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AN EXPERIMENTAL STUDY FOR EVALUATION OF SHEAR STRENGTH PARAMETERS WITH GEOSYNTHETICMATERIALS AND CLAY BY USING LARGE-SCALE DIRECT SHEAR TEST BOX

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ABSTRACT

Clay soil is a highly complex particulate material, which is high swelling property and abundantly available in nature. Due to the rapid growth in the development, most of the construction works are may executing in clay soils also and sometimesclay soils are mostly adopted for construction of embankments, as base and sub-base coarse in pavements, filling low lying areas. Primitively, the embankments were constructed with very flat slopes, whereas, with the introduction of concept of retaining, many structures have been developed and designed as per the conditions. The most advance and widely adopted retainment systems is by mechanically stabilized earth (MSE) or reinforced earth, RE, technique, where the soil is reinforced to reduce the forces on the walls and in turn this reinforcement holds the wall and increases stability of the soil. One such reinforcement, termed as geo-synthetic material, is widely adopted, now-a-days, for increasing the stability of RE Walls. In RE walls, the selected geo-synthetic material will be sandwiched between two clay layers to enhance tensile strength of clay and hold the fascia panels in position. In such conditions, interface friction gets generated between geo-synthetics and clay soil. The interface depends on various parameters, such as type and gradation of clay, physical and chemical properties of the clay and material of geo-synthetics and drainage conditions. With this in view, the present study is proposed to study the interface friction between various geo-synthetics and different geo-materials including different claysoils and flyash. Such a study, would give an indication of the values to be adapted for frictional resistance, to the engineer, to practically design/analyze the stability of the retaining wall.

Keywords: Geo-Synthetics,MSE–wall, Fly-ash, Geo-composite, Geo-pipes, Geo-grid, Direct shear test.

INTRODUCTION

Generally, the soil in nature is found to be in combination of one or more size of particles. Hence, soil is highly complex material both by the particle matrix and also its behavior. In the terms of engineering, the soil has been considered to be a material with good shear strength, compressive strength but weaker tensile strength. Due to its abundance and good strength, soil is considered as the top and easily available and first priority as a good engineering fill material in the major engineering structures like embankments, fills, retaining and mining facilities.The past studies, it has been observed that the interface studies have been considered important for the design and analysis of retaining earth walls. It has been observed that these studies have been confined only for the soils and normal stress, whereas the present-day requirement is the use of flyash in the retaining walls has not been explored. In this context, an idea has been formulated to use the flyash not only as a single retainment material, but also with the concept of using them in layers sandwiched by soil. With this in view, the present study has been formulated to study the interface behavior of the clay with flyash and different geosynthetics. With this study, the effect of the interface of clay can brought to light.

Shear strength

There are various methods for determining the shear strength of the soils vis-à-vis Direct shear test, Triaxial test, Unconfined compressive strength and Vane shear test. The shear strength of the soil is majorly governed by type of soil, compaction parameters, normal stress and rate of strain. The shear strength of the soil is generally expressed with Mohr-Columb equation 1

$\tau = C + \sigma \tan\phi$……… (1)

where,

τ is shear strength of the soil in kN/m^2,c is the cohesion in kN/m^2

σ is normal stress in kN/m^2

ϕ is angle of internal friction in (°)

The parameters c, Ø termed as shear parameters are fixed for a given soil. Hence, in broader terms, the shear strength of the soil is only effected by the normal stress.

Retaining wall

A Retaining wallshould be designed properly to meet stability (external and internal) and economic considerations as shown in fig 1.1 When the geo-synthetic material is used as reinforcing material, interface friction between soil and geo-synthetic material plays an important role in the design of R.E wall to safe guard the structure against pullout. Therefore,it is important to know the behavior of interface friction between different soils and geo-synthetic materials along with the properties of soils such as unit weight of soil, angle of shearing resistance, cohesion intercept and angle of wall friction. And for the test purpose soil is replaced with clay and deformations were observed in the direct shear test properties of material were mentioned in the table no 1.

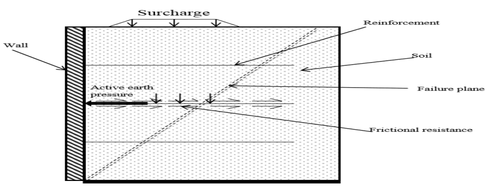


Fig 1: Force diagram of Retaining wall

1. OBJECTIVES

Hence from the existing literature, it has been observed that the interface studies have been considered important for the design and analysis of retaining earth walls.It has been observed that these studies have been confined only for the soils and normal stress, whereas the present-day requirement is the use of flyash in the retaining walls has not been explored.

1. To study the interface behavior of the clay with flyash and different geosynthetics

2. To understand Behavior of shear strength parametersof soil angle of Shearing Resistance and cohesive property with geosynthetic material

2. METHODOLOGY

The various tests performed for the study as per the standards. The tests include the index tests for soil classification, the engineering tests to understand the behavior of the soils. These tests were performed on three materials namely clay (C), locally available and Flyash (F) and reinforcement.

Materials Used:

a. Reinforcement

Various reinforcements are used to improve the tensile capacity of soils, especially in earth retaining structures, in the construction of reinforced earth walls, reinforced slopes, embankments on soft soils, landfills and other foundation soils. The different reinforcing materials used are: Plant roots, Steel bars (Wire grids), Steel strips, Steel/cast iron Sheets and Geosynthetics.

b. Geo -Textile

Geo-textile is a flexible, textile-like fabric manufactured from continuous poly propylene filaments, UV stabilized to prevent degradation when exposed to sun light. They possess robust and durable, with optimum permeability and soil filtration characteristics. These are used to provide filtration, separation or reinforcement in soil, rocks and waste materials.

Fig 1: Geo-textile

c. Geo-Grid

Geo-grids are stiff or flexible polymer coated grid like sheets manufactured from high strength polyester yarns, with large apertures used primarily as reinforcement for unstable soils and waste masses.

Fig2: Geo-grid

d. Geo-Composite

These are the hybrid systems of any, or all, of the above geo-synthetic types which can function as specifically designed for use in soil, rock, waste and liquid related problems andThese are used for separation, reinforcement, filtration, drainage, and liquid barrier.

Fig3: Geo-composite of geotextile and geogrid

e. Process of Methodology

The following test procedures are carried out for the study as per the standard codes are mentioned below:

- Hydrometer Analysis (IS: 2720(Part 4) -1985)
- Standard proctor test(lightcompaction)(IS:2720 (Part VII)-1980)
- Unconfined Compressive Strength(IS:2720 (Part VIII)-1983)
- Liquid Limit & Plastic Limit (IS: 2720 (Part V)-1985)
- Specific Gravity (IS:2720(Part III/Sec 1)-1980)
- Direct Shear Test (IS: 2720(Part 13)-1986)
- Sieve Analysis :(IS:2720(Part IV) -1985)

Test procedure:

a. Modified Direct Shear Test

In order to cater for the need of the experimentation for the present study, the conventional direct shear test has been slightly modified. With the modification, the shear properties of the soil, sandwiching a geosynthetic (Geo-textile or Geo-grid) has been determined. For this, a portion of oven dried sample has been taken into a tray, mixed with corresponding optimum moisture content (OMC) uniformly. In this method, the lower half was compacted with sample above porous grid plate by fixing the geosynthetic material between the two halves, compact the upper half with sample and place the shear grid plate above it. The loading pad was placed on the top grid plate and the whole assembly was placed in the box of the modified direct shear apparatus as shown in the fig 3.1. The test was conducted by applying horizontal shear load up to failure of the sample. The shear load readings indicated by the proving ring assembly and the corresponding longitudinal displacements were noted at regular intervals. A minimum of three tests were performed on same sample compacted to its corresponding optimum moisture content (OMC) separately and readings were noted accordingly. Cohesion intercept and angle of internal frictional corresponding sample-geosynthetic interface were arrived at.

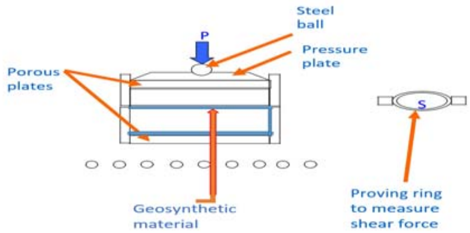


Fig 3.1: Modified direct shear test modelAnd the interface behavior between geomaterial and clay and flyash were studied and for the test purpose large-scale direct shear device (450mm x 450mm x 130 mm) box is considered (Liu et al,2009) and the procedure as per the (IS: 2720(Part XIII)-1986) followed, coming to the proportions of material has been chosen in terms of thickness first the test was conducted for conventional clay and flyash the properties of clay and flyash as mentioned in below table number 1, followed by combination of material as shown in figures 4.1,4.2 and 4.3, 70% of direct shear test box filled with sand in two layers and remaining 30% of thickness of the shear box is with any one of the geosynthetic material placed in between sand layers and load is applied and then valves are taken from both dial gauges, then the interface behavior was observed between the geosynthetic material and sand and the Shear displacement between the layers is observed and graphs between Shear Stress and Normal Stress are plotted, like the first layer clay and immediately the next layer is any one of the geosynthetic material and again the top layer of the Shear box is clay, similarly the test was repeated for more combinations and the results were given in the table number 2.

3. RESULTS AND ANAIYSIS

The analysis of the results obtained from the various tests performed on the geo-material is included in the subsections of the Table no 2. As the part of the study, three geo-material, i.e. Clay (C), Flyash (F) and reinforcement, has been considered and the geosynthetic material, Non-Woven Geo-textile (GT), Geo-Composite (GC) and Geo-grid (GG) have been used as the reinforcement material.

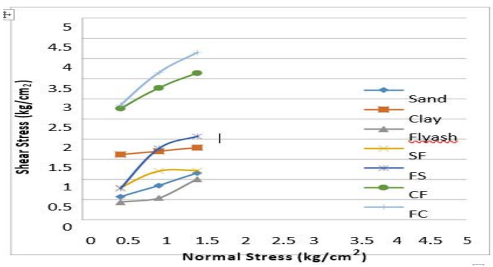
Table 1: Properties of the geo-material

	Geo-Materials	
	clays	Flyash Silt Sized
Classification	CI	particles
specific gravity	2.41	2.31
maximum dry density (g/cc)	1.71	1.373
liquid limit(%)	42	_
Optimum moisture content (%)	16	16
plastic limit(%)	33%	_
angle of internal friction (Ø)	0	-
Cohesion (kg/cm^2)	0.44	-

It can be observed that the geo-materials considered for the study covers a wide range of soil size ranges, Clay (Black Cotton Soil). Also, the geo-synthetic products used in the study are the different types of material used for the reinforcement of the backfill material in RE walls. Also, to observe the effect of layers of soil, Flyash (widely available fill material) has been considered in the layers. Hence, the effect of the layers of clay and flyash and vice versa has been considered for the analysis. So, four combinations of such layers, Clay in the lower box and flyash in top box (CF) and vice versa (FC) has been considered for the study.

Influence of geo-material on the shear stress

Direct shear tests have been performed on the various combinations of geo-material, as discussed above. In the test, the shear strength has been analyzed for the various combinations for the given range of normal stress (0.5, 1.0, 1.5 kg/cm^2). It has been observed, that the shear stress is increasing with the increase of normal stress, for all the material and the combination in layers. Interestingly, it has been observed that the combination of layers with flyash has been observed to improve the shear strength. It can be attributed to the fact that the flyash, having the particle size in the range of silt has better bonding with the sand, than with sand itself. In case of clay, the bonding is expected to be more as clay is a good binding agent and the interface of the two layers is observed to yield maximum resistance to the shear under the given normal stress.



Graph 1: Effects of Geosynthetics on the shear strength of caly, flyash, sand

Influence of geo-synthetics on the shear strength of Clay

Though the same effect of the increase of the shear strength with the inclusion of the geo-synthetics can be observed for clays (graph 4.2a.), the addition of geo-textile (woven and non-woven) and geo-composite has shown no major increase on the shear strength (Ingold 1983 and Zaini et al.2012). But, the geogrid interface has increased the shear strength of the clay. This can be due to the mobilisation of the strength due to the bonding between the clay-clay interface in the opening of the geo-grid and the bonding of clay and geo-grid at their interface (Kamalzare& Moayed 2011; Alfaro et al.1995; Tatlisoz et al.1998and Liu et al.2009).

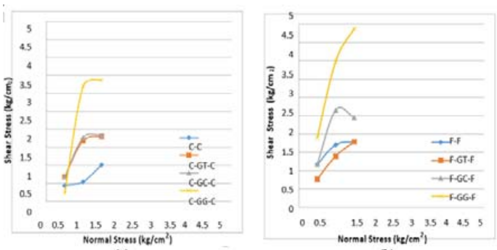
Fig 4.1: Shearing of clay with geo-composite interface

Influence of geo-synthetics on the shear strength of flyash

With the flyash, similar results of that of interface with clay have been observed, other than the improvement of shear strength due to the inclusion of geo-textile and geo-composite. But, it can be clearly observed from Fig.4.2 graph, that there is no major increase in the shear resistance due to reinforcement geo-composite or geo-textile. Even then, the geo-grid shows a very clear, distinct and major impact on the shear strength of the flyash

(a) (b)

Fig 4.2: Shearing of Flyash with geo-composite interface



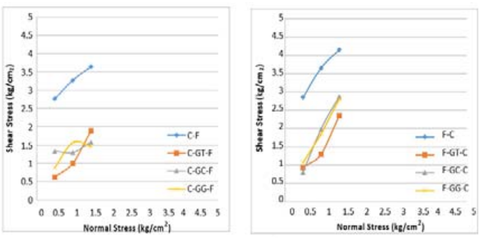
(a) (b)

Graph2: Effect of Geosynthetics on the shear strength of clay&Flyash

Influence of geo-synthetics on the shear strength of clay-flyash interface

The shear strength characteristics of the clay flyash interface have depicted a very unique and different trend than others. It can be observed from graph.4.3 (a) & (b), that the inclusion of reinforcement material has negative impact, i.e. the shear strength of the material has been observed to decrease with the geo-synthetic material irrespective of their type. This can be attributed to the fact that the bonding between the flyash and the clay as explained in the above section (4.2) has induced higher shear resistance than the obtained values using geo-synthetics

Fig 4.3: Shearing at the interface of a) F-GC-C and b) C-GC-F



(a) (b)

Graph 3: Effect of Geo-textile, Geo-grid, Geo-composite on the shear strength of (a)clay and (b)Flyash

Table 2: Direct Shear Results of Interface Friction

Material	Normal Stress (kg/cm²)			C(kg/cm²)	Ø (°)
	0.5	**1**	**1.5**		
	Shear Stress(kg/cm²)				
Clay	1.17	1.7	1.79	0.93	31.8
Flyash	0.44	0.54	1.01	0.09	29.7
CF	0.76	3.27	3.64	0	70.9
FC	2.85	1.65	4.15	1.58	52.4
C-GT-C	0.77	1.39	1.79	0.3	45.6
F-GT-F	0.68	1.68	1.81	0.09	48.5
C-GT-F	0.62	1	1.89	0	51.8
F-GT-C	0.93	1.3	2.35	0.11	54.8
C-GC-C	1.18	2.65	2.45	0.49	51.8
F-GC-F	0.68	1.77	1.84	0.27	49.2
C-GC-F	1.34	1.3	1.58	1.17	13.5
F-GC-C	0.8	1.98	2.87	0	64.2
C-GG-C	1.9	3.99	4.88	0.61	71.4
F-GG-F	0.23	3.2	3.37	0	72.3
C-GG-F	0.87	1.57	1.46	0.71	30.5
F-GG-C	2.8	1.07	1.86	2.85	0

5. CONCLUSIONS

From the above study, the following conclusions can be made:

1) From the studies conducted on different material and a combination of the layers, it has been observed that the clay-flyash and flyash-clay layers have yielded higher shear strengths. Hence, it can be deduced that the inclusion of flyash as layers not only enhances the interface shear strength but also reduces the lateral pressures substantially.

2) It has been observed that the inclusion of geosynthetics, i.e. geotextile, geocomposite and geogrid in the order of increase of tensile strength, have been detrimental in improving the shear resistance, with an anomaly for clay flyash mixtures. Also, it can be concluded that the shear strength at the interface increases with the tensile strength on the geosynthetic material.

3) The converse has been observed for the clay-geosynthetic-clay interface with more shear resistance than that observed for clay-geosynthetic-flyash layers.

4) In the study, it has been observed that the clay-flyash interface, which has yielded higher shear strength without any geosynthetic has shown an negative impact, i.e. decrease in the shear strength at the interface with the addition of geosynthetic, irrespective of the type or the tensile strength of the material.

From the total study, it can be concluded that an R E wall, with a combination of clay-Flyash layers reinforced with geo-grid has the maximum stability than any other combinations.

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