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Experimental Investigation of Use of Geosynthetic in Road Pavements

Deepak Nagal[#1], Narendra Patil[#2], Nandini Patil[#3], Shrilekha Palav[#4], P.M.Wale[#5]

[#1-4]UG Students, Civil Engineering Department, Savitribai Phule Pune University, Pune
[#5]Assistant Professor, Civil Engineering Department, Savitribai Phule Pune University, Pune

[1]Deepaknagal44@gmail.com,
[2]narendraspatil.11@gmail.com
[3]nandinipatil.np96@gmail.com
[4]sp12031997@gmail.com
[5]pmwale_sits@sinhgad.edu

Abstract—
The increase in urbanization led to the scarcity of the land for road construction, due to which land with high water content and low bearing capacity had to be used. In the past history many different methods have been proposed so as to improve the unfavourable conditions prevailing in various locations such as the locations with low bearing capacity soil, water logging conditions, land movements, etc. The application of geosynthetics has proved to be the most promising solution of all the alternatives. Various types of geosynthetics have been used to fulfil various functions such as filtration, separation, drainage, reinforcement, mitigation of reflective cracks, by the use of a single or combination of two or more geosynthetics. This use of geosynthetics has also contributed towards the goal of being one of the most economical and practically applicable alternatives. This paper also studies the characteristics and the basic information of geosynthetics commonly in case of pavement such as geotextile, geogrid, geonets, geomembrane, GCL and geo- composite having an unequivocal function. It includes the comparison of the pavement constructed with the help of geosynthetics and the conventional pavements against various parameters such as bearing capacity, moisture content, economy, maintenance required and the life period of the pavement. The use of geosynthetics is increasing at a very rapid rate and is being accepted worldwide and hence there rises the necessity for detailed study.
Keywords— Geosynthetics, bearing capacity, OMC, CBR, cost analysis.

I. INTRODUCTION

From the very beginning it has been seen that the construction field has encountered various complex problems. Of all the solutions including various innovative construction techniques one of the major hand in problem solving was the introduction of innovative materials. This continuous evolution of material positively affected the development of new heights for construction. Among the different sectors, development of road pavement right from earthen roads, gravel roads, asphalt roads, concrete roads and the construction material plays an important role. The roadways now largely affects the economic development of any nation including passenger transportation, freight traffic, etc. so it is necessary to have continuous improvement in road construction to ensure smooth transition of the traffic to and fro.

In the past decades it has been observed that there has been a rapid and continuous increase in the traffic on the Indian roads and no sight of even a slightest decrease of this ever-increasing traffic. Due to this the road pavements are subjected to unplanned traffic intensities which led the

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planners to make to use of the land with unfavourable conditions in the pavement construction which causes regular pavement distress. To eliminate this, there have been numerous propositions are made to achieve economy, to increase the bearing capacity and life period of the road pavement. Of all the proposed alternatives such as the chemical stabilization, soil replacement, vertical drains, stone columns and reinforcement using geosynthetics, the application of geosynthetics has proved to be most promising and effective. The use of geosynthetic has demonstrated the increase in the overall strength of the road pavement with decrease in the thickness of the pavement layers.

Multiple geosynthetics have been used individually or as a combination of two or more so as to serve various functions like filtration, Reinforcement, Stiffening, drainage etc. Observations state that there has been an increase in the application of the geosynthetics by 10% to 20% per year. Due to this increasing popularity the availability of the geosynthetic material has become easy, while maintaining the economy of the construction.

Geosynthetic now comes out as an emerging technology to face various challenges in road construction. According to 'American society for testing & materials'(ASTM),Geosynthetic is defined as planar products manufactured from polymeric materials used with soil, rock, earth or other geochemical engineering related material as an integral part of manmade projects ,structure system. It is basically a term used describe a range of polymeric products for civil engineering construction works. The geosynthetic material are well known above other alternatives as they perform multiple function individually or can be as various combinations to solve complex problems faced. This paper basically defines the various types geosynthetic, their function and applications, and also the comparison of the conventional road pavement with the pavement constructed using geosynthetic material on the grounds of strength, life span, cost etc.

In-spite of good field evidence, the specific conditions or mechanisms that govern the increased performance of geosynthetics are unclear and unstated. This causes a difficulty in the selection of various parameters of geosynthetics for a particular function. The study of selection of various selection parameters and the analysis of the selected geosynthetic was done. This study has led to increased popularity and attention towards the geosynthetic and its applications.

A. Motive:

The main motive of the project is to solve the problems faced during construction of road pavements such as reduced strength, requirement of periodic maintenance, and speedy deterioration of road pavements more effectively than any other alternatives and providing increased strength, reduction in maintenance cost, increase in the life span, reduction in time and cost of construction.

B. Objectives:

The project considered in this paper performs the following functions so as to demonstrate the application and the information about the geosynthetics in detail.

The Objectives are stated below:

- To study the different types of geosynthetics and the application of the most commonly used in the road pavement construction and its properties.
- To test the load carrying capacity of the pavement constructed with the help of geosynthetic.
- To compare the various design and performance parameters of the pavement constructed with geosynthetic and the conventional pavement.
- Compare the costs of the road construction with and without geosynthetic.

C. scope of project:

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The scope of the project is to check improvement in the performance of the road pavement by using geosynthetic materials like geogrid, geotextile, etc. in the road construction for applications like separation, improving the bearing capacity, etc. by using various tests like CBR to decrease the cost of construction and maintenance of the road. Geosynthetic is becoming more chosen method or alternative than other as it provides more effective solution along with other advantages such as:

a) Easily available material due to increasing popularity.
b) Reduction in time and cost of construction.
c) Easy handling as no heavy machines are required.
d) Provides longer life span.

II. GEOSYNTHETIC

The geosynthetic is commonly defined as any material used in combination with the soil, rock or any geotechnical material as an integral part of man-made projects called as geosynthetic. There are numerous types of geosynthetics that can be used so as to perform any one individual or multiple functions. Each geosynthetic application may involve a single geosynthetic function or a combination of such functions to develop mechanical or hydraulic mechanisms aimed at enhancing the roadway performance. The types and functions of geosynthetic are explained below;

A. Types of Geosynthetics:

1. *Geotextile*: It is a permeable textile material used with foundation soil, rock, earth, etc. It reduces subgrade deformation when used at top of subgrade. There are two types of geotextiles: Woven and Non-Woven. Geotextile is one of the largest groups of geosynthetics.
2. *Geogrid:* Geogrides are usually made from extruding and stretching high density polyethylene. The high tensile strength and stiffness of geogrid are effective as soil and aggregate reinforcement.
3. *Geonets:* they are also called as geospacers and are obtained from polymeric ribs. They are used for reinforcing the existing or new road pavements, patch works, etc.
4. *Geocomposites*: They are combination of two or more geosynthetic materials. These combinations provide benefits over individual layers. They are specially designed to meet drainage and protection requirements.
5. *Geomembrane*: They are impervious sheets of polymeric materials used primarily for lining and covering of liquid or solid facilities. Increase in the moisture content the clay tends to swell and causes effect on pavement. Geomembrane are used to minimize this effect and also provides the strength of the soil.
6. *Geosynthetic Clay Liners*: They are thin layer of bentonite clay sandwiched within two geotextile or bonded to a geomembrane. GCL are commonly used to replace compacted clay layers.
7. *Geofoam*: geofoam is a product of polymeric expansion process in foam consisting of many closed but gas filled cells making it light weight. They are used in embankments built over weak soils, under roads, under storage tanks consisting cold liquids.

B. Functions of Geosynthetic in Road Pavement:

1. *Separation*: In this function the geosynthetic used maintains the integrity and functionality between the two different layers of the road pavement having two dissimilar materials.
    - Property of Geosynthetic- Survivability during Installation.
2. *Reinforcement*: In this function the used geosynthetic improves the overall stability of

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the pavement by developing the tensile forces ultimately improving the bearing capacity and the life period the pavement.

- Property of Geosynthetic- Geosynthetic tensile strength.

3. *Drainage*: In this function the geosynthetic allows the flow of the liquid in its particular plane so as to serve efficient drainage purpose. This function ensures the flow of the right quantity of the liquids through the planned layers.
    - Property of Geosynthetic- Geosynthetic transmissivity.
4. *Filtration*: The liquid is allowed to flow across the plane of the geosynthetic and the fines are retained on the other side of the plane. This helps to control the moisture content in the soil.
    - Property of Geosynthetic- Geosynthetic permittivity.
5. *Stiffening*: The main purpose to be fulfilled in this function is to control the deformations of the geosynthetic soil composite.
    - Property of Geosynthetic- Stiffness of geosynthetic soil composite.

III. METHODOLOGY

The main motive of the research was to evaluate the increase in the performance of the road pavements such as strength or load carrying capacity. This evaluation basically consisted of following three steps;

A. *Sample Collection*: The soil sample required for the test is taken from the soil on which the NH48 is constructed. We collected the sample from near the Swami Narayan temple situated in vadgoan, pune. The soil can be classified into red soil type. The texture of soil sample can be classified into silt. We tested the optimum moisture content of soil and it was 22%.

B. *Standard Proctor Test:* Standard proctor test is used to understand the compaction characteristics of different soils with change in moisture content of the soil. At the optimum moisture content the soil becomes most dense and achieves its maximum dry density by removing the air voids. The test procedure was according to IS: 2720 (Part 7) 1980- Methods of Testing Soil. Part 7- Determination of water content-dry density relation using light compaction.

The test is carried out on a sample passing through 20 mm IS sieve and oven dried for 24hrs. Then it divided into three equal parts and applied with water content of 18%, 22% and 26% respectively followed by incubation of 24hrs. The test is advanced further by weighing the mould and applying grease to mould as well as collar. Then the moulds are filled with sample soil in 3 layers, compacting each layer by 25 blows of 2.6kg hammer having 310mm drop. The moulds are then weighed with soil. The bulk density and dry density of the soil sample is calculated and the graph of dry density vs moisture content is plotted. The highest point on the curve gives the optimum moisture content (OMC) and maximum dry density (MDD) of the sample.

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Fig.1: preparation of sample and testing

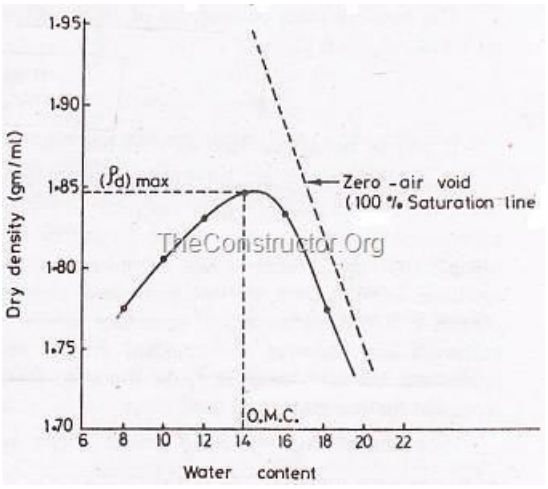

Fig.2: graph of dry density vs moisture content

C. California Bearing Ratio Test: CBR test is used to evaluate the potential strength of the subgrade and foundation. CBR is the ratio expressed in percentage of force per unit area required to penetrate a soil mass with a standard circular plunger of 50 mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in a standard material. The test was conducted according to IS: 2720 (Part 16) 1987 Methods Of Testing Soil, part 16 – Laboratory Determination Of CBR.

For test oven dried sample passing through 19 mm IS sieve is taken. Then it is mixed with the water to give required moisture content (OMC). Then the collar is attached to mould and then is clamped with base plate and mould is lubricated with grease. The spacer disc is then inserted over base plate along with filter paper on it. The soil water mixture is then filled in the mould in three equal layers, compacting each layer with 55 blows of 4.9kg hammer having drop of 450 mm. then collar is removed from the mould and weight of mould with soil is then recorded. Mould is then inverted and clamped again with the base plate. The surcharge weights of 2.5kg are placed on the soil sample in the mould. Then this assembly is kept under the loading machine and the load is applied on the soil sample through penetration plunger at the rate of 1.25mm/min. the loads are recorded at the penetration depths in the intervals of 0.5mm till 12.5mm penetration depth. And the CBR value of the sample is determined by dividing the loads at 2.5mm and 5.0mm penetration depth by standard loads.

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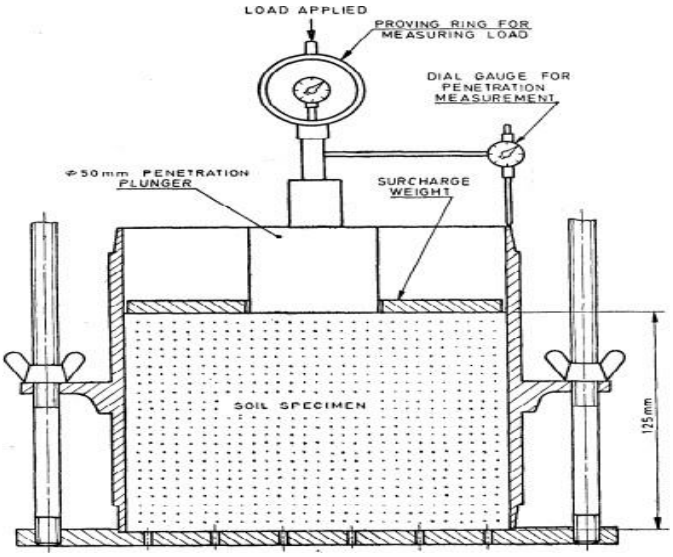

Fig.3: testing of CBR specimen

IV. RESULTS AND DISCUSSION

As discussed in the methodology it is necessary for determining the strength of the subgrade & also the geosynthetic. This was done by conducting the California Bearing Ratio (CBR) test. Standard proctor test proved helpful to find the optimum moisture content (OMC) & Maximum Dry density (MDD).

A. Standard Proctor Test: The standard proctor test is a standard laboratory test conducted using IS 2720(part7)-1965.The following results were observed.

TABLE I

OBSERVATION TABLE OF STANDARD PROCTOR TEST

Sr.no.	**Mass of mould + soil (gm)**	**Mass of soil (gm)**	**Bulk Density (gm/cm2)**	**Water Content %**	**Dry Density (gm/cm3)**
1	7300	1850	0.697	18	0.586
2	7350	1900	0.716	22	0.59
3	7270	1820	0.686	26	0.553

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On plotting these values so as obtain the moisture content vs dry density curve, we get the OMC & MDD value.

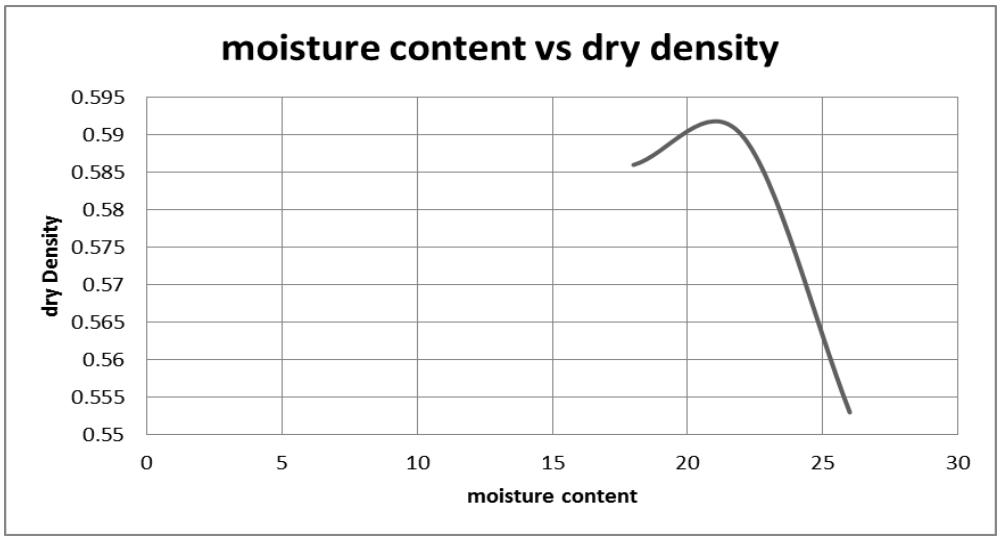

Fig.3: graph of dry density vs moisture content

Therefore, from the above observations, the results are as follows:

Optimum moisture content = 22% And maximum dry density = 0.59gm/cm3

B. *California Bearing Ratio Test:* the tests were conducted on two types of samples, viz. With geosynthetic material and without geosynthetic material and confirming to *IS 2720 (part 16) 1987.*

The results were recorded for the penetration value of 2.5mm and 5mm.

TABLE II OBSERVATION TABLES FOR CBR TEST

a) With using geosynthetic		
Penetration(mm)	**Load (kn)**	**CBR value**
2.5	290	21.58
5	457.5	22.70
B) Without using geosynthetic		
Penetration(mm)	**Load (kn)**	**CBR value**
2.5	221	16.44
5	339	16.83

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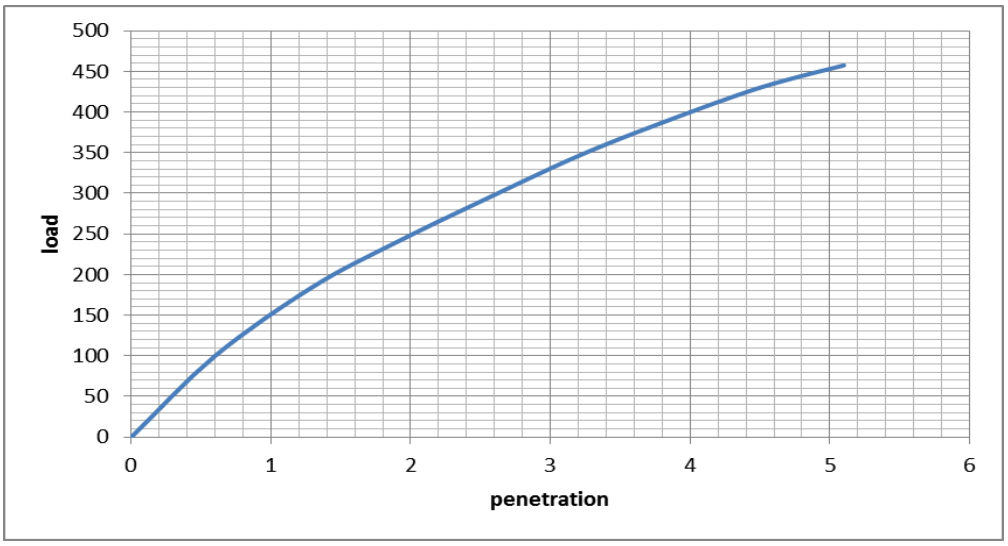

Plotting the above results on load vs penetration graph.

Fig.5: graph of penetration vs load With using geosynthetic in a road pavement

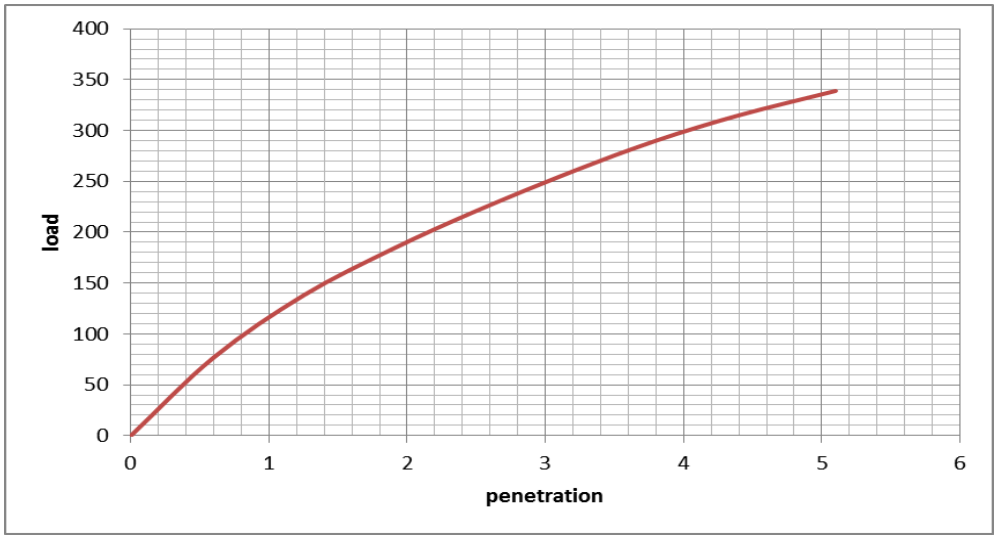

Fig.6: graph of penetration vs load without using geosynthetic in a road pavement

C. *Cost Analysis:* Along with the testing of increase in the load carrying capacity of the specimen with the application of geosynthetic material, it is important to find the cost related along with it.

1. *Conventional Road Cost (Without Using Geosynthetic Material):*

   Total according to SSR-2019-20 for following details:

   L=375m, B=5m, D=0.3m

   Total amount = **16,79,524.00 Rs.**

2. *Cost Of Road Using Geosynthetic Material:*

   Rate of Geotextile = 150rs/sq.m

   Therefore, total material cost = 150 * 375 * 5= 2,81,250.00

   Labour cost for geosynthetic material application= 64rs/sq.m SSR-2019-20 (pg.no.90)

   Therefore, total labour cost = 64 * 375 * 5=1,20,000.00

Therefore, total increase in cost of road for application of geosynthetic in road pavement

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= 2,81,250 + 1,20,000**= <u>4,01,250.00 Rs.</u>**

As form the above conclusion using the SSR 2019-2020 it is seen that there is an overall cost increase by rupees 4,01,250 /- due to application of geosynthetic material.

V. CONCLUSION

A. *Increase Strength*: It was observed that after the application of geosynthetic material into specimen the load carrying capacity increased. In general the increase in strength was about 30-35%. Therefore in the region having unfavourable conditions for construction of road pavements like low bearing capacity. Geosynthetic can be effectively used in a simple way replacing other methods like soil replacement, chemical stabilization.

B. *Cost reduction*: Although from the cost analysis it is clearly evident that there is an increase in the cost of construction of pavement due to the application of geosynthetic road pavements. But in the view of long run it proves to balance out or even reduce the extra cost induced due to regular short interval maintenance of road pavements, re-construction of parts, and provision of extra structures to improve subsoil condition. Also in the comparison of the other alternatives such as soil replacement, chemical stabilization, geosynthetic has less initial cost of construction ultimately proving as the most effective solution.

C. *Life span:* It has been observed that in most of the cases there is faster deterioration of the pavement due to less strength than that actually required for prevailing conditions of at the site of construction. As concluded earlier, geosynthetic is most promising solution for providing best conditions for construction. This shows there is an increase in life span of the pavement than that of original condition or other alternatives.

D. *Study of types and application of geosynthetic*: Working with geosynthetic as an emerging technology, required a detailed study of types of geosynthetics & their functions, properties and application like the use of geotextile for separation, geogrid for strength parameter etc. This study helps us to know the details of material & their better application on unfavourable ground conditions.

E. *Time saving in construction*: The application of the geosynthetic material is a simple process and requires less time as it is already manufactured according to required standard sizes & just needs placing it in the proper manner or prescribed manner by the engineer. On the contrary other alternatives require a lot of time and efforts for their execution, which also on one hand increases the cost of construction.

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