A Study on the Improvement of CBR using Waste Plastic Mat as Geocell

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***Abstract*— Today the world is facing a major problem in scarcity of materials for infrastructure development. On the other hand disposal of waste materials generated in the development process is also a main concern. Kuttanad region in Alappuzha district, the soil is very weak and the pavements are damaged due to low strength .In this context, usage of locally available waste plastic bottle is used to improve the strength of sub grade soil. Waste plastics are increasing now a days and it is a serious threat to the biotic community. So using waste plastic mat, waste plastics can be used in an appropriate way. Soft soils can be improved with reinforcement in the form of randomly distributed fibres of natural and synthetic types. Waste plastic bottle is used to make mats which is induced in the sample to increase the strength. Mats of varied thickness are used. They are placed at 2cm, 4cm, 6cm and 8cm depth. CBR tests are performed individually for each. For further results CBR tests are performed by using sand which is filled in the mat. Tests are made for optimum conditions of depth,ie, 4cm.Test result, shows that the CBR value is increasing upto a particular limit of thickness and depth.**

Keywords— Black cotton soil, Waste plastic mat as geocell, CBR

I. INTRODUCTION

Today the world is developing at a faster pace. Well built and maintained highways plays a major role in nations development.To achieve these developments every country requires good infrastructure.Recent decade have experienced a massive rise in demand for land owing to rapid industrialization and urbanzation and subsiquent rise in infrastrauture building.Development of any country can be closely monitored by the improvement in infrastructural facilities in which transportation plays a key role. The quality and durabilty of a payment and is greatly affected by the type of subgrade soil over which such pavements structure are to be constructed.Roads plays a prominant role as they connect door to door.The subgrade soil is integral part of pavements which provides support to the pavement.The construction and maintanance of these roads is becoming more difficult due to increasing traffic day by day.Inorder to have a good road which can accomodate this traffic we required good quality construction materials but the world is facing a scarcity of quality construction materials as they are depleting rapidly.Goverment also imposing taxes and many cleareances are neccessary for using these materials.The behaviour of road surface depends on strength of fill material and the sub grade below it.Problamatic soil such as expansive soil are normally encounter in foundation engineering designs for highways, embankments, retaining walls, back fills etc.Exapansive soil are referred to as black cotton soil because of their suitabilty of growing cotton.Black cotton has varying colors ranging from light grey and black.The mineralogy of this soil is dominated by the presence of montmorillonite which is characterized by large volume change from wet to dry seasons and viseversa.Expansive soils are those which have high swelling and shrinking charecteristics,extremyl low CBR value and shear strength.Because of alternate swelling and shrinkage of expansive soil, lighly loaded civil engeering structures like residential building,pavements,canal lining are severly damaged.If the sub grade soil has high shrinkage and swelling properties ,it creates problems in the maintanence of highways and runways such as:

1.Cracking of pavements
2.Undulation on the surface of pavements
3. Damage to drainge systems under pavements due to volume changes

It is a risk to construct pavement over such soil because of alternate shrinking and swelling .Several types of ground improving techniques involving stabilizing or reinforcing the soil are used to increase the strength and make these types of soil suitable for construction. In recent decade geo systhetic have been adopted by engineers to the world as a soil reinforcing techniques due to ease of construction and cost efficiency.Geo cell is the most advaced form of geosysthetics .Geocell is a three dimensional , polymeric ,honey comb cell like structure created by welding high intensity thermoplastic sheet.Cellular confinement system have more attractive features due to its 3D structure than any planar geosynthetic reinforcement.Geosynthetics are human made materials made from various types of polymers used for construction purpose. Geocell can provide better lateral confinement to infill soil.The term geocell has two parts“geo”which means earth and “cell” which means cellular type of shape for infill material like soil. Many techniques have been evolved to strengthen the highway soil subgrade.Most of them primarily involve strengthening using chemical admixtures.One of the recent techniques is the use of geosynthetics.Geosynthetics can be placed within the subgrade to strengthen it and also can be placed at the interface between subgrade an sub base.Since sub grade CBR is taken as the criterion for the design of flexible pavements,the thickness of the component layers(sub base and base course) will be reduced when the subgrade CBR is high.Here in this study the effect of inclusion of waste plastic as in the form of geocell was found out.The beneficial use of waste plastic is that it is quite cheaper and the effect of waste plastic can be used in an appropriate way.Now a days the amount of waste plastic is increasing ,and it is a serious threat to the biotic community.So inorder to use the waste plastic in an appropriate manner,waste plastic bottle rings are made in the form of mat,which acts as a geocell.In the present study,reinforcement technique is implemented and experimental study was conducted on waste plastic mat reinforced Kuttanad soil.Reinforced soil is a set of theories,principles and application methods and it is one of the branches of geotechnical science to stabilize and improve soil engineering properties such as strength,hardness and deformability.Reinforcement soils can be obtained by either incorporating continous inclusions (eg:sheet,strip or bar) within a soil mass in a defined pattern or mixing discrete fibres varingly within a soil fill.In this study,waste plastic bottle rings are made in the form of a mat which acts as a geocell and reduces the cost of construction due to locally available waste material.The reinforced soil samples were subjected to CBR test with varying thickness of waste plastic rings from 1cm,2cm,3cm,4cm and 5cm.Mats were placed at different epths from top 2cm,4cm,6cm and 8cm. The sample is compacted at optimum moisture content and maximum dry density.For every optimum value for different thickness,set of CBR tests were done by using sand filled in the mat.The strength charecteristics is determined using waste plastic rings for subgrade by using waste plastic in an effective way.

II.LITERATURE REVIEW

Waste plastics are increasing now a days and it is a serious threat to the whole community.So inorder to use this in an apprropriate manner,plastic mats are formed which acts as geocell to increase the strength of soil subgrade thereby pavement strength can be accelerated.Geocells are most advanced form of geosynthetics.Expansive soils are those which have low CBR value,inorder to increase the strength mats are placed at different levels which acts as geocell.Geocells as a reinforcement in soil has also been conducted in the recent years. Now a days the effect of waste plastic can be reduced by using it in an appropriate manner. The following are the literature regarding the subject.

Phani Kumar Vaddi, D.Ganga ,P.Swathi Priyadashini(2015) made an experimental investigation on CBR for mechanically stabilized expansive soil using waste rubber tyre chips and concluded that compaction, CBR charecteristics of expansive soil are dependent on clay content present in the soil.The MDD and CBR values for the expansive soil are low when compared to lime and tyre chips. The OMC in genaral increase with increasing the placement of lime and MDD decreases with increase in lime.The rubber tyre chips stabilization increases the CBR value. The optimum percentage of lime and percentage of rubber tyre chips is obtained as 6%.

Chowdhury Swaraj and Suman Shakthi (2014) made a review of studies on geocell-reinforced foundations and concluded with results that the inclusion of geocell as reinforcement increase the bearing capacity of the foundation over soft soil.Geocells made out of materials of higher strength and having smaller aperture in orthogonal direction show better improvement in performance. The effects of geocell are pronounced when the foundation soil is in dense state.

Manish Yadav and Arvind Kumar Agnihotri (2014) made astudy about the application of geocells in reinforcement of soiland derived at a conclusion that the application of geocell reinforcement reduce the settlement of soil. The use of geocell is suitable from the stability as well as economical point of view.

Aminaton Marto,Mohsen Oghabi, Amin Eisazadeh (2012) made an experimental test to find the effect of geocell reinforcement in sand and its effect on bearing capacity and obtained results that the better performance of the footing can be obtained if the depth of the cellular mattress is 0.05B from the base of the footing in the case of sand beds. The optimum width of cellular mattress is obtained as around b/B =5 in the sand and the optimum depth of planar reinforcement is (u/B)=0.35 and for 3D geotextile it is (u/B)=0.1.With the increase in number of planar reinforcement layers ,the height of geocell reinforcement and the reinforcement width,the bearing pressure of the foundation bed increases and the footing settlement decreases.

Koteswara Rao et.al (2012) have studied the influence of rubber strips on the improvement of CBR values on expansive soil.The CBR value has been increased in percentage of rubber strips upto an optimum percentage of rubber strips an there after CBR value has been decreased with further increase in percentage of rubber strips.The observed that the CBR value of the expansive soil has been increased b 88% with aition of 5% Rubber strips as an optimum.

Thankur et.al (2012) have studied the effect of geocell reinforced recycled asphalt pavement (RAP) bases over weak subgrade under cyclic plate loading and found that geocell has improved the performance of RAP bases over weak subgrade as compared with the unreinforced base section and geocell significantl increased the percentage of resilient deformation of the RAP base.The geocell reinforcement reduced the vertical stresses transferred to the subgrade by distributing load over a wider area.

A.K Choudhary, K.S.Gill, J.N.Jha (2011) studied about the improvement in CBR values on expansive soil sub grades using geosynthetics and conclude that the insertion of reinforcement within the expansive soil sub grade is found to be effective in controlling the swelling significantly. The percentage reduction in swell potential however depends on number of reinforcing layers and the type of reinforcement used. The CBR value of the soil increases significantly with increase in number of reinforcing layers and their relative position within the soil and type of reinforcement.

According to Pokhareal et.al (2010) due to three dimensional structure , the geocell can provide lateral confinement to soilparticles within soil particles within cells.The geocells provides the vertical confinement in two ways:

1.The friction between infill material and the geocell wall.
2.The geocell–reinforced base acts as a mattress to restrain the soil from moving upward outside the loading area.

Han et.al (2010) investigated the load transfer mechanism between infill and geocell by carrying both experimental and

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 09, September-2016

numerical studies on the behaviour of geocell-reinforced sand under a vertical load.The studies showed that geocells could increase the bearing capacity and elastic modulus of the reinforced sand by providing confinement for the infill material.

According to Han et.al(2008),geocells have three dimensionalcellular structure which can be used to stabilize foundations byincreasing bearing capacity and reduce settlements.

Emersleben et.al (2008) have studied about the bearing capacity improvement of gravel base layers in road constructions usinggeocell and concluded that geocell layer placed within the gravel base layer of an asphalt paved construction reduced the vertical stresses on subgrade during vehicle crossing about 30% and increased the laer moulusof the gravel base layers compared to an unreinforced layer.As a result the measured deflection on the asphalt surface were also reduced.

Sitharam et.al(2007) investigated the settlement response of geocell reinforced soil underlying soft clas.They reported a substantial reduction in footing settlement providing geocell reinforcement in the soft clay bed.

Krishnaswami et.al applied uniform surcharge pressure on laboratory scale model of geo cell reinforced embankments supported over soft clay founations.Geocell of different thickness were placed above the soft soil foundation and embankments were made above this layer of geocell . They concluded that providing a geocell base improved the performance of the embankment in term of the maximum surcharge load and the deformations.

Dash et.al through model tests in laboratory to study the bearing capacity of strip footing based on geocell reinforced sand.They varied several parameters like cell size,material,tensile strength and height and width of the geocell for sand of different relative densities. The optimum height and width of the Geocell was determined to be 2 and 4 times respectively the width of the footing .They also concluded that cell size and orientation has a considerable effects on the performance of geocells.

Dash et.al measured the functioning of Geocell-reinforced strip footing in sand when planar reinforcement is added along with Geocells. They found that the placement of a planar geogridunderneath the geocell mattress increased the bearing capacity of footing and stabilized it against rotation.However, this effect was not so profound for large height of geocellmatress and an optimum value of 2 times width of the foundation was achieved.

Dash et.al also studied circular footing supported on geocell-reinforced sand and found that Geocell improved the bearing capacity of the footing and reduced its surface having. They concluded that the geocell enables the load to be redistributed uniformly over a broader area.

Zhou and Wen, by conducting tests on geocell-reinforced sand cusion over foundation of soft cohesive soil taken from the Qin-shen railway established a decrease in the settlement of underlying soil.The also noticed an increase of 300% and a decrease of 44% in the subgrade reaction coefficient and deformation respectively.

Moghaddas Tafreshi and Dawson studied the application of cyclic loads to geocell-reinforced sand foundations and found that the application of geocell decresed the settlement under cyclic loading.The optimum value for depth and width of the geocell was found to be 0.1 and 0.3 times the footing width respectively.

Dash and Bora studied the effects of both stone column and geocell in improvement of soft clay foundations.The found that the maximum increment in bearing capacity ue to stone column and geocell alone was 3.7 fold and 7.8 fold respectively.When used in combination with adequate spacing and depth, stone column and geocell showed as much as 10.2 fold increment in bearing capacity of soil.They suggested that the optimum length and spacing of stone column that can be used are 5 and 2.5 times the diameter respectively.The maximum height of geocell that can be adopted was found to be equal to depth of foundation.

Vinod et.al has reported the results of model tests on the settlement behaviour of strip footing resting on geocell reinforced sand during cyclic loading and concluded that geocell reinforced founation exhibit a four fold increase in ultimate bearing capacity of footing compared to unreinforced counterparts.

According to Pokhareal et.al due to three diamensional structure, the geocells can provide lateral confinement to soil particles within cells.

J.N Shah et.al, made study on the improvement in CBR value of expansive soil subgrades using geosynthetics.Two different type of reinforcements:jute geotextile and geogrid were used in the investigation.Insertion of reinforcement within the expansive soil subgrade is found to effective in controlling the swelling significantly.The percentage reduction in swell potential however depends on number of reinforcing layers and the type of reinforcement used.The CBR value of the soil increases significantly with increase in number of reinforcing layers and the position within the soil and type of reinforcement.

According to Rajagopal et.el (1991) geocell imparts apparent cohesive strength even to cohesionless soils and imparts apparent cohesive depend on the tensile modulus of the geosnthetic used to form the geocell.

III.OBJECTIVES OF STUDY

- To find the CBR improvement using waste plastic mat as geocell.
- To determine the optimum depth corresponding to max CBR value.
- To determine the optimum thickness corresponding to max CBR value.
- To find the improvement of CBR using sand filling in the mat.
- To determine the maximum percentage increase in CBR value.

IV.MATERIALS USED

A.SOIL

The soil used in this study is a naturally occurring soil, collected from Kuttanad, a unique agricultural region in Alappuzzha district in the state of Kerala. Fig. 1 shows the particle size distribution curve of soil used. From the test results, the soil can be classified as silt of medium compressibility according to Indian Standard Classification system. Table I shows the properties of soil.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 09, September-2016

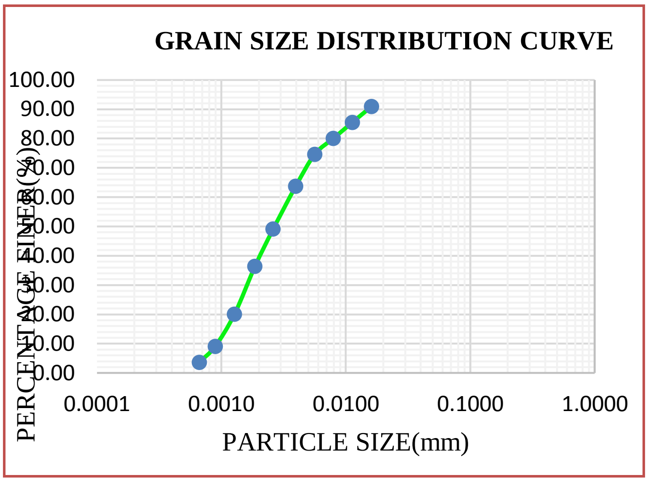

Fig.1.Grain size distribution curve

Table I.Properties of soil

Properties	Results
Field moisture content(%)	90
Maximum dry density(g/cc)	1.365
Optimum moisture content(%)	29
Specific gravity	2.22
Clay content(%)	40
Silt content(%)	52
Sand content(%)	8
Liquid limit(%)	44
Plastic limit(%)	36.36
Plasticity index(%)	7.34
IS classification	MI Soil
Shrinkage limit(%)	32.94
Unconfined compressive strength(KN/m^2)	46.79
CBR(%)	0.28

B.WASTE PLASTIC

Waste plastic rings are made from plastic bottles and tied each other and formed a mat.Mats of different thickness are made of same tensile strength.Tensile strength of waste plastic used for making plastic mat is obtained as $2.66*10^{-3}$ N/mm^2.Individual rings of diameter 3.5cm is taken to form a mat. The mat consist of an overall diameter of about 10.5cm.Fig.2 shows waste plastic. Fig.3 shows the mat placed in CBR mould.

Fig.2.Waste plastic

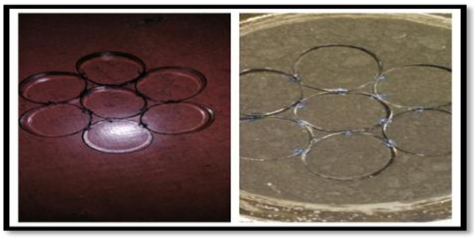

Fig.3.Mat placed in CBR mould

C.SAND

The sand used in this study is a naturally occurring sand, collected from from Muthalapozhy, Perumathura which is in Thiruvananthapuram district. Fig.4 shows the particle size distribution curve of soil used. Table II shows the properties of sand.

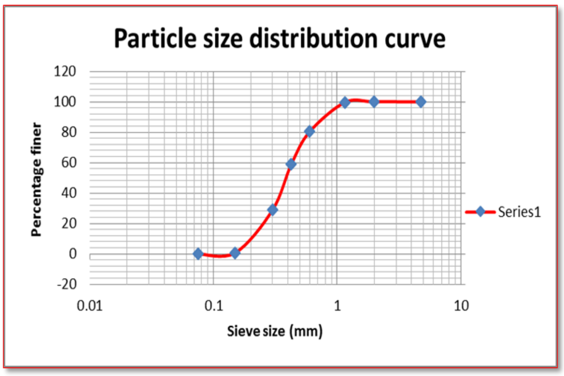

Fig.4.Particle size distribution curve

Table II.Properties of sand

Properties	Results
Specific gravity	2.65
Fine sand content(%)	59
Medium sand content(%)	41
Minimum density index(g/ccc)	1.48
Maximum density index(g/cc)	1.76
Minimum void ratio	0.51
Maximum void ratio	0.788
Density of soil sample (g/cc)	1.63
Angle of internal friction	25^0

V.EXPERIMENTAL SETUP AND METHODOLOGY

CALIFORNIA BEARING RATIO (CBR)

In 1928 California Division of Highways in U.S.A develop CBR method for pavement design.At the beginning of the second world war ,the Corps Engineers of USA made survey of the existing method of pavemnent design and adopted CBR method for designing airport pavements.The strength of the subgrade is most often expressed as California Bearing Ratio(CBR),which is the ratio of test load to standard load at a specified penetration by standard plunger.In India the design of flexible pavement is primarily on the basis of the CBR value of subgrade CBR(IRC:37-2001).

CBR tests were carried out in accordance with IS:2720(Part 16)-1987. The laboratory CBR apparatus consist of a mould of 150mm diameter with a base plate and a collar, loading frame with the cylindrical plunger of 50mm diameter. Breifly

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 09, September-2016

the penetration test consists of causing a cylindrical plunger of 50mm diameter to penetrate a pavement component material at 1.25mm/minute. The load values to cause 2.5mm penetration and 5mm penetration are recorded. These loads are expressed as percentages of standard load values at respective deformation levels to obtain CBR value. The standard load values obtained from the average of a large number of tests on crushed stones are 1370kg and 2055kg respectively at 2.5mm and 5mm penetration. The surcharge weight is placed on the top of the specimen in the mould and the assembly is placed under the plunger of the loading frame. The load values are noted corresponding to penetration values of 0,0.5,1,1.5,2,2.5,3,4,5,7.54,10 and 12.5mm.The load penetration graph is plotted. Alternatively the load values are plotted against the penetration values. Two typical curves may be obtained. The normal curve is with convexity upwards and the load corresponding to 2.5mm and 5mm penetration values are noted. Sometimes a curve with initial upward concavity is obtained, indicating the necessity of correction. In this case the corrected origin is established by drawing a tangent from the steepest point on the curve. The load values corresponding to 2.5mm and 5mm penetration values from the corrected origin are noted.

The causes for initial concavity of load penetration curve calling for correction in origin are due to: the bottom surface of the plunger or the top surface of soil is not truly horizontal, with the result the plunger surface not being in full contact with the top of the specimen initially and the top layer of the specimen being too soft or irregular.

Normally the CBR value at 2.5 mm penetration which is higher than that at 5 mm penetration is reported as normal CBR value. However, if the CBR value obtained from the test at 5 mm penetration is higher than that of 2.5mm , then the test is to be repeated for checking. If the check test again gives similar values, the higher value obtained at 5mm penetration is reported as CBR value .

Tests were conducted for samples with and without plastic mats at different depths.Waste plastic bottle rings are cut into rings of different thickness .Each ring combine to form a mat like structure.Waste plastic mats of various thickness such as 1cm,2cm,3cm,4cm and 5cm are taken. Individual tests are carried out for each thickness placed at varying depths of about 2cm, 4cm, 6cm, and 8cm.Fig.5 shows a pictorial representation of mats placed at varying depths.

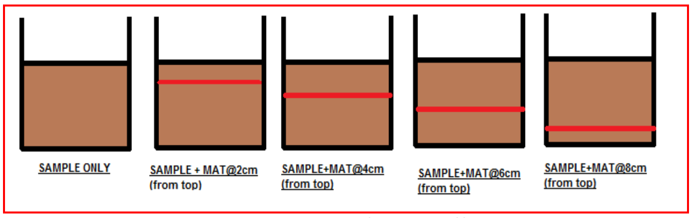

Fig.5.Pictorial representation of mat at different depths

VI.RESULTS AND DISCUSSION

A. Inclusion of waste plastic mat of **1***cm thick at varying depths*

Waste plastic mat of 1cm thickness is placed at varying depths of 2cm,4cm,6cm and 8cm. Individual tests are carried out at different depths with constant thickness. Result shows that the strength of soil increase for 2cm,4cm and there is no increase in strength for 6cm and 8cm. After 4cm there is no change of ,because load transfer beyond 4cm does not take place. Table III shows the CBR value at different depths. Fig.6 shows the load penetration curve at varying depths

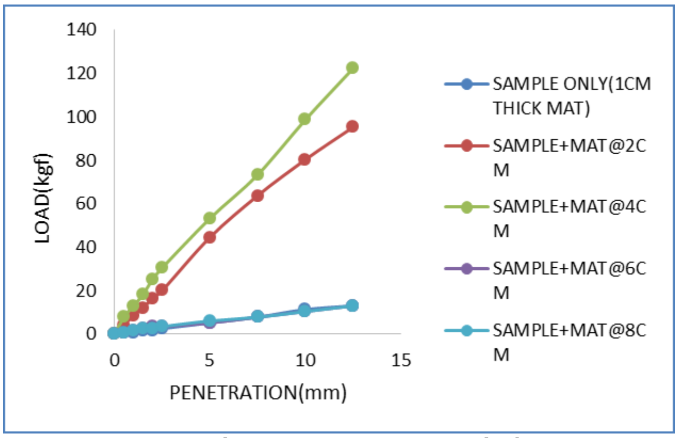

Fig.6.Load penetration curve at varying depths

Table III.CBR value at different depths

Depth (cm)	CBR (%)
Sample only	0.28
Mat at 2cm	2.3
Mat at 4cm	2.9
Mat at 6cm	0.29
Mat at 8cm	0.28

B. Inclusion of waste plastic mat of **2***cm thick at varying depths*

Waste plastic mat of 2cm thickness is placed at varing depths of 2cm,4cm,6cm and 8cm. Individual tests are carried out at different depths with constant thickness. Result shows that the strength of soil increase for 2cm,4cm and there is no increase in strength for 6cm and 8cm. After 4cm there is no change of ,because load transfer beyond 4cm does not take place. Comparing the values of 1cm thick, increment in CBR value is noted for 2cm thick mat. Table IV shows the CBR value at different depths. Fig.7 shows the load penetration curve at varying depths.

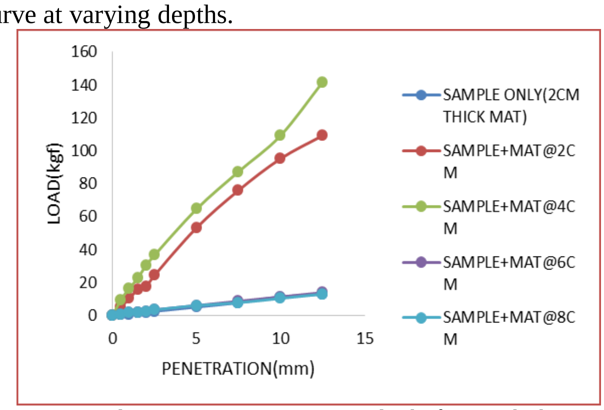

Fig.7.Load penetration curve at varying depths for 2cm thick mat

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 09, September-2016

Table IV CBR value at different depths

Depth(cm)	CBR(%)
Sample only	0.28
Mat at 2cm	2.8
Mat at 4cm	3.3
Mat at 6cm	0.29
Mat at 8cm	0.28

C. Inclusion of waste plastic mat of **3***cm thick at varying depths*

Waste plastic mat of 3cm thickness is placed at varing depths of 2cm,4cm,6cm and 8cm. Individual tests are carried out at different depths with constant thickness. Result shows that the strength of soil increase for 2cm,4cm as in case discussed above and there is no increase in strength for 6cm and 8cm. After 4cm there is no change of ,because load transfer beyond 4cm does not take place. Table V shows the CBR value at different depths. Fig.8 shows the load penetration curve at varying depths.

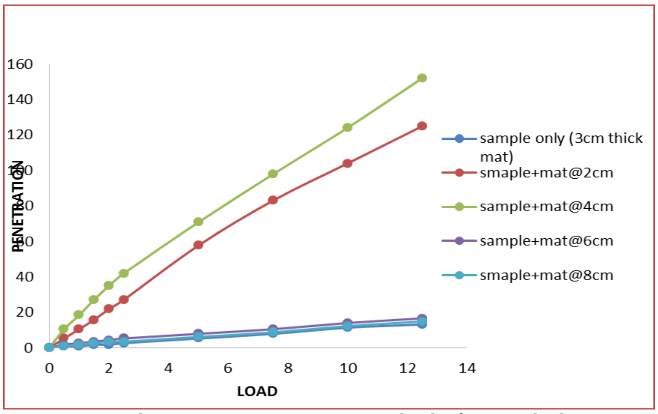

Fig.8.Load penetration curve at varying depths for 3cm thick mat

Table V CBR value corresponding to different depths

Depth(cm)	CBR(%)
Sample only	0.28
Mat at 2cm	2.9
Mat at 4cm	3.6
Mat at 6cm	0.29
Mat at 8cm	0.28

D. Inclusion of waste plastic mat of **4***cm thick at varying depths*

Waste plastic mat of 4cm thickness is placed at varying depths of 2cm,4cm,6cm and 8cm. Individual tests are carried out at different depths with constant thickness. Result shows that the strength of soil increase for 2cm,4cm as in case discussed above and there is no increase in strength for 6cm and 8cm. After 4cm there is no change of ,because load transfer beyond 4cm does not take place. Values obtained for different depths with mat of thickness 4cm is same as the values obtained for 3 cm thick mat.

Using 5cm thick mat is not possible because when mat is placed between the layers and compacted the waste plastic mat get destroyed due to its increased thickness. So mat of 3cm or 4cm thickness is taken as the optimum.

E. Inclusion of waste plastic mat at a depth **2***cm from top*

Waste plastic mat of varying thickness from 1cm,2cm,3cm,4cm and 5cm is placed at 2cm from top and inividual test is carried out for each thickness. For each increment of thickness, CBR value shows increase in strength of the subgrade soil. Change is carried out upto 3cm thickness and value corresponding to 4cm is same as that of 3cm. Beyond 4cm, ie, for 5cm thickness during compaction the mat gets ruined due to increased thickness. Table VI shows the CBR value for varying thickness at a depth of 2 cm.Figure 9 shows the load penetration curve of sample with mat of varying thickness placed at 2cm from top.

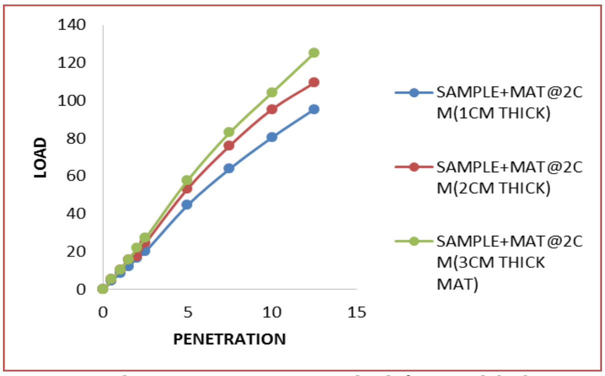

Fig.9.Load penetration curve at 2cm depth for varied thickness

Table VI CBR value at depth 2cm

Thickness(cm)	CBR(%)
Sample only	0.28
1cm thick mat	2.3
2cm thick mat	2.8
3cm thick mat	2.9
4cm thick mat	2.9

F. Inclusion of waste plastic mat at a depth **4***cm from top*

Waste plastic mat of varying thickness from 1cm,2cm,3cm,4cm and 5cm is placed at 4cm from top and inividual test is carried out for each thickness. For each increment of thickness, CBR value shows increase in strength of the subgrade soil. Change is carried out upto 3cm thickness and value corresponding to 4cm is same as that of 3cm. Beyond 4cm, ie, for 5cm thickness during compaction the mat gets ruined due to increased thickness. The strength for 4 cm is higher compared to 2 cm depth . Table VII shows the CBR value at different depths. Figure 10 shows the load penetration curve of sample with mat of varying thickness placed at 4cm from top.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 09, September-2016

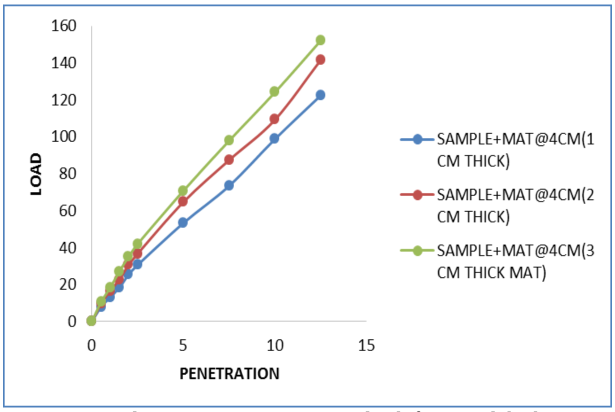

Fig.10.Load penetration curve at 4cm depth for varied thickness

Table VII .CBR value at depth 4cm

Thickness(cm)	CBR(%)
Sample only	0.28
1cm thick mat	2.9
2cm thick mat	3.3
3cm thick mat	3.6
4cm thick mat	3.6

G. Inclusion of waste plastic mat at a depth **6***cm and* **8***cm from top*

Waste plastic mat of varying thickness from 1cm,2cm,3cm,4cm and 5cm is placed at 6cm and 8cm from top and individual test is carried out for each thickness. At 6cm and 8cm load transfer does not take place and the CBR value corresponding is similar to or somewhat near to CBR corresponding to sample only.

From the test results, it is clear that for 4 cm thick mat the CBR value is higher and it is of normal subgrade strength. According to depth strength corresponding to 4cm depth is higher.

H. Inclusion of waste plastic mat of varied thickness at optimum depth 4cm along with sand filling

Cohesionless sand carried from Muthalapozhy, which is in Thiruvananthapuram district is used as filling for mat to study the improvement of strength charecteristics. Placement of sand is done for optimum stages for each mat thickness. Individual CBR tests are conducted for each phase.

Sample is prepared as such for CBR tests and waste plastic mat is placed at 4cm which is the optimum depth from the above test results. Sand is filled in the mat. Test result shows that there is increase in strength by sand filling. CBR value corresponding to 2.5mm penetration for 1cm thick mat with sand is equal to 5.76%.

Sample prepared for 2cm thick mat placed at optimum depth along with sand filling and results shows an increase in CBR value of about 7.15%.Similarly, tests carried out for 3cm thick mat and CBR value obtained as 8.2%.Table VIII showing CBR value for different thickness at optimum depth 4cm.Figure 11 shows the load penetration curve for different thickness mat filled with sand. From the test results, 30 times increase in CBR value is obtained for sample with mat filled with sand.

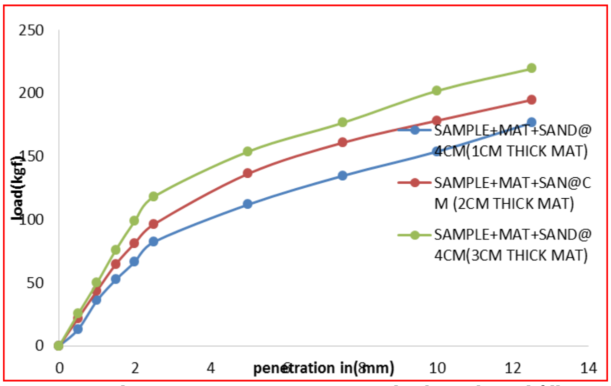

Fig.11.Load penetration curve at optimum depths with sand filling

Table VIII CBR value along with sand filling

Thickness(cm)	CBR(%)
1cm thick mat	5.76
2cm thick mat	7.15
3cm thick mat	8.2

VII.CONCLUSIONS

The conclusions drawdown from above studies are stated below:

- The soil subgrade is a layer of natural soil prepared to receive the layers of pavement materials placed over it. The Kuttanad region covering about 875 km^2 is a unique agricultural area in the world. A good portion of this area lies 1-2 m below MSL and is submerged for major parts of the year.
- The area is susceptible to seasonal ingress of saline water as a result of tidal inflow from the sea. During the monsoons, the rivers and rivulets pour fresh water into the area. The depth of the loose deposits extends to more than 30 m in many places.
- Difficulties are encountered in laying good roads in the area to provide transport facilities. At many places road embankments have failed due to the poor bearing capacity of the sub-soil. Continuous settlements of road embankments are not uncommon.
- Inorder to increase the strength of subgrade soil, this paper deals with the inclusion of waste plastic mat as geocell in the soil.
- Waste plastics are increasing now a days and to use it effectively to increase the strength of soil, plastic mats are made and used as geocell.
- Wastes are increasing day by day and the use of waste plastic bottle is very active in our day to day life. Recycling or reusing it is very uncommon .They are dumped into the environment and becomes a serious threat to the whole life.
- One of the main cause of pollution is the waste plastic because it is not degradable. While burning itself large amount of air pollutants are apreading in to the atmosphere.
- Water bodies are also get polluted due to the concentration of wastes plastics.
- So inorder to decrease the effect of waste plastic, this paper focus to reduce the effect of waste by using it in an appropriate manner.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 09, September-2016

- Waste plastic bottles are made in the form of mat to use plastic in appropriate way and to reduce environmental pollution
- When these mats are placed in between the soil, their occurs a confinement effect within the soil.
- Mats of different thickness of 1cm,2cm,3cm,4cm, and 5cm are used at varying depths of 2cm,4cm,6cm and 8cm.Tests are carried out with each thickness at varied depths.
- By considering thickness, strength increases till 3cm thickness and for 4 cm there is no change in the load carrying capacity and hence the CBR value obtained is same as for 3cm thick mat ie, 3.6%.
- 5cm thick mat is placed to know the load carrying effect, but when compacting the mat gets ruined due to increased thickness.
- Mats of different thickness are placed at varying depths of 2cm,4cm,6cm and 8cm .Strength and load carrying capacity shows that strength increases when mats are placed at 2cm and 4cm ,greater for 4cm depth.
- After that load transfer has no effect at greater depths from top and hence at 6cm and 8cm there is no change in the strength gain in the soil.
- At 4cm depth the strength is maximum and hence 4cm is taken as the optimum as in the case of depth.
- Another set of tests are carried out in order to notice the effect of strength by using sand which is filled in the mat and then sample is prepared. Tests are done by taking the optimum depths of each mat thickness. From the test results it shows that the sand filled mat of 1cm thick has a CBR value of 5.76%.
- For 2cm thick mat with sand filling obtained a CBR value of 7.15%
- For 3cm thick mat with sand filling obtained a value of 8.2%.
- From test results,30 times increase in CBR value is obtained from sample with mat filled with sand.
- In this case mat of 3cm thickness at 4cm depth refers to the optimum condition.
- From this analysis it is clear that waste plastics can be used in an effective way and the use of this can increase the strength of low strength soil by using sand in addition.

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