Experimental study on Geo Textiles and Geo Membrane for Deteriorated Concrete in Offshore Structures

Vijaya Sundravel K, Barath K, Jayasurya V, Jeeva S, Karthi A, Ramesh S

***Abstract*— Due to increasing rate of population, urbanization and industrialization in India, the demand for land is becoming increasingly more at alarming rates. This necessitates the use of unsuitable land for soils for various Civil Engineering applications.**

There are three basic classification of soil in nature viz: sand, silt and clay. Clay soils are generally classified as "expansive". This means that a given type of clay will tend to expand (increase in volume) as it absorbs water and it will shrink (lessen in volume) as water is drawn away.

Structures, which include lightly loaded buildings, pavements, underground pipelines constructed on expansive soils to severe distress caused by swelling/shrinkage nature of such clays during summer and winter seasons due to fluctuations in water table.

There are many methods for improvement of ground. Some of them are compaction grouting, vibro systems, jet grouting, wet soil mixing, dry soil mixing, column methods, pre compression/pre loading, Thermal methods and soil reinforcement using geo-synthetics and coconut fibers.

Of the above mentioned ground improvement techniques, the soil reinforcement using Geo-synthetics is the latest development, which can be used for the improvement of any type of soil and particularly for the above mentioned clay soils with the view of increasing bearing capacity and reducing compressibility.

Geo-synthetics (Geo-grid, Geo-membrane and Geo-textile) are used as separator, filter reinforcement and for drainage purposes. In this paper the study of the performance of geo-synthetics on the settlement characteristics of soft clay in which soil pertaining high Free Swelling Index was studied.

***Index Terms*— Geo synthetics, Geo-grid, Geo-membrane, Geo-textile**

Manuscript received April 21, 2020

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I. INTRODUCTION

Due to increasing rate of population, urbanization and industrialization in India, the demand for land is becoming increasingly more at alarming rates. This necessitates the use of unsuitable land for soils for various Civil Engineering applications.

There are three basic classification of soil in nature viz: sand, silt and clay. Clay soils are generally classified as "expansive". This means that a given type of clay will tend to expand (increase in volume) as it absorbs water and it will shrink (lessen in volume) as water is drawn away.

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Of the above mentioned ground improvement techniques, the soil reinforcement using Geo-synthetics is the latest development, which can be used for the improvement of any type of soil and particularly for the above mentioned clay soils with the view of increasing bearing capacity and reducing compressibility.

Geo-synthetics (Geo-grid, Geo-membrane and Geo-textile) are used as separator, filter reinforcement and for drainage purposes. In this paper the study of the performance of geo-synthetics on the settlement characteristics of soft clay in which soil pertaining high Free Swelling Index was studied.

GEO-SYNTHETICS:

Earth reinforcement is an effective technique and reliable for increasing strength and stability in soils. This technique is used today in a variety of applications ranging from retaining structures and embankments to sub grade stabilization beneath the footing and pavements. Reinforcement can vary greatly in form (strips, sheets, grids, fibers, fabrics) texture (rough or smooth) and relative stiffness (high such as steel or less as polypropylene fabrics) and woven and non-woven fabrics.

The strain/deformation in any direction could be controlled by introducing the reinforcement (geo-synthetics) by way of frictional forces acting against deformation. The three main areas where geo-synthetics soil reinforcement may be applied are: (1) Foundations, (2) Slopes and embankments, and (3) Retaining walls

Synthetic polymers with high strength for use as soil reinforcement materials are available. They are mainly made of polyester, polyamide, and polyethylene .The materials used for soil reinforcement generally have high U.V degradation and corrosion resistance. The strain behavior of these polymers is time dependant i.e. the creep of these products is significant. The material requirements are depend on loading conditions and the life time of the structure.

Unlike many other types of geotextiles, geo-grids are used almost entirely for reinforcement. The large aperture size limits their effectiveness as a filtration layer unless used with a widely graded soil with the most coarse material (gravel or rocks) adjacent to the grid. The main uses of geogrids are

1. Beneath aggregate in unpaved roads
2. Beneath ballast in railroad construction
3. Beneath surcharge fills
4. Repairing slope failures and landslides
5. To stabilize leachate collection stone as veneer reinforcement
6. As inserts between geo membranes
7. Reinforcement of embankment fills and earth dams
8. As three dimensional mattresses for landfill bearing capacity
9. To reinforce landfills to allow for vertical reinforcement

Table I (a) Use of Geosynthetics in Geotechnical Engineering Application

Application	**Primary Function**	**Product**
Soil reinforcement		
Vertical walls	Reinforcement	Geotextiles / Geogrid
Embankment	Reinforcement	Geotextiles / Geogrid
Steep slopes	Reinforcement	Geotextiles / Geogrid
Stabilization of sub-grade	Reinforcement, separation and filtration	Geotextiles / Geogrid
Rail road track, bed stabilization, asphalt overlay	Drainage / Separation, stress relieving, water proofing	Geotextiles / Geocomposites
Subsurface drainage	Filtration	Geotextiles
Sedimentation control / Silt fence	Sediment retention, filtration / separation	Geotextiles
Erosion control, Filter / Canal lining	Filtration / separation seepage control	Geotextiles / Geomatresses
Surface Erosion control	Turf Reinforcement	Geomats
Sub-surface drainage	Filtration / Fluid transmission / Radial consolidation	Prefabricated vertical composites
Geomembrane protection	Protection / cushion	Geotextiles

II. METHODOLOGY

A.MATERIAL SELECTION

MECHANICAL / SEDIMENTATION ANALYSIS:

This method is used to determine the distribution of particle size, finer than 75 micron sieve and to plot the grain size distribution curve.

2.b. ATTERBERG LIMIT:

Atterberg limits are a set of index tests performed on fine grained silt/clay soils to determine the relative activity of the soils and their relationships to moisture content. The liquid limit, plastic limit and shrinkage limit define the relative stages of behavior as indicated below when the soil moves from the solid to liquid state.

The soil classification of fine grained soils based on these limits is also shown below. The limits of "GOOD CLAY" and "BAD CLAY", if there is such a thing, is defined as a liquid limit less than 50 and plasticity index less than 20 for silts and clays (ML/CL designations). The materials classified as CH, MH and OH are typically unsuitable for reinforced wall construction and should be avoided.

Keystone recommends limiting the LL<40 and PI<15 when dealing with plastic soils when ever possible to avoid the transitional zone of normal soil classification.

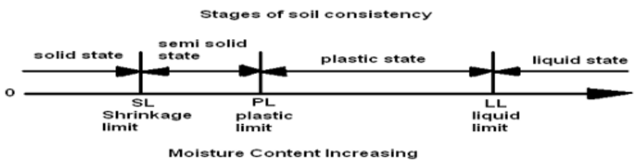

Figure 2 (b)

Plastic limit:

Plastic limit is the water content corresponding to the arbitrary limit between the plastic and the semi solid states of consistency of a soil. It is defined as the minimum water content at which a soil will just begin to crumble when rolled into a thread approximately 3mm in diameter.

The plasticity index is calculated from a relation

$$I_p = W_l - W_p$$

2. c. Shrinkage limit:

Shrinkage limit is defined as the maximum water content at which a reduction in water content will not cause a decrease in the volume of a soil mass.

FREE SWELL INDEX:

Take two 10gm soil specimens of oven dry soil passing through 425 micron IS sieve. Each soil specimen shall be poured in each of the two glass graduated cylinders of 100ml capacity. One cylinder shall then be tilted with kerosene oil and the other with distilled water up to the 100ml mark.

After removal of entrapped air, the soils in both the cylinders shall be allowed to settle. Sufficient time shall be allowed for the soil sample to attain equilibrium state of volume without any further change in the volume of the soils. The final volume of soils in each of the cylinders shall be read out.

FSI % = ((Vd-Vk)/Vk) * 100

Where Vd and Vk are volume of soil in distilled water and in kerosene respectively.

Table II (a) Degree of Expansiveness and Differential Free Swell

Degree of Expansiveness	DFS (percent)
Low	Less than 20
Moderate	20 to 35
High	35 to 50
Very high	Greater than 50

PROCTOR COMPACTION TEST:

To assess the amount of compaction and the water content required in the field, compaction tests were done on the same soil in the laboratory. The tests provide a relationship between the water content and the dry density. The optimum water content at which the maximum dry density were obtained from the relationships provided by the tests.

SWELL PRESSURE:

An expansive soil, wetted with water, and when restrained, exerts pressure, which is known as swell pressure.

To measure the swell pressure different methods are adopted, such as

1. constant volume method
2. volume changes with different applied loads
3. consolidation method

Factors influencing swell pressure

1. initial moisture content
2. dry densities
3. height of specimen
4. volume change

ANALYSIS OF SWELLING WITHOUT GEO-GRID

The soil was compacted in the CBR mould to maximum dry density corresponding to 80% of optimum moisture content. This mould is kept in water with perforated plate on both sides, dial gauge are fitted in opposite direction over the top of plate. The sample is allowed to swell freely and the observations were taken at regular time intervals. A semi log plot was drawn between time Vs swelling and the maximum swelling were recorded corresponding to above condition. The same procedure was adopted for **kumarapalayam sample** also.

III. RESULT AND DISCUSSION

Table III (a) Observation of swelling for bhavani sample

TIME IN MINUTE	SWELL IN mm	TIME IN MINUTE	SWELL IN mm	TIME IN MINUTE	SWELL IN mm
0	.01	324	5.73	4335	18.66
15	.015	963	11.93	4405	18.82
30	.015	1170	12.255	4460	18.73
45	.015	1205	12.345	4480	18.75
60	.045	1360	12.825	4510	18.76
75	.027	1361	12.885	4810	19.27
90	.066	1545	13.05	5035	19.30
105	1.17	1510	13.23	5175	19.42
135	1.875	1560	13.335	6230	19.47
150	2.385	1585	13.485	6250	19.48
165	2.685	1605	13.53	6340	19.48
180	2.94	2540	15.885	6400	19.48
195	3.225	2615	16.17	6462	19.48
210	3.525	2670	16.23	6475	19.48
225	3.99	2710	16.44	6540	19.48
240	4.29	3070	17.07	6660	19.48
255	4.65	3960	18.18	7680	19.48
270	5.025	4080	18.45	7875	19.48
285	5.37	4150	18.66	7877	19.48

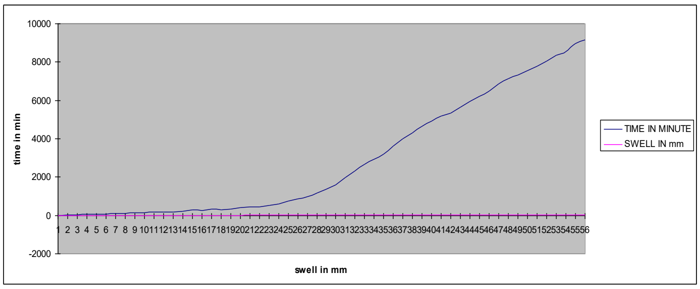

Figure III (a)

ANALYSIS OF SWELLING WITH GEO-GRID

For the sample with geo-grid, the geo-grid is placed at the centre of the compacted soil mould and the remaining procedure was same as that of soil without geo-grid and the readings are tabulated below.

Table III (b) Observation of swelling with Geo-grid for bhavani sample

Time in min	Swell in mm	Time in min	Swell in mm	Time in min	Swell in mm
0	.01	427	3.54	3070	9.1
15	.01	457	3.87	3631	9.46
30	.01	550	4.34	4080	9.79
45	.01	963	5.59	4150	9.86
60	.02	1072	5.73	4375	9.96
75	.15	1148	6.13	4436	10.02
90	.36	1202	6.34	4560	10.07
105	.64	1318	6.66	4898	10.2
135	1.03	1514	7.17	5248	10.28
150	1.31	1510	7.27	5495	10.32
165	1.47	1560	7.33	5984	10.43
180	1.62	1585	7.41	6353	10.53
195	1.79	1698	7.44	6871	10.59
210	1.93	2042	8.03	7145	10.66
225	2.2	2239	8.32	7638	10.71
347	3.12	2515	8.53	9226	10.71
380	3.33	2710	8.82	8128	10.71

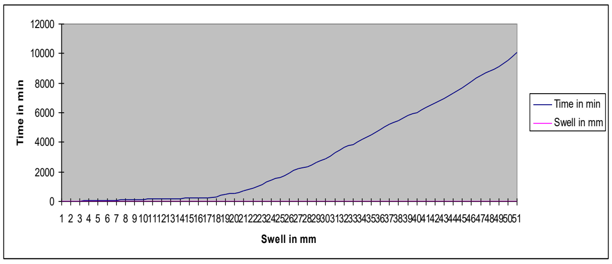

Figure III (b)

Table III (c) DETERMINATION OF SWELLING PRESSURE:

Swelling pressure with out geo-grid				Swelling pressure with geo-grid			
swelling pressure kg/cm2	**Settlement in mm**	**swelling pressure kg/cm2**	**Settlement in mm**	**swelling pressure kg/cm2**	**Settlement in mm**	**swelling pressure kg/cm2**	**Settleme nt in mm**
0	1220	.288	1095	0	1172	.288	1073
.018	1210	.306	1089	.018	1170	.306	1068
.036	1201	.324	1087	.036	1160	.324	1065
.057	1194	.342	1081	.057	1151	.342	1061
.072	1185	.36	1078	.072	1140	.36	1060
.09	1176	.378	1073	.09	1130	.378	1056
.108	1170	.396	1068	.108	1126	.396	1050
.126	1160	.414	1065	.126	1118	.414	1045
.144	1151	.432	1061	.144	1111	.432	1037
.162	1140	.45	1060	.162	1104	.45	1031
.182	1130	.468	1056	.182	1099	.468	1027
.198	1126	.486	1050	.198	1095	.486	1025
.216	1118	.504	1045	.216	1089	.504	1020
.234	1111	.522	1037	.234	1087	.522	1014
.252	1104	.54	1031	.252	1081	.54	1009
.27	1099	.558	1027	.27	1078	.558	1006

The sample after swelled to the maximum limit (ensuring that no further movement of dial reading for an hour/two hour), the mould was kept on CBR apparatus, then the pressure increment was applied slowly and compression was taken.

The swelling pressure obtained by increasing load method. The plot was made between load Vs compression/settlement. The results were tabulated for the soil without reinforcement.

Also for the **sample with geo-grid**, the **geo-grid is placed at the centre of the compacted soil mould** and the remaining procedure was same as that of soil without geo-grid.

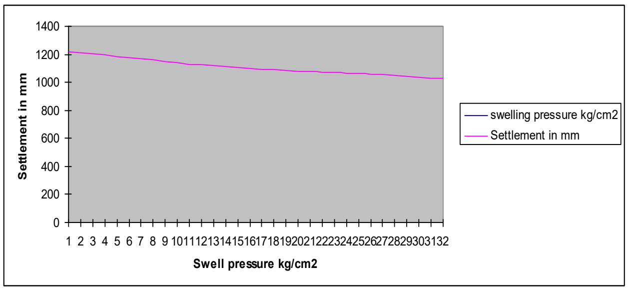

Figure III (c) Without Geogrid

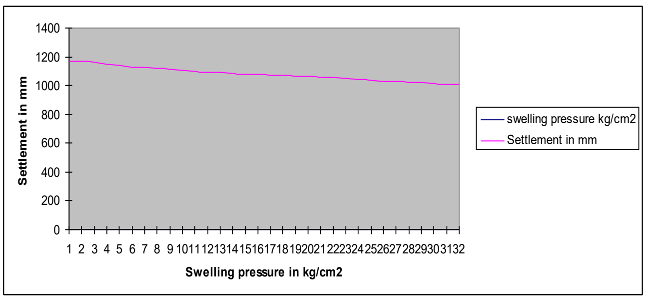

Figure III (d) With Geogrid

IV RESULTS AND DISCUSSION:

At last the results are compared between swelling and swelling pressures of soil samples with out and with geo grid.

Table IV (a) With out geo-grid

Sample	Swell in cm	Swell pressure in kg/cm2
Bhavani	1.9485	.5630
Kumarapalayam	1.576	.3645

From the above results, when FSI increases, the amount of swelling and swelling pressure increases and vice versa

Table IV (b) With geo-grid

Sample	Swell in cm	Swell pressure in kg/cm2
Bhavani	1.0717	.3097
Kumarapalayam	.8768	.2017

Thus by using the Geo grids as reinforcement material the swelling pressure was reduced by 45% than the soil without Geo-grid.

CONCLUSION

Based on the experimental investigation the following conclusions are listed below:

- The test results of compressive strength shows that there is 9% increase in strength when silica fume is replaced up to 20 %.
- The test results of tensile strength shows that there is 12% increase in strength when silica fume is replaced up to 20 %.

- The test results of flexural strength shows that there is 10% increase in strength when silica fume is replaced up to 20 %.

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