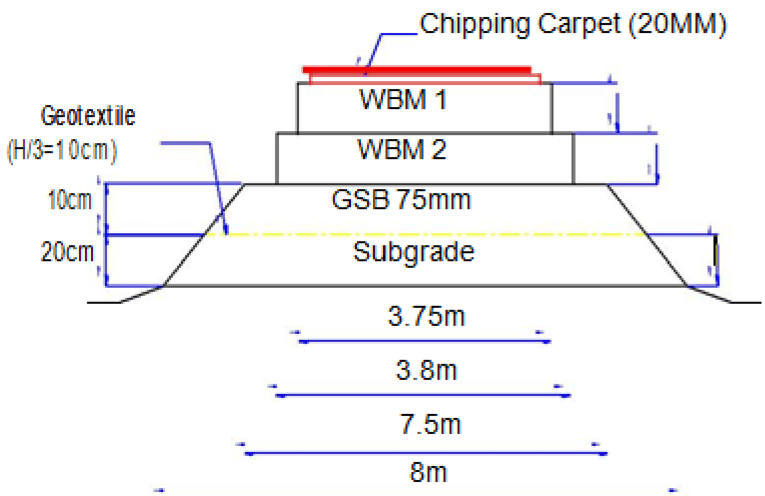


Design of Section H2:

Chain age from 825m to 850m

Thickness of subgrade 300m

Jute reinforcement are placed at a depth of h/3 from top of subgrade. h/3 = 300/3 = 100m as shown in Fig.

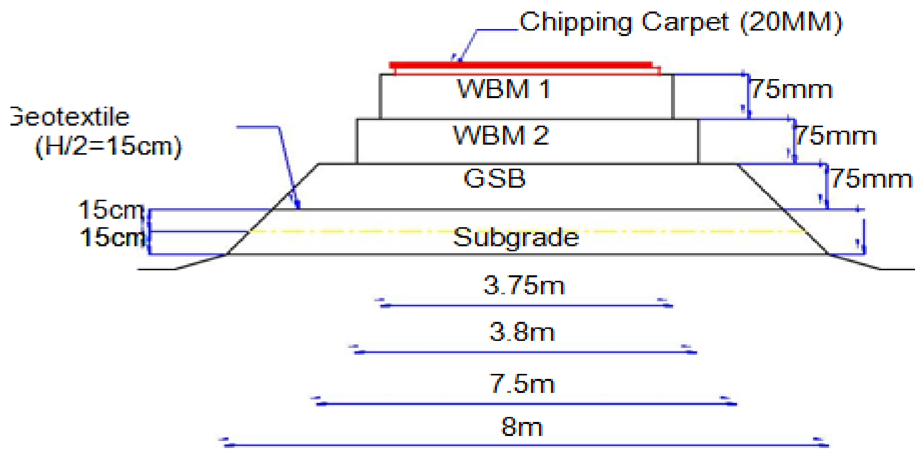


<u>Design of Section H3</u>

Chain age from 825m to 850m

Thickness of sub grade 300m

Reinforcement are placed at a depth of h/3 from top of subgrade. h/2 = 300/2 = 150m as shown in Fig.



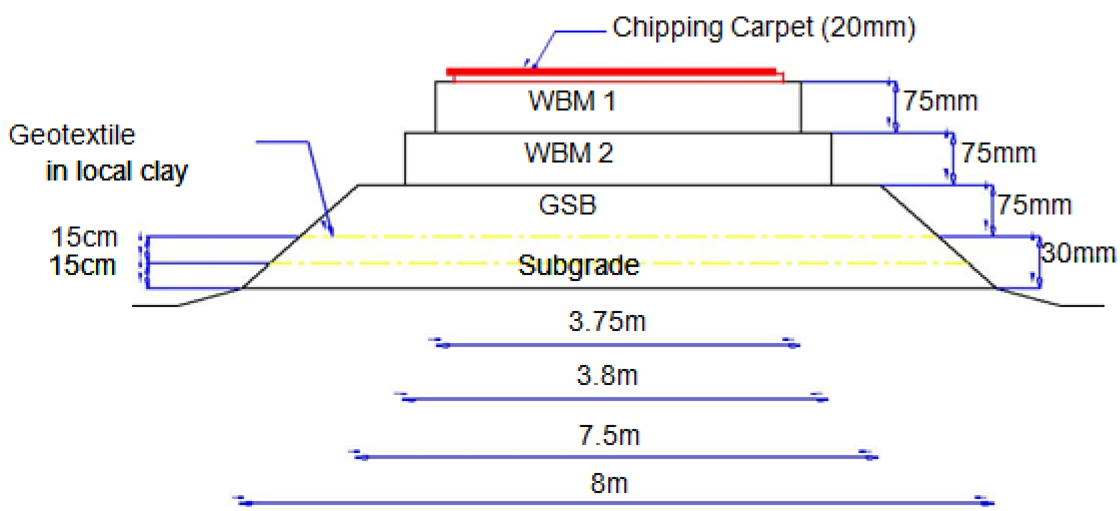
Design of Section H4:

Chainage from 1460m to 1480m

Thickness of subgrade 300mm

Top 30cm depth of the sub grade is locally available clay

Reinforcement are providing at the top and 15cm from the top of locally available clay material as shown in Fig



Design of Section V3

Chain age from 1130m to 1155m

Thickness of subgrade 300mm

Reinforcements are placed at a depth of h/3 from top of subgrade. h/3 = 300/2 = 150mm as shown in Fig.

5.0 CONCLUSION

The available literature involving field, laboratory and numerical study results demonstrate that Geo synthetics materials can use separation, reinforcement, and filtration, drainage, and containment functions of the pavement. Pavement performance can be improved by placing geo synthetics at the upper one-third of the base course layer. Geo grids helps in less accumulated permanent deformation in the subgrade layer by redistributing the traffic load over a wide area on the subgrade. Approximately half of the thickness reduction resulting from geo grid reinforcement is possible in clay subgrade by interlocking effect when it is placed in a convex shape.

Modified AASHTO design results that about 20% to 40% base course reduction is possible using geo grid in pavement design, with greater percentage reduction for stronger subgrade materials. Future research works are needed for designing the geo grid reinforcement pavement by Mechanistic-Empirical design method and efforts are needed to establish the guideline for placement of geo grid in the pavement.

The CBR values thus reported with Geo textiles at various depths of soil samples gives varied results.

1) The CBR value is comparatively least for sample in which Geotextile is not used and thus pavement thickness is higher.

2) The CBR value recorded for sample in which Geotextile used is higher than of in which Geotextile is not used and thus pavement thickness is less

3) The CBR value is maximum for sample where Geotextile is places at depth of 6cm (middle) of CBR mould and thus Pavement thickness is minimum

4) The use of Geotextile thus reduces the pavement thickness.

5) Thus use of Geotextile improves and stabilizes the sub base properties

REFERENCES

[1] Masad, E. A., and Little, D. N.(2012). "Comparing finite element and constitutive modeling techniques for predicting rutting of asphalt pavements" International Journal of Pavement Engineering, 13(4), 322-338.

[2] Abduljauwad, S. N. (1996)." Effect of geotextile on permanent deformation in salt-encrusted subgrade soils" Transportation Research Record: Journal of the Transportation Research Board, No. 1534, Transportation Research Board, Washington, D.C., pp. 40–49

[3] Qin, H., and Liu, X. (2010). "Unsaturated creep tests and empirical models for sliding zone soils of Qianjiangping landslide in the Three Gorges.", Journal of Rock Mechanics and Geotechnical Engineering 20(2), pp.49-54.

[4] Bhosale, S.S. and B.R. Kambale (2008) "Laboratory Study on Evaluation of Membrane Effect of Geotextile in Unpaved Road," The 12th International Conference of International Association for Computer Methods and Advances in Geo mechanics, Goa, India, 4385-4391.

[5] Tan and K.W. Leong (2005) "Performance of Geotextiles Stabilized Unpaved Road Systems Subjected to Pretensioning," Geo-Frontiers-2005, Annual ASCE Conference Proceedings, Austin, Taxes, USA, Vol. 155, 405-412.

[6] Attoh-Okine (2008) "Effect of Geogrid in Granular Base Strength – An Experimental Investigation," Construction and Building Materials, Vol. 22, 2180-2184.

[7] Giroud, J.P. and J. Han (2004) "Design Method for Geogrid-Reinforced Unpaved Roads I. Development of Design Method," Journal of Geotechnical and Geo environmental Engineering, ASCE, Vol. 130, No. 8, 775-786

[8] Giroud, J.P. and J. Han (2004),"Design Method for Geogrid-Reinforced Unpaved Roads Calibration and Applications," Journal of Geotechnical and Geo environmental Engineering, ASCE, Vol. 130, No. 8, 787-797.

[9] Hu, Y.C. and Y.M. Zhang (2007) "Analysis of Load-Settlement Relationship for Unpaved Road Reinforced with Geogrid," First International Symposium on Geotechnical Safety and Risk, Tongji University, Shanghai, China, 609-615.

[10] Lyons, C.K. and J. Fannin (2006) "A Comparison of Two Design Methods for Unpaved Roads Reinforced with Geogrids," Canadian Geotechnical Journal, Vol. 43, 1389-1394.