Chapter 1

INTRODUCTION

1.1 GENERAL

Soil has been used since the most ancient civilizations as a construction material. However, due to insufficient tensile strength, designers had to improve its resistance by using mechanical processes (compaction, draining), chemical processes (stabilization), or by inclusion of resisting elements (reinforcement).

In the past, natural inclusions have most often been used to improve the mechanical properties of soils and structures: straw in clayey soils to develop construction material; palms or branches at the base of structures founded on soft soils and so on. It is also interesting to mention the reinforcement of natural slopes provided by plant roots in the nature.

During the past thirty years, the important development of Reinforced Earth, and the concept of reinforced soil as a construction material, introduced by its inventor H. Vidal, in the sixties, has contributed to the birth of a new area of soil improvement: soil reinforcement. This area is based on a generalization of the "reinforced soil" concept, including various techniques, for slopes and embankments, retaining walls, foundations, and dams.

The concept of soil reinforcement is based on the existence of a strong interaction between the soil and the inclusion. The most common interaction was thought to be friction, but constant research explored passive resistance from the transverse members of grid type of reinforcement. Frictional interaction requires good mechanical properties of the soil, particularly in terms of friction angle and drainage; granular soils are best adapted for this kind of reinforcement. Passive resistance is generally associated with anchors, which needs more sophisticated inclusions. It can be mobilized in ill types of soils, including saturated fine-grained soils, where frictional properties are poor. The number, type, and arrangement of the inclusions may be quite variable. Depending on the type of the inclusion, two extreme cases may be considered (Schlosser et al, 1983):

a. A “uniform inclusion”, for which the soil-reinforcement interaction can develop at any point along the inclusion. In this case, a relatively high and uniform density of reinforcements will result in a new composite material called "Reinforced Soil". The behavior of the reinforced soil mass can be investigated through laboratory testing, considering a representative sample of the new composite material.

b. A “composite inclusion”, which consist of an inclusion reinforced at a particular locations where the soil-reinforcement is concentrated. Generally, as for multi-anchorage systems, these points are located at the ends of the inclusions.

Birds and animals which use reinforced soil system do so through instinct; the early application of the principles of earth reinforcement.

The action and relevance of reinforcement in soil can be illustrated by considering an element of the cohesionless soil. If a vertical load is applied to the soil, the element will strain laterally. As well as compress axially, if reinforcement is added to the soil element in the form of horizontal layers, provided there is adhesion or interaction between the reinforcement and the soil, the composite will be restrained as if acted upon by a lateral force due to the effect of the soil-reinforcement interaction to restrict the strain.

In the recent past polymeric materials are being used in earthworks construction with ever increasing frequency. The term "Geosynthetics" was recently coined to encompass a diverse range of polymeric products designed for geotechnical purposes. One such purpose is the tensile reinforcement of soils. As tensile reinforcement, polymers have been used in the form of textiles, grid, linear strips and single filaments to reinforce earth structures such a road embankments, steep slopes and vertically faced soil retaining walls. A considerable number of retaining structures have been successfully constructed using the tensile reinforcing properties of 'Geosynthetics" their primary means of stabilization. Despite such successes sufficient uncertainty exists concerning the performance of these new materials, their manner of interaction with the soil and the new design methods needed that many authorities are still reticent concerning their use in permanent works.

In this study nylon rope of 1/4 inch thick is being considered for using as soil reinforcement in the form of grids at 6 X 6 inches spacing. To determine the resistance of the ropes under different normal stresses simulating the 2, 4, 6 and 8 feet high embankments, pullout tests are performed. Tests are conducted on c- φ soils of Risalpur which is collected at the back National Institute of Transportation building. Pullout test apparatus is fabricated. It comprised of clamp for holding the nylon ropes during pullout action and proving rings to determine the pullout resistance under different normal pressures. The normal load is applied with help of jack and proving ring arrangement. Laboratory tests are performed to determine the properties of the selected soil. Elongation test and tensile strength test is conducted on nylon to check its behaviour. The pullout tests are conducted on different moisture contents i.e. dry and wet of optimum.

1.2 PURPOSE OF THE STUDY

The literature on the subject has gained momentum rapidly for the last three decades or so. In the beginning steel strips were being used as reinforcement by Henry Vidal who shaped this discipline into a scientific one. Now the materials range has been significantly broadened i.e. Polymers synthetic ropes, plastics, geo-grids and sheets (woven and non-woven). With the introduction of these new materials, the mechanisms involved in bringing about the reinforcing effect also gets changed, and in some cases still not very well understood. In addition to the mechanism, there are other numerous factors which may effect the reinforcing capacity or interaction between the two elements i.e. the soil and reinforcement, for instance the geometry of the reinforcement, soil structure, type of reinforcement, (strip, geo-grids, etc), and materials (polymers, steel, etc) of the reinforcement etc.

The interaction between the grid type reinforcements and soil need to be investigated. Because the presence of transverse ribs in the reinforcement is likely to complicate the mechanism rather than that of simple mechanism of interfacial friction between soil and strip reinforcement.

The present day design methods of reinforced soil structure are all based on pullout capacity of composites. The bases are the bond or anchorage capacity, the determination of which is found to be dependent on factors like boundary conditions, scale effect, etc.

1.3 OBJECTIVES

a. To carry out literature review and desk study of the research carried out on the subject.

b. To analyze and understand the frictional and bearing mechanism mechanisms in the longitudinal and transverse members of the reinforcement.

c. To carry out laboratory testing on the soil sample retrieved from the field which includes:

- To measure the ultimate tensile strength and elongation in the nylon ropes using pulling test for creep.
- To measure the interaction of the ropes during test with the help of dial gauges.
- To measure the resistance offered by reinforcement under different normal stress.

d. To carry out the analysis of the data and to draw the conclusions from it.

1.4 SCOPE OF THE STUDY

The scope of this study was limited to;

a. Three-grain size distribution tests,

b. Three Atterberg limit tests,

c. Three standard proctor compaction tests,

d. Three direct shear tests, ten pullout tests. Pullout tests were conducted on different soil conditions i.e. wet of optimum and dry of optimum.

e. Elongation and tensile strength tests on nylon.

1.5 RESEARCH METHODOLOGY

a. Literature Search: Relevant literature on the subject available in the library, Internet, journals and publications on the soil reinforcement was consulted.

b. Soil and Site Selection: Site was selected at the back of the National Institute of Transportation building and local soil of Risalpur was used in the field tests.

c. Test Pits: Two test pits were dug for the collection of undisturbed and disturb samples from the depth of four feet.

d. Sampling: Undisturbed samples were recovered in accordance with ASTM D1587 and D4220 using tubes (4 X 6 inches) from the test pits. Disturbed samples were also collected to determine the physical properties of the soil.

e. Laboratory Testing: Laboratory tests were performed on the samples retrieved from the test pits.

- Water content (ASTM D2216)
- Specific gravity (ASTM D854)
- Atterberg limits (ASTM D4318)
- Grain size analysis (ASTM D421 and D422)
- Classification of soil (ASTM D2487)
- Direct shear (ASTM D3080)
- Elongation test on nylon
- Tensile Strength test on nylon

f. Field Testing: Pullout tests were carried out to determine the pullout resistance of the nylon ropes under different normal pressures, simulating 2, 4, 6, 8 ft height overburden of the embankment. Tests were done in the test pit already available at the backside of soil lab of Military College of Engineering Risalpur Cantonment.

1.6 OUTLINE OF THE DISSERTATION

This dissertation is compiled and described in the following sequence:

Chapter 1: This chapter is limited to the description of purpose, objectives, scope, research methodology, and outline of this study.

Chapter 2: In this chapter light is thrown upon the background of soil reinforcement. The order is started with history of soil reinforcement. Description of ancient and modern structures used as soil reinforcement is done. The types of soil reinforcement in which strip and grid reinforcements are briefly highlighted. A chronological mechanism between soil and strip reinforcement is detailed in this chapter. Finally the theories of mechanism of soil strip reinforcement are presented.

Chapter 3: In this chapter the development of polymeric materials (geotextiles, geogrids, geomembranes) and its use as a soil reinforcing materials has been described. The use of geotextiles in earthworks for reinforcement and separation at the base of an embankment on soft soil started as the Reinforced Earth early development. The application of geotextiles to roadways embankments and slopes has been highlighted. According to Giroud and Carroll (1983), the largest quantity of geotextiles is now utilized for roadway construction, principally temporary and construction roads. Then the properties of polymers are discussed like extensibility, creep behaviour.

Chapter 4: This part is consisted of research methodology, which includes measures of laboratory and pullout tests. The procedures of the laboratory tests, i.e. classification, Atterberg limit, specific gravity, moisture content, standard compaction, direct shear are presented. Elongation and tensile strength test on nylon is also described in this section. Lastly the development of the pullout test and its procedure is detailed.

Chapter 5: This chapter is devoted to presentation and discussion on the laboratory tests performed on the disturbed and undisturbed samples. The pullout tests performed on the samples were discussed in detail in this part of the chapter. The difference between the results of pullout tests on wet and dry side of optimum moisture content is also highlighted. Lastly the summary on the results is presented.

Chapter 6: This chapter circumscribes the recommendations for the further study and concludes this dissertation.