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Advanced Use of Geotextiles in Pavement Design

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Abstract— The various geosynthetic products have the broadest range of properties that will strengthen the pavement design by adhering to the strict nomenclature associated with geotextile materials. Considerable increase in length of roads in India has increased the necessity of rapid, economic and sustainable construction methodologies. Thus, at various construction stages of pavement the use of additives has gained significance over the period of time. Geotextiles are an important product for increasing the strength of the soil subgrade. The use of geotextiles in soil subgrade pavements has resulted in a massive increase in the value of geotextile products. This improves not only the strength but also the drainage characteristics of the soil subgrade. Keeping the use of geotextile in pavement application in mind, it can be divided into several parameters such as separation, filtration, drainage, reinforcement, and mitigation. Geotextile also functions as a permeable synthetic textile material.

This Study involves a stretch of village road in Ganderbal district. Test were conducted on the virgin soil with various percentages of geotextiles. These percentages of addition of geotextiles were in the order of 0.5 %, 1 %, 1.5 %, 2 % and 2.5 %. Lab tests on the specimen provided us with the effect of increase of geotextile percentage on the properties of soil such as liquid limit, plastic limit, MDD, OMC and CBR value. At 2.5 % of geotextile added, the most favorable properties were obtained. On the test section of the road 2.5 % geotextile was introduced between subgrade and sub-base and field test, DCP was performed to evaluate the penetration of geotextile road and compare it with non-geotextile road. The average values obtained for test road section with and without geotextiles are 5.44mm/blow and 6.05mm/blow respectively.

I. INTRODUCTION

When dealing with difficult construction sites in the past, the conventional practice was to either replace the unsuitable soils or bypass them with costly deep foundations. Furthermore, the age-old problem of land scarcity and the need to rebuild ageing infrastructure in urban areas, increased awareness of seismic hazards, and regulations mandated for various environmental problems have fueled the evolution of a number of ground improvement techniques over the last 25 years. Innovative ground modification approaches are routinely used now to solve unique soil-related problems, and often are considered to be the most economical means to improve an undesirable site condition.

Geosynthetics 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.

Geotextile use is now one of the most important practices in pavement design and construction. It has already been shown to be beneficial in almost all conditions, with the exception of a few. Pavement with varying traffic volumes faces problems such as depression on the surface, cracks, unstable sub base, drainage and seepage, and so on, depending on a variety of factors such as soil properties, sub base properties, and so on. The following are the main characteristics of geotextiles that are relevant to this project:

A. Physical Properties: - Specific gravity, density, thickness, stiffness, and so on are examples of physical properties.

B. Mechanical properties: - Tensile strength, flexibility, compatibility, tearing strength, bursting strength, puncturing strength, and other

C. Endurance Properties: - Elongation, abrasion resistance, clogging length, and flow, among other things.

1.1 Geotextiles

Geotextiles were first used as erosion control devices as an alternative to traditional granular fill. The initial selection criteria for geotextiles in filtration applications were permeability, soil retention capacity, strength, and elastic modulus. French researchers began using geotextiles for separation and reinforcement purposes in the late 1960s.They installed non-woven needle-punched fabrics in unpaved roads, rail road foundations, and soil embankments, recognizing the ability of these fabrics to prevent the mixing of dissimilar materials and the fouling of granular layers. They also realized the ability of fabrics to dissipate pore water pressures by allowing within plane flow of water.

1.1.1 Types of Geotextiles

Geotextiles are made up of polymers such as polyester or polypropylene. They are divided into 3 categories on the basis of the way they are prepared, woven fabric geotextile, non-woven geotextile and knitted geotextile.

Woven Fabric Geotextiles: - Geotextiles are commonly found to be woven and are produced using techniques similar to those used to weave traditional clothing textiles. This type is distinguished by the appearance of two parallel sets of threads or yarns. The yarn that runs along the length is referred to as warp, and the yarn that runs perpendicular to it is referred to as weft.

Non-Woven Geotextiles: -Nonwoven geotextiles are made of continuous filament yarn or short staple fiber. Fiber bonding is accomplished through the use of thermal, chemical, or mechanical techniques, or a combination of these methods. Geo-fibers obtained through mechanical interlocking or chemical or thermal bonding have a thickness of 0.5-1 mm, whereas chemically bonded non-wovens are typically 3 mm thick.

Knitted Geotextiles: -Knitted geotextiles are made by interlocking a series of yarn loops together. All knitted geosynthetics are created by combining the knitting technique with another method of geosynthetics production, such as weaving. Aside from these three geotextiles, other geosynthetics used include geonets, geogrids, geo-cells, geomembranes, geocomposites, and so on, each with their own distinct features and applications.

1.1.2 Applications

Separation - in which a geosynthetic placed between two dissimilar geotechnical materials, prevents intermixing;

Filtration - in which a geotextile allows passage of fluids from a soil while simultaneously preventing the uncontrolled passage of soil particles;

Drainage - in which a geosynthetic may collect and transport fluids in its own plane;

Reinforcement - in which, a geosynthetic resists stresses and contains deformations in geotechnical structures by the tensile characteristics.

II. OBJECTIVES

The main objectives of our study are as follows:

1. To study the influence of soil properties, aggregate properties, and geotextile properties on geosynthetic use in pavements.
2. To develop a laboratory testing plan that would allow for a direct evaluation of the benefit of geotextile separators for a variety of pavement structures.
3. To measure the shear strength and penetration resistance of soil, aggregate, and asphalt layers by using a portable testing device called the Dynamic Cone Penetration (DCP).

III. MATERIAL & METHODOLOGY

The selected project is being undertaken in Jammu and Kashmir to develop roads in a small village of Ganderbal district.

Fig 1: soil

3.1 GEOTEXTILES

Geotextiles are permeable fabrics that, when combined with soil, can separate, filter, reinforce, protect, or drain. They are typically constructed of polypropylene or polyester. Non-woven geotextile from The Crewel Fabrics Srinagar was used.

Fig 2: Geotextile

3.2 EXPERMENTAL PROCEDURE

STAGE 1: This stage involved the collection of soil samples from the study area as well as collection of geotextiles from the vendor.

STAGE 2: The soil samples were taken to the lab and a number of experiments like sieve analysis, liquid limit, plastic limit, Standard proctor test and CBR tests were carried out to determine the properties of soil.

STAGE 3: In this stage the geotextiles in the percentages of 0.5%, 1%, 1.5%, 2% and 2.5%were added to the soil sample.

STAGE 4: Effect of varying percentages of geotextiles on plastic limit and liquid limit was found out by calculating platic limit and liquid limit for the percentages of geotextiles as mentioned in stage 3.

STAGE 5: In this stage we calculated the MDD and OMC for soil specimen at varying percentages of geotextiles through standard proctor test.

STAGE 6: The CBR values for soil samples were calculated for different percentages of geotextiles.

STAGE 7: We compared the values of the percentage addition of geotextiles and choose the percentage at which CBR value was maximum.

STAGE 8: We added the geotextile to the test section of the road in the percentage for which the lab results were maximum.

STAGE 9: Field test like Dynmaic cone penetometer was carried out on pavement for both the stretches with and without Geotextile.

STAGE 10: The values of penetration were compared and a conclusion was drawn.

Table 1: Properties of soft soil

Soil properties	Description
Liquid limit	59.14
Plastic limit	46.23
Plasticity index	12.91
Optimum moisture content	17.1
Maximum dry density	1.97
CBR value (soaked)	3.15
Specific gravity	2.45

IV. RESULTS AND DISCUSSION

4.1 Effect of Liquid Limit

Geotextiles were added in the percentages of 0.5%,1%,1.5%,2% and 2.5% to the soil sample and the liquid limit was calculated for these soil samples. The values in the below table show the values of liquid limit for various percentages of geotextiles.

Table 2: Values of liquid limit for varying percentages of Geotextiles

Geotextile (%)	Liquid limit (%)
0	59.14
0.5	58.18
1	54.38
1.5	51.41
2	45.61
2.5	40.36

There is a decrease in liquid limit as we increase the percentage of geotextile. As we increase the percentage to 0.5% the value of liquid limit decreases by 1.62% and kept on decreasing as we increase the value of geotextile to 40.36 for 2.5 % geotextile addition which is a decrease of 31.75%. The values of liquid limits from the above table are represented in the graph below.

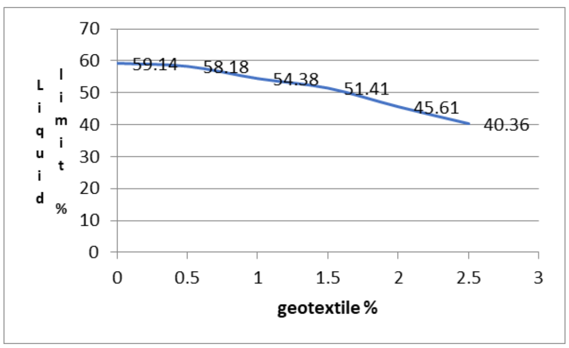

Fig 1: Liquid limit vs geotextile percentage Graph

4.2 Effect of Plastic Limit

Geotextiles were added in the percentages of 0.5%,1%,1.5%,2% and 2.5% to the soil sample and the Plastic limit was calculated for these soil samples. The values in the below table show the values of Plastic limit for various percentages of geotextiles.

Table 3: Values of Plastic limit for varying percentages of Geotextiles

Geotextile (%)	Plastic limit (%)
0	46.23
0.5	42.12
1	37.36
1.5	33.27
2	30.38
2.5	28.63

There is a decrease in Plastic limit as we increase the percentage of geotextile. As we increase the percentage to 0.5% the value of Plastic limit decreases by 8.89% and kept on decreasing as we increase the value of geotextile to 28.63 for 2.5 % geotextile addition which is a decrease of 38.07%. The values of Plastic limits from the above table are represented in the graph below.

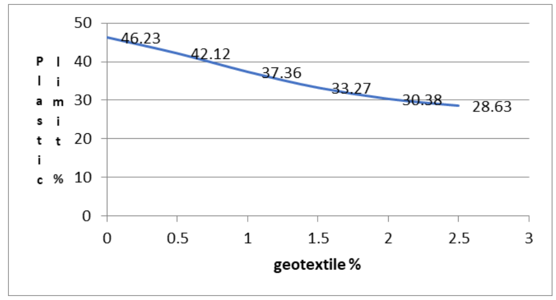

Fig 3: Plastic limit vs geotextile percentage Graph

4.2 Effect of compaction properties

Maximum dry density (MDD) and optimum moisture content (OMC) of all trial mixtures were determined in the laboratory in accordance with IS: 2720 (Part 8) - 1983. A standard proctor test was performed to determine the correlation between dry density and moisture content.

Table 4: MDD and OMC for varying percentages geotextile mix

Geotextile (%)	OMC (%)	MDD(g/cc)
0	17	1.97
0.5	14	1.98
1	13	1.99
1.5	12	2.02
2	12.1	2.11
2.5	12	2.23

The above table shows the values for OMC and MDD for various percentages of geotextiles. It can be seen that as we increase the percentage of geotextile in soil there is a decrease in OMC and increase in MDD. The same has been shown in the graph below.

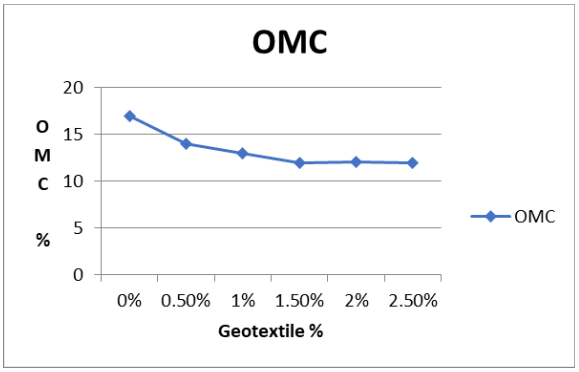

Fig 4: OMC vs varying percentages of geotextile mix

The above graph shows the decrease in OMC as the percentage of geotextile is increased.

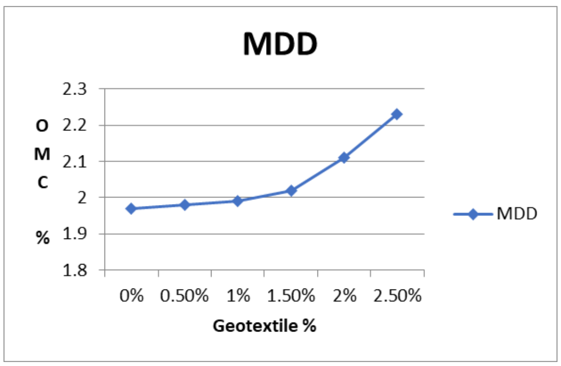

Fig 5: MDD vs varying percentages of geotextile mix

The above graph shows the increase in MDD as the percentage of geotextile is increased.

4.3 Effect of CBR

The specimens have been compacted at their OMC and MDD from the Proctor test, and the test was run until 12.5mm of penetration was achieved. The test was performed on soaked samples.

Table 5: CBR values for Soil Mixed With varying percentages of Geotextile

S no	Geotextile (%)	CBR (%)
1	0	3.15
2	0.5	3.88
3	1	3.59
4	1.5	4.04
5	2	4.11
6	2.5	5.61

From the values of CBR from the above table it can be seen that we increase the value of Geotextile there is an increase in the value of CBR with most increase being for 2.5% geotextile addition an increase of 78 %.

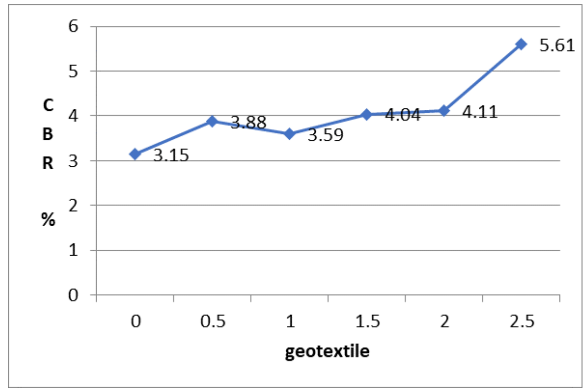

Fig 6: CBR vs geotextile percentage graph

4.4 Dynamic Cone Penetration Test

DCP test is conducted on the pavement and the depth of penetration is taken as 300 mm and the penetration value obtained is plotted with the number of blows in graphs. The initial/reference reading was found to be 20mm.

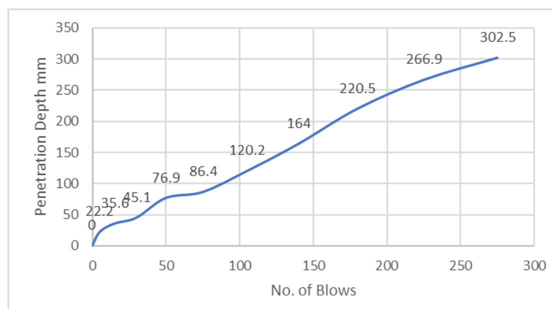

Fig 7: Penetration vs no of blows for road without geotextile

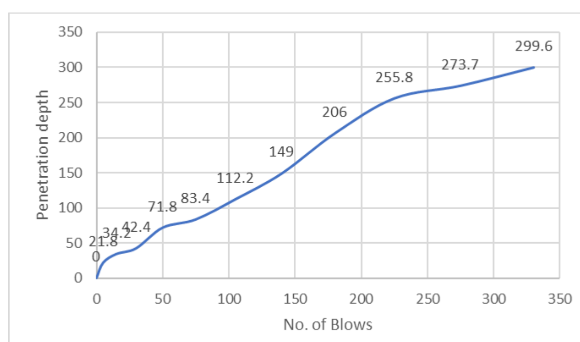

Fig 8: Penetration vs no of blows for road with geotextile

The average values obtained for without geotextile test and with geotextile-reinforced test sections are 6.05 mm/blow 5.44 mm/blow respectively.

V. CONCLUSION

The effects of increase of geotextile percentage on soil are as such: -

1. With increase in geotextile percentage both liquid limit and plastic limit decreased.
2. With increase in geotextile percentage while OMC decreased and MDD increased.
3. Increase in percentage of geotextile in the soil sample caused CBR to increase and the maximum value being 78 % increased for 2.5 % geotextile.
4. The average values obtained for without geotextile test and with geotextile-reinforced test sections are 6.05 mm/blow 5.44 mm/blow respectively.
5. It can be seen that all geotextile reinforced sections required higher number of blows for penetrating of 300 mm depth of subgrade than that of unreinforced section. Therefore, it can be concluded that there is an increase in the strength of pavement in the geotextile reinforced section.

REFERENCES

[1] *Olukayode Olawalw Alao, Ifedapu Oduyemi, September, 2011,*"The Use of Geosynthetics in Road construction (Case Study – Geotextile."*Bachelor of Engineering in Civil EngineeringAdvisor: Engineer(Mrs) A.B Oluyemi.*

[2] *Cazzuffi, D. (1987), "The use of geomembranes in Italian dams. "Water Power and Dam Construction.."Pages: 17-21*

[3] *Bhavesh Joshi, Dr. R.P Arora, Nov 2015, "Pavement Design By Using Geotextile."International Journal of Civil Engineering and Technology (IJCIET) Volume 6, Issue 11, Nov 2015, pp. 39-44,*

[4] *Al-Qadi, I. L., T. L. Brandon, R. J. Valentine, and T. E. Smith. 1994"Laboratory Evaluation of Geosynthetic Reinforced Pavement Sections", In Transportation Research Record: Journal of the Transportation Research Board, No. 1439, TRB, National Research Council, Washington, DC, 1994, pp. 25-31.*

[5] *Al-Qadi, I., T. I. Brandon, and S. A. Bhutta. Geosynthetic Stabilized Flexible Pavements. Proceedings of Geosynthetics '97, Long Beach, CA, Mar 10-13, 1997, pp. 647-661.*

[6] *Ravindra Kumar , Utsav Singh , Priyanshu Saini , Varun Sharma, Matloob Ali, 2020, International Journal of Engineering research and technology, Volume 09, Issue 06 (June 2020).*

[7] *Aniket, S.Raut, Akshay, A. Dahiwade, Kamalshil R. Jangale3 Pratik O. Lawhale4 Sujesh D. Ghodmare, 2016,"Performance and Evaluation of Pavement Design with and without using Geotextiles",IJSRD - International Journal for Scientific Research & Development| Vol. 4, Issue 03.*

[8] *A.A. Bhosale, Swapnil K Sutar, Manjunath S Dhage, Rahul M Hattalage, Nadeem Maner, Amit B Jadhav, April, 2017,*"*Application Of Geotextile Used In Road Pavement Construction",International Journal of Engineering Technology, Management and Applied Sciences, April 2017, Volume 5 Issue 4, ISSN 2349-4476.*

[9] P.Rajendra Kumar, *"Laboratory Study of Black Cotton Soil Blended With Copper Slag and Fly-Ash*", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 2, February 2017

[10] Bharath Goud "*Stabilization of Black Cotton Soil with Copper Slag and Rice Husk Ash – An Environmental Approach",* International Journal of Science and Research, Volume 7 Issue 5, May 2018.

[11] Jaber Shahiri, *"Utilization of Soil Stabilization with Cement and Copper Slag as Subgrade Materials in Road Embankment Construction"*, International Journal of Transportation Engineering, Vol.5/ No.1 summer 2017.