iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** IX **Month of publication:** September 2018

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IX, Sep 2018- Available at www.ijraset.com

Experimental Study of Geotextiles in Flexible Pavements

Kalaiselvi M[1], Selvakumar T[2], Padmasri .G[3]
[1]Lecturer, Department of Civil Engineering, Central Polytechnic College, Chennai, Tamilnadu, India
[2]Lecturer, Department of Civil Engineering, Government Polytechnic College, Cheyyar, Tamilnadu, India
[3]U.G.Student, Meenakshi Sundararajan Engineering College, Chennai, Tamilnadu, India

Abstract: Geotextile will be one of the component of the geosynthetic family. They are permeable fabrics, when it is used in association with soil, it will have the possess to separate, filter, reinforced, protected, or drained. Typically it is made from polypropylene or polyester, geotextile fabrics come under the basic formed; wovened, needle will be punched, or heat has been bonded. Geotextiles were originally considered to be an alternative to granular soil filters. The original, and still sometimes used, term for geotextiles will be filter fabrics. Using geotextiles in secondary roads to unchangeable weak sub grades will be an accepted practice over the past thirty years. Geotextiles were originally intentional to be an alternative to be a granular soil filters. An exact term for geotextiles is filter fabrics. Works were originally begun. Thus by using geotextile was used in construction of pavements to improve its various qualities like filtration, drainage, separation etc. The geotextiles which is used in pavements which have soil that contract and expands and that is weak in handling load.
Keywords: Geotextile, Geosynthetic, Filter fabrics, Granular, Drain.

I. INTRODUCTION

Geosynthetics are the generally polymeric products used to solve civil engineering problems. This includes eight main product categories: geotextiles geonets, geogrids, geocells, geomembranes, geosynthetics clay liners, geofoam, and geocomposites. The polymeric nature of the products makes them suitable for use in the ground where high levels of durability are required. Properly formulated, however, they can also be used in exposed applications.

Geosynthetics are available in a wide range of forms and materials, each to suit a slightly different end use.

These products have a wide range of applications and are currently used in many civil, geotechnical, transportation, geoenvironmental, hydraulic, and private development applications including roads, airfields, railroads, and embankments, retaining structures, reservoirs, canals, dams, erosion control, sediment control, landfill liners, landfill covers, mining, aquaculture and agriculture.Inclusions of different sorts mixed with soil have been used for thousands of years.

A fundamental problem with using natural materials (wood, cotton, etc.) in a buried environment is the biodegradation that occurs from microorganisms in the soil. With the advent of polymers in the middle of the 20th Century a much more stable material became available. When properly formulated, lifetimes of centuries can be predicted even for harsh environmental conditions.The first papers on geosynthetics in the 1960s (as we know them today) were as filters in the United States and as reinforcement in Europe.

The International Geosynthetics Society (IGS) founded in 1982 has subsequently organized worldwide conference every four years and its numerous chapters have additional conferences. Presently separate geosynthetic institutes, trade-groups, and standards-setting groups are active.

Approximately twenty universities teach stand-alone courses on geosynthetics and almost all include the subject in geotechnical, geoenvironmental, and hydraulic engineering courses. Geosynthetics are available worldwide and the activity is robust and steadily growing.

An experimental investigation is carried out to study the tensile strength of geotextile material and the increase in CBR value of soil reinforced with geotextile material. The main objective is to improve the performance of unpaved structure by adding geotextile material to the unpaved structure.

II. MATERIALS

Geotextile, material that can pass water from wicker (woven) or non-woven (non-woven) from the threads or synthetic fibres used in ground work, the synthesis of thin sheets, flexible, permeable used for soil stabilization and improvement

Fig. 1. Laying of Geotextile

The geotextiles require more strain than the geogrids to develop the required strength for stability. This slight difference Fig. 1 in strain might indicate that the geogrids outperforms the geotextiles. However, the installed costs of the geotextile test section saved huge amount over the installed cost of the geogrid section. Since both materials performed equally well, utilizing geotextiles instead of geogrids seems to be the logical choice.

III. TYPES OF GEOTEXTILES

Geotextiles are generally classified into natural fibres and synthetic fibres. Natural fibres are further classified into jute grids, paper strips and wood shavings. Synthetic fibres or conventional fibres are classified further as follows

A. Woven Monofilament

Woven monofilament geotextiles are manufactured from extruded polypropylene to create a very dimensionally stable, highly permeable geotextile. Monofilaments Fig. 2. have superior resistance to soil and biological clogging, providing proven erosion control along highway and waterway embankments. Stability and strength, coupled with clog-resistant, high-flow properties, make this fabric ideal for use under hard armour systems.

Fig 2. Woven Monofilament

B. Woven Multifilament

Garware Woven Polypropylene multifilament Geotextiles, GWF PP series are made of individual multifilament Fig 3. yarns woven together into a stable fabric structure with a superior combination of mechanical and hydraulic properties. These product series has excellent resistance to biological and chemical environments normally found in soils and are stable against short-term exposure to ultraviolet radiation.

Fig 3. Woven Multifilament

C. Woven Slit-Film Mono and Multi Filament

As new applications for these innovative plastic filter cloths were being developed, so did the inventiveness of the weavers and producers of these fabrics. Today woven geotextiles consists of monofilament, multifilament, slit-filament yarns Fig 4. – 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 all 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

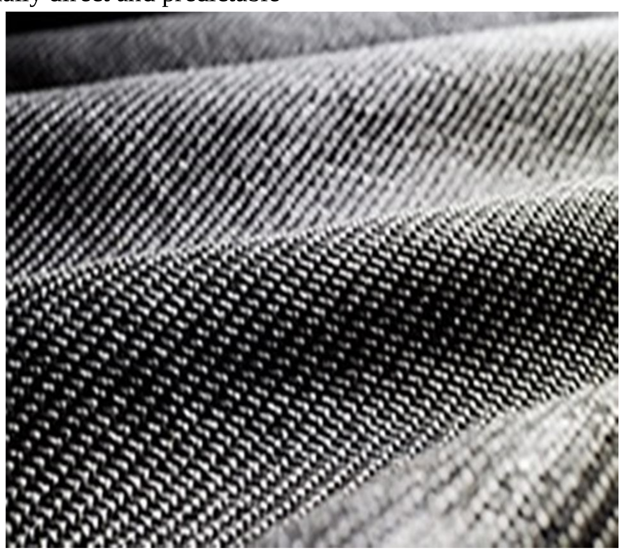

Fig 4. Woven Slit-Film Mono and Multi Filament

D. Reinforcement of subgrade soil

Soil reinforcement Fig 7. has been in vogue in crude form since ancient times. This technique has aroused so much interest and awareness amongst engineers in recent times. It employs prefabricated elements (precast skin units or panels and reinforcing strips, sheet or nets) which can be easily handled, stored and assembled. The flexible nature of reinforced earth mass enables it to withstand large differential settlement without distress. Reinforced earth thus permits construction of geological structures over poor and difficult subsoil conditions. Reinforced earth walls are consequently economical when height of structure is large, or ground conditions are unfavourable and suitable backfill materials are locally available. The reinforced soil is a good technique and an economical alternative to stabilization of natural or artificial slopes. The artificial slopes can be cut off or fill.

The road generally consists of sub grade, sub base, base and wearing course. The sub grade, Fig 8.which is made of existing soil, is an important part of road construction. The economy of road construction depends on it. However, if the sub grade is made of weak of and highly expansive soil, such as black cotton, it is customarily to replace a part or whole soil by select soil (cbr 2: 7%) to achieve economy in construction. If the select soil is not available in the nearby areas and is to be transported from long distance, then there is an increase in cost and time of construction. Hence, there is a need for soil improvement by using jute geotextile, in which we can use locally available weaker soil.

Fig 7. Without Reinforcement

Fig 8. With Reinforcement

IV. METHODOLOGY

A. Site Investigation

The soil sample was collected from Nungambakkam in Chennai and the geotextile material was collected from Aaron India Pvt.Ltd at Kilpauk Fig 9.

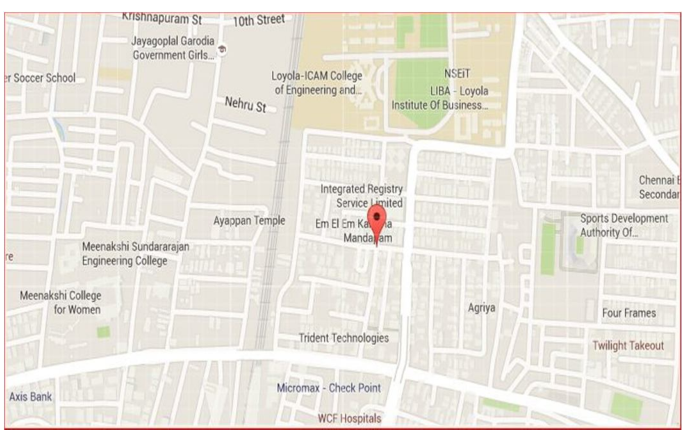

Fig 9. Place Where Soil Sample was Collected

B. Selection of Material

The soil sample was collected from Nungambakkam in Chennai and the geotextile material was collected from Aaron India Pvt Ltd. The soil sample was collected at a distance of 1m below ground level. In such a way three samples were collected each at an interval of 2m from each other. The type of geotextile material purchased was non woven continuous filament heat bonded made of polyester/polypropylene.

C. Index Properties Test

1) *Liquid Limit Test:* This test is performed to determine the liquid limit of obtained three soil samples. When water is added to dry soil, it changes its state of consistency from hard to soft. If we add water to a fine grained soil, then water will change its consistency from hard to semi hard. If we continue to add more water then again the soil will change its state of consistency from semi hard to plastic and finally reach a liquid consistency stage. When the soil reaches liquid consistency state, it has to remain non cohesive to retain its shape under its own weight. It will start to deform its shape. So the amount of water which is responsible for this state of consistency of soil is called liquid limit of soil. Liquid limit of soil is a very important property of fine grained soil (or cohesive soil) and its value is used to classify fine grained soil. It gives us information
2) Procedure: Adjust the Casagrande cup of liquid limit apparatus with the help of grooving tool gauge and the adjustment plate to give a drop of exactly 1cm on the point of contact on the base. Take about 120gm of an air dried sample passing 425 sieve and mix the soil thoroughly with some distilled water to form a uniform paste. Place a portion of the paste in the cup of the liquid limit device; smooth the surface with spatula to a maximum depth of 1cm. Draw the grooving tool through the sample along the symmetrical axis of the cup, holding the tool perpendicular to the cup. Turn the handle at a rate of 2 revolutions per second and count the blows until the two parts of the soil sample come in contact with each other, at the bottom of the groove along a distance of 10mm. Transfer about 15gm 0f the soil sample forming the wedge of the groove that flowed together to a water content bin, and determine the water content by oven drying. Transfer the remaining soil in the cup to the to the main soil sample in the bowl mix thoroughly after adding a small amount of water. Repeat steps 4 to 7.obtain at least five set of readings in the range of 10 to 40 blows. Record the observations in the table.
3) *Plastic Limit Test:* Plastic limit is defined as the lowest moisture content and expressed as a percentage of the weight of the oven dried soil at which the soil can be rolled into threads one-eighth inch in diameter without the soil breaking into pieces. This is also the moisture content of a solid at which a soil changes from a plastic state to a semisolid state.
4) *Procedure:* Take about 30gm of air dried soil sample passing through 425µ sieve. Mix thoroughly with distilled water on the glass plate until it is plastic enough to be shaped into a small ball. Take about 10g of the plastic soil mass and roll it between the hand and the glass plate to form the soil mass into a thread of as small diameter as possible. If the diameter of the thread becomes less than 3mm without cracks hen it indicates that the water added to the soil is more plastic than its plastic limit. Hence the soil is kneaded further and rolled into thread again. Repeat the rolling and remoulding process until the thread start just crumbling at a diameter of 3mm. If the soil sample start crumbling before 3mm water added is less than the plastic limit of soil. Hence add some water and make it uniform. Roll that soil mass until it crumbles at a diameter of 3mm. Collect a piece of crumbled soil thread in an air tight container and determine its moisture content. The observations are recorded in tabular format and average plastic limit value is obtained.

Formulae to Find Index Properties

Plastic Limit = (weight of water / weight of oven dry soil) *100
and Liquid Limit

Plasticity Index, IP = WL – WP

Flow Index, IF = (W1 – W2) / log (N2 / N1)

Toughness Index, IT = IP / IF

5) *Tensile Strength of Geotextile Material:* Various m/c and structure components are subjected to tensile loading in numerous applications. For safe design of these components, their ultimate tensile strength and ductility one to be determine before actual use. Tensile test can be conducted on UTM. A material when subjected to a tensile load resists the applied load by developing internal resisting force. These resistances come due to atomic bonding between atoms of the material. The resisting force for unit normal cross-section area is known as stress. The value of stress in material goes on increasing with an increase in applied tensile load, but it has a certain maximum (finite) limit too. The minimum stress, at which a material fails, is called ultimate tensile strength.

6) *Procedure:* The load pointer is set at zero by adjusting the initial setting knob. The dial gauge is fixed and the material for measuring elongation of small amounts. Measuring the dimensions of the test piece by measuring scale at least at three places and the mean value is determined. Now the material is gripped between upper and middle cross head jaws of the m/c. Set the automatic graph recording system. Start the m/c and take the reading and the material is loaded gradually and the elongation is noted until the specimen breaks.
7) *Standard Proctor Compaction Test:* The Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. The term Proctor is in honor of R. R. Proctor, who in 1933 showed that the dry density of a soil for a given compactive effort depends on the amount of water the soil contains during soil compaction. His original test is most commonly referred to as the standard Proctor compaction test; later on, his test was updated to create the modified Proctor compaction test.
8) *Procedure*: Take about 3kg of air dried soil. Sieve the soil through 20mm sieve and take the soil that passes through for testing. Take 2.5kg of the soil and add water to bring it to its moisture content of about 4% for coarse grained soil and 8% for fine grained soil. Clean, dry and grease the mould and base plate. Weigh the mould with base plate and fit the collar. Compact the wet soil in three equal layers by the rammer with 25 evenly distributed blows in each layer. Remove the collar and trim off the soil flush till top of the mould. In removing the collar rotate it to break the bon between it and the soil before lifting it off the mould. Clean the outside of the mould and weigh the mould with soil and base plate. Remove the soil from the mould and obtain a representative soil sample from bottom middle and top for water content determination. Repeat the above procedure by increasing water content (say 6, 8, 10 %...). Tabulate the obtained value of dry density and moisture content and plot a graph accordingly to obtain optimum moisture content and maximum dry density.

Formula

Dry density ɣd = ɣ/ (1+w)

Bulk density ɣ = V/W

Where

w = water content

V = volume of soil and

W = weight of soil

9) *California Bearing Ratio Test:* It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material. The California Bearing Ratio Test (CBR Test) is a penetration test developed by California State Highway Department (U.S.A.) for evaluating the bearing capacity of sub grade soil for design of flexible pavement. Tests are carried out on natural or compacted soils in water soaked or un-soaked conditions and the results so obtained are compared with the curves of standard test to have an idea of the soil strength of the sub grade soil.
10) *Procedure*: Normally a specimens each of about 5 kg must be compacted so that their compacted at the soil’s optimum moisture content. Weigh of empty mould, add water to the first specimen (compact it in five layer by giving 56 blows per layer). After compaction, remove the collar and level the surface, take sample for determination of moisture content. Weigh the mould with the compacted specimen. Place the mould in the soaking tank for four days (ignore this step in case of unsoaked) CBR. After four days, measure the swell reading and find %age swell (ignore this step in case of unsoaked). Remove the mould from the tank and allow water to drain (ignore this step in case of unsoaked). Then place the specimen under the penetration piston and place surcharge load of 5kg. Apply the load and note the penetration load values. Draw the graphs between the penetration (in) and penetration load (in) and find the value of CBR. Draw the graph between the %age CBR and Dry Density, and find CBR at required degree of compaction.

Formula

CBR value in % = (obtained load for that a penetration/standard Load for
that particular penetration) * 100

V. RESULTS AND ANALYSIS

A. *Index Properties Test*

Table 1: Observations of Index Property Test

Sample	LL	PL	PI	FI	TI
1	26.81	19.9	6.91	29.6	0.233
2	26.75	20.1	6.65	29.2	0.227
3	26.83	19.92	6.91	29.8	0.231
Average	26.8	20	6.82	29.53	0.231

1) *Result*

Liquid limit = 26.8%
Plastic limit = 20%
Plasticity index = 6.82%
Flow index = 29.53%
Toughness index = .231

2) *Inference*

Liquid limit < 35% - low compressibility soil
Liquid limit < 50% and plasticity index falls between 4% to 7% and hence the soil type - Clayey Silt Soil (CL-ML)

B. *Tensile Strength Test of Geotextile Material*

Table 2: Tensile Strength Test Result

S.No	Specimen	Tensile Strength
1.	Geotextile Material	5KN

Fig 10. Tensile Strength Test

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IX, Sep 2018- Available at www.ijraset.com

C. Standard Proctor Compaction Test

Table 3: Standard Proctor Test Results

S.No	Water Content in %	Weight of Mould With Soil in Kg	Weight of Soil in Kg	Bulk Density in g/cc	Dry Density in g/cc
1	2	3.909	1.028	1.160	1.137
2	4	3.916	1.035	1.170	1.125
3	6	4.023	1.142	1.293	1.219
4	8	3.934	1.053	1.193	1.104
5	10	3.928	1.047	1.186	1.078

Fig 11. Standard Proctor Test

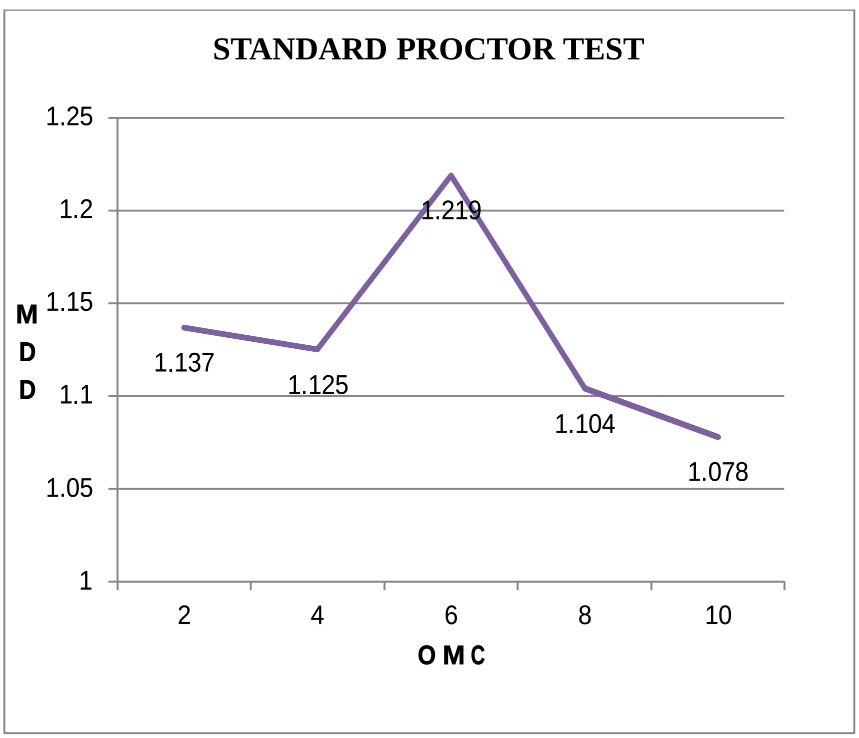

Fig 12. OMC - MDD Chart

Where OMC = Optimum Moisture Content
MDD = Maximum Dry Density

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
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D. California Bearing Ratio Test

Table 4: Observation of CBR Test on Unsoaked Soil

S.No	Penetration (mm)	Proving Ring Reading		Load (Kg)	
		Without Reinforcement	With Reinforcement	Without Reinforcement	With Reinforcement
1	0	0	0	0	0
2	0.5	10	20	9.807	196.14
3	1	20	30	196.14	294.21
4	1.5	25	40	245.17	392.28
5	2	30	45	294.21	441.35
6	2.5	35	50	343.24	490.35
7	3	40	55	392.28	539.38
8	4	45	60	441.31	588.42
9	5	50	65	490.35	637.45

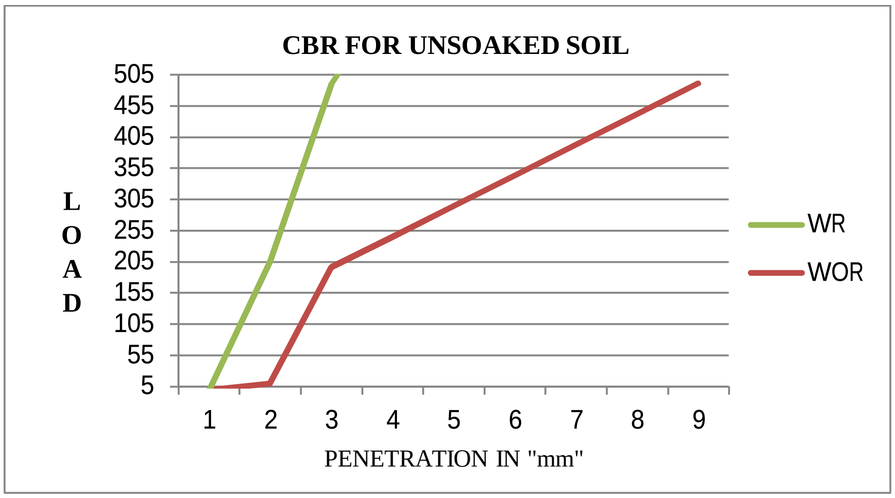

Fig 13. CBR Value for Unsoaked Soil

WR – With Reinforcement, WOR – Without Reinforcement

Table 5: Observations for CBR Test on Soaked Soil

S.No	Penetration (mm)	Proving Ring Reading		Load (Kg)	
		Without Reinforcement	With Reinforcement	Without Reinforcement	With Reinforcement
1	0	0	0	0	0
2	0.5	1	5	9.8070	49.035
3	1	5	10	49.035	98.070
4	1.5	10	15	98.070	147.10
5	2	15	20	147.10	196.14
6	2.5	20	25	196.14	245.17
7	3	25	30	245.17	294.21
8	4	30	35	294.21	343.21
9	5	35	40	343.24	392.28

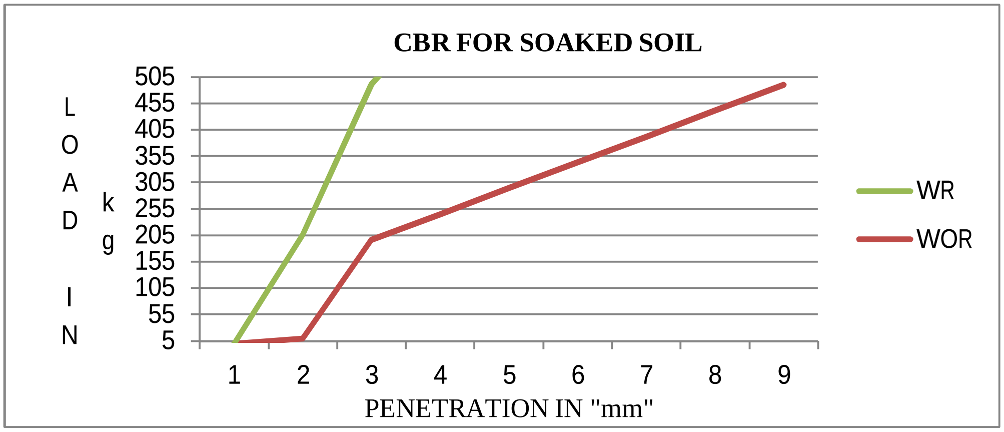

Fig 14. CBR Value for Soaked Soil

WR – With Reinforcement, WOR – Without Reinforcement

Table 6 Standard Load Value For CBR Penetrations

S.No	Penetration in Plunger (mm)	Standard Load (Kg)
1	2.5	1370
2	5	2055
3	7.5	2630
4	10	3180
5	12.5	3600

Table 7 Results of CBR Test

S.No	Type of Soil	CBR Value in %	
		Without Geotextile	With Geotextile
1	Soaked Soil	15.5	18.48
2	Unsoaked Soil	24.45	33.4

From the above results it is clear that the CBR value of soil increases with adding geotextile material to the soil beneath the pavements in turn proving that the strength, performance and life time of soil increases by adding geotextile material in soil beneath pavements.

Fig 15. CBR Test of Soil Sample

VI. CONCLUSION

The conveyance structures and its efficiency is measured on the amount of water transported in safe condition, which must be nearest to the amount of inlet water. An impermeable and light - weight materials like polymer materials specially geotextiles, with low hydraulic roughness, used in its proper section and slope, by providing an efficient design. Moreover, over a time, an operation of the canal changes to the design performance, due to an action of water and an environment on a structure which will be subjected to ageing.

Ageing results in: (a) Water losses (b) Reduction in the water flow (c) Structure deterioration and (d) Detachment of the lining materials. Generally, in an adequate strength of soil and movement of a soil particles by the water flow cause low tensile strength of the soil materials. One of the methods in strengthening of soils is utilizing the polymer materials.

The above results have been shown that the soil is reinforced material and its CBR value increases and indicating that the strength of the soil and pavement increases. The geotextile had found to be performing its functions dexteritly even after its tensile strength and decreases through the years after its installation.

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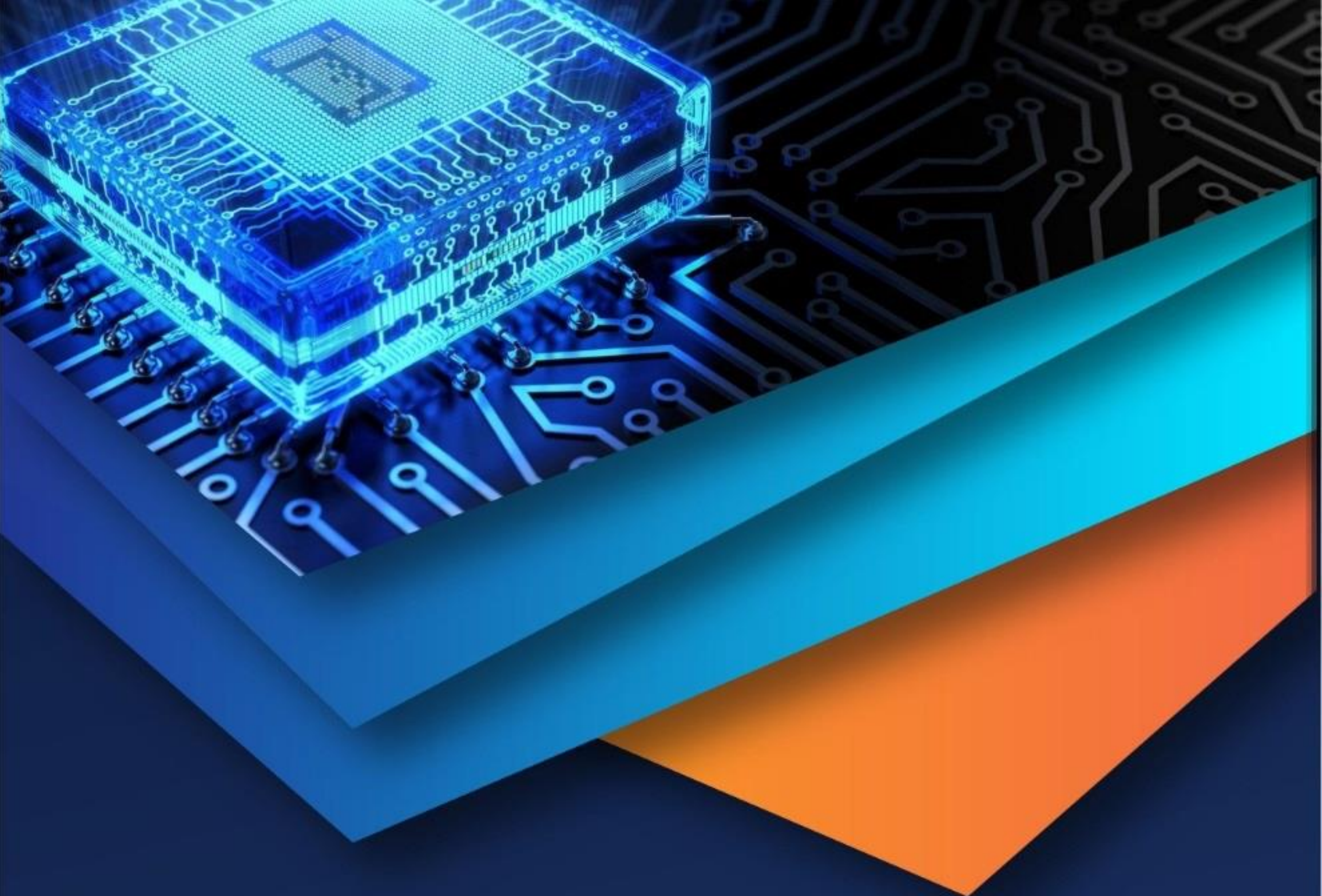

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