Pullout Characteristics of Anchored Coir Geotextile Embedded In Compacted Granular Soil

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Abstract. The soil reinforcement interaction is a major issue in the design of reinforced soil structures. In order to study it, pullout parameters such as pullout friction or cohesion between reinforcement and soil are selected. The pullout parameters determined by means of the pullout test. The reinforcements were embedded in a granular medium. Reinforcements increase the shear stress in the soil mass through the tensile force in the reinforcement. The reinforcement used were natural geotextiles, mainly due to its eco-friendly and biodegradable nature. The natural geotextiles were anchored in order to enhance the pullout resistance. Wooden achors were used due to its non-corrosive nature. On adding anchors, the passive pressure area between the anchors and the geotextile increases during the pullout procedure, as a result of which the pullout resistance of the reinforcement increases. The Geotextile-Anchor (G-A) system is tested using the pullout tests where the variables are anchor density, anchor length (20 cm, 15 cm, and 10 cm) and overburden pressure (2kPa, 3kPa, and 5kPa). From the experimental results, the pullout resistance of soil under loading conditions increased on the provision of anchors in the reinforcement and its effectiveness increases with increase in overburden pressure.

Keywords: Geosynthetics, Pullout resistance, Geotextile Anchor system (G-A), Pullout test, Interaction

1 Introduction

In the design of reinforced soil structures soil reinforcement interaction is a noteworthy issue. To improve the tensile strength of soils, various reinforcements has been generally used in many soil structures. The reinforcement increases the shear stress in the soil mass through the tensile force in the reinforcement. Thus reduce the horizontal deformations, and in this manner expanding the general strength of structures. Permanent loads, vehicular traffic loads, seismic loads and loads during construction as compaction loads are the major tensile forces acting on the geosynthetics. Among natural common fibres, because of high lignin content coir fibre is commonly used as is most grounded and durable. Tensile strength of plain-woven fiber geotextile was expressed as a perform of fibre strength, yarn properties and weaving pattern. Grid-Anchor, the reinforcement system were utilized so as to upgrade the pull-out resistance. From the previous studies conducted by Subaida et al. (2008), it has been discovered that the relative mesh opening size and tensile strength of geotextile oversee the pullout opposition of woven coir geotextiles. Mosallanezhad et al. (2015) examined the result of new Grid-Anchor (G-A) system and reasoned that with an increase in the number of anchors on the geogrid surface pullout resistance shows an increment. Addition of anchor is more intense under higher overburden pressures. By adding anchor, an extra passive pressure area (between the geogrid and the anchor) created during pullout procedure, which thus results in the improvement of pullout resistance of reinforcement. In the present study reinforcement used was natural geotextiles, mainly due to its eco-friendly and biodegradable nature and single wooden anchor were used due to its non-corrosive nature. The Geotextile-Anchor (G-A) system is tested using the pullout tests where the variables are anchor length and overburden pressure.

2 Materials used

2.1 Soil

The soil is collected from foundation laboratory. Various laboratory test to find soil properties such as specific gravity, paricle size distribution, relative density and friction parameters. Table 1 list out the properties of soil.

Table 1. Properties of soil

PROPERTIES	VALUES
Specific gravity	2.64
Effective particle size, D_{10} (mm)	0.13
D_{30} (mm)	0.39
D_{60} (mm)	0.48
Coefficient of uniformity(C_u)	3.69
Coefficient of curvature (C_c)	2.43
Relative Density, Dr(%)	21
Cohesion(kN/m^2)	0
Angle of Internal friction, φ	35°
Soil classification	SP

2.2 Geotextile

Coir geotextiles are nowadays widely used for soil bioengineering application. Coir woven geotextiles of 400gsm, 700gsm, 900gsm and 1500gsm were used for this study. It was obtained from Trivandrum, Kerala. Table 2 represents the properties of geotextile.

Table 2. Properties of coir geotextile

Specification /Nomenclature	G400	G700	G900	G1500
Mass per unit area(g/m^2)	444	738	943	1550
Thickness	6.6	6.8	7.1	8
Opening Size(cm)	4.3 x 4.0	2.0 x1.7	1.2 x 1.02	0.9 x 0.9
Tensile Strength (kN/m)	4.6	7.2	9.7	11

2.3 Anchor system

In this study a novel anchor system is introduced to increase the pullout resistance of coir geotextile. For this single wooden anchor were used due to its non-corrosive nature with varying anchor length (200 mm, 150 mm, and 100 mm) , width 15mm and thickness 10 mm.

3 Methodology

Pullout test was conducted on coir geotextile to determine the frictional resistance of coir. The pullout assembly comprised of a box 610 mm long, 460 mm wide and 340 mm deep profound with a space at mid-tallness to oblige geotextile sample based on ASTMD6706-03.The normal pressures of 2, 3 and 5 kPa were applied using special arrangements and pullout force were applied using screw jack which was measured using proving ring. The proving ring was placed among jack and clamping system. By using LVDT pullout displacements were measured and it is connected to a Data logger, where displacements are recorded. Ratio of length and width of sample was fixed as 2 as per ASTM standards. The test setup is shown in figure 1. Test were conducted in two groups, soil reinforced with (a) unanchored geotextile and (b) geotextile with anchor system. Tests were conducted with three different overburden pressures of 2kPa, 3kPa and 5kPa. Effect of single anchor and anchor densities of 4 different groups of 22 anchors/m^2, 40 anchors/m^2, 52 anchors/m^2 and 82 anchors/m^2 were done in vertical upward direction of anchors.

Fig. 1. Pullout test setup

3.1 Test procedure

The pullout box is 610 mm long, 460 mm wide and 305 mm deep profound with an opening at the mid-height from which the geotextile has to be pulled out. Pullout force were applied using screw jack and a proving ring placed among jack and clamping system measures it. By using LVDT pullout displacements were measured So as to set up a homogeneous sand sample, gauged amount of sand was permitted to fall from 500mm height by sand pouring technique. At the point when sand was filled upto the opening dimension, geotextile specimen of width 200mm was put on the highest point of the leveled sand. The front end of the geotextile was clamped and connected to the loading device. After that sand was filled in layers upto top level and levelled. The loading cap was then placed and the desired overburden pressure was applied. By using screw jack pullout force was applied.

4 Results and discussion

4.1 Pullout resistance of different types of geotextiles

The pullout test were conducted on different types of geotextiles. Types of geotextiles includes G400, G700, G900 and G1500 woven coir geotextiles. Results obtained from a series of pullout tests are presented as pullout resistance with pullout displacement graphs. Fig. 4.1 shows the variation of pullout resistance with pullout displacement for different geotextiles under various overburden pressures of 2, 3 and 5kPa. G1500 coir geotextile shows maximum value of pullout resistance in all overburden pressures and G400 shows minimum value. Considering all geotextiles, pullout resistance increases with increase in overburden pressures.

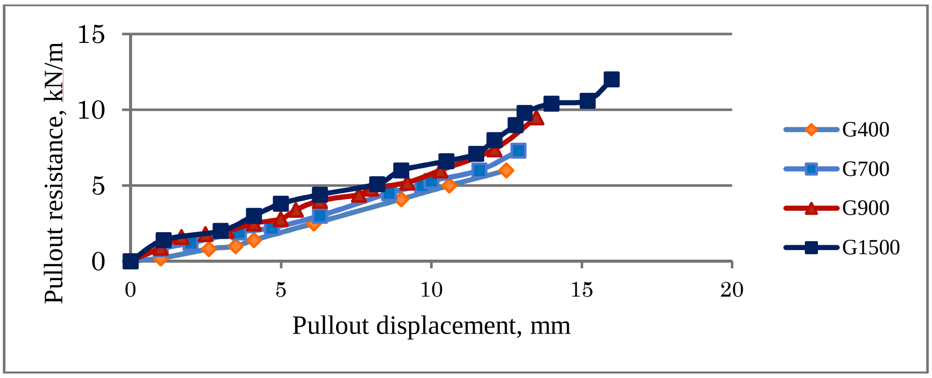

Fig. 2. Variation of pullout resistance with pullout displacement under 2kPa

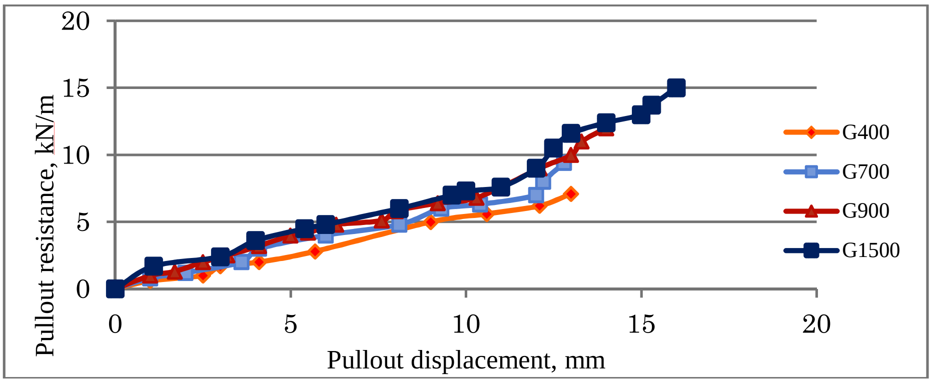

Fig. 3. Variation of pullout resistance with pullout displacement under 3kPa

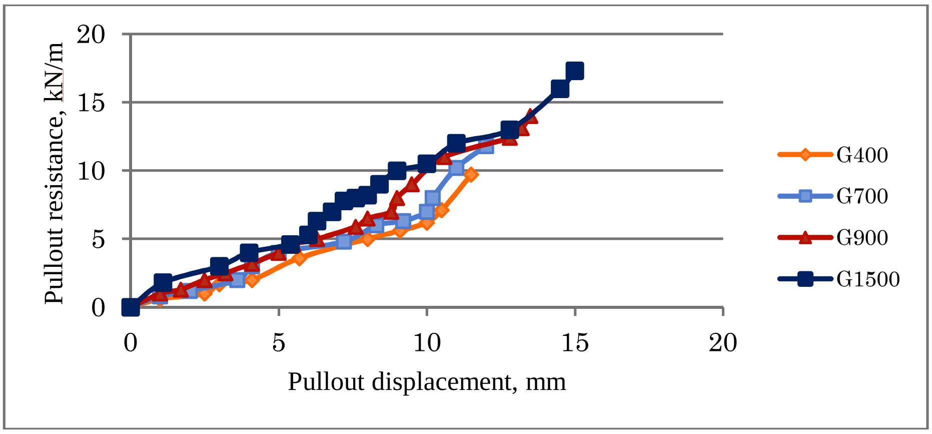

Fig. 4. Variation of pullout resistance with pullout displacement under 5kP

4.2 Effect of anchor density on pullout resistance increase

To decide the impact of anchor density on pullout resistance increment, pull-out experiments were directed on the G-A system, with four different anchor densities and four distinctive coir geotextiles with varying overburden pressures. These are as follows:

1. Group D1 with density equal to 22 anchors/m^2
2. Group D2 with density equal to 40 anchors/m^2
3. Group D3 with density equal to 52 anchors/m^2
4. Group D4 with density equal to 86 anchors/m^2

Each of these 4 groups and sole geotextile was tested with three different overburden pressures of 2, 3, and 5kPa. From the figure, with an increase in the number of anchors, an increase is observed in pullout resistance. This increase in pullout resistance is considerable under high overburden pressures only. By adding anchors, an extra passive pressure area between reinforcement and anchor created in the pullout test at the top surface of the reinforcement. Pull-out force is provided only by the frictional resistance (friction between geosynthetic and soil) in case of geosynthetics like woven and non- woven geotextiles. Relative mesh opening size and tensile strength of geotextile oversee the pullout opposition of woven coir geotextiles. Closely woven geotextiles offer good pullout resistance due to high interface friction. Pullout resistance of open meshed geotextile is because of good interlocking and bearing resistance. Under low overburden pressure reinforcement shows less extension. That is relative displacement between soil and reinforcement becomes decreased and bearing resistance cannot develop. Under low overburden pressures top soil on geotextile moves along with geotextile. This is due to that under low overburden pressure proper interaction between soil and geotextile cannot develop fully. Thus addition of anchors have no effect on pullout resistance. But in case of higher overburden pressure, pullout resistance increases with anchor density. Pullout resistance increases with increase in anchor densities and it is considerable under higher overburden pressures. Pull-out force is provided only by the frictional resistance (friction between geosynthetic and soil) in case of geosynthetics like woven and non- woven geotextiles. Comparison of the ordinary geotextile with that of G-A system at an equal overburden pressure was done by using the pull-out resistance ratio.(PRR) parameter and is defined as :

$$PRR = \frac{Pullout\ resistance\ of\ Geotextile-Anchor\ system}{Pullout\ resistance\ of\ Geotextile} \quad (1)$$

Figure 5, 6, 7 and 8 shows the variation of PRR with anchor densities under 2kPa, 3kPa and 5kPa respectively for all geotextiles. PRR value of G1500 geotextile is 2.1 under 5kPa. This means that pullout resistance of G1500 anchored coir geotextile is 2.3 times greater than unanchored geotextile. PRR value is minimum for G400 geotextile and its value is 1.5 under an overburden pressure of 5kPa. G700 and G900 shows a PRR value of 1.8 and 2.0 respectively. PRR value increases with increase in overburden pressures.

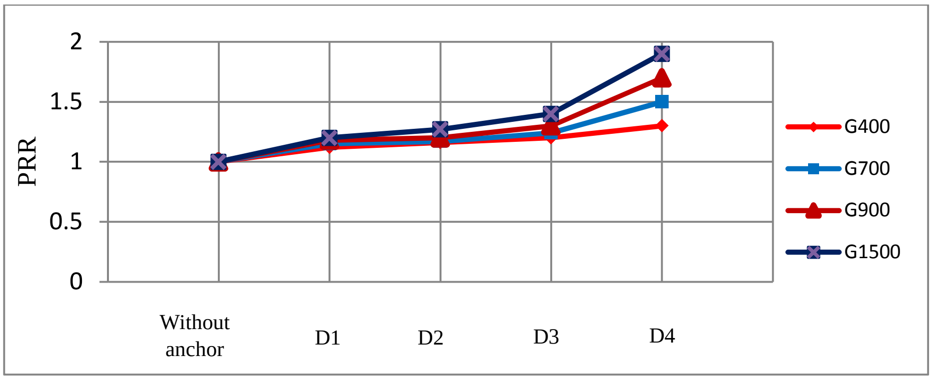

Fig. 5. Variation of PRR with anchor density under 2kPa

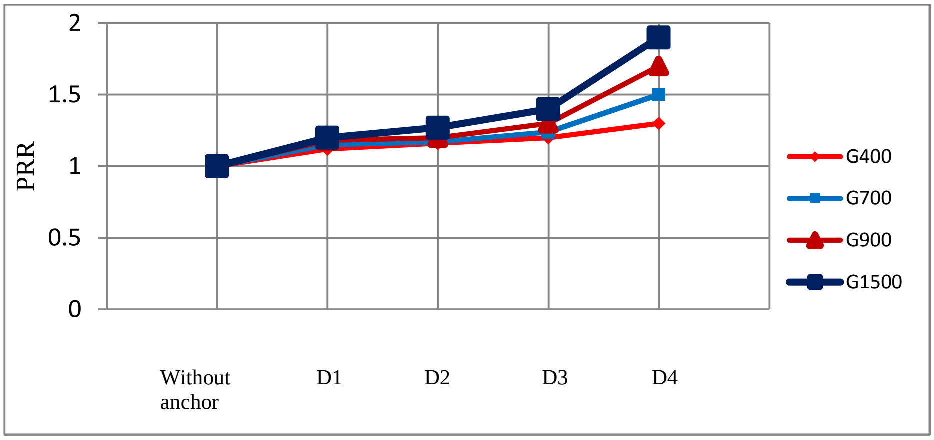

Fig. 6. Variation of PRR with anchor density under 3kPa

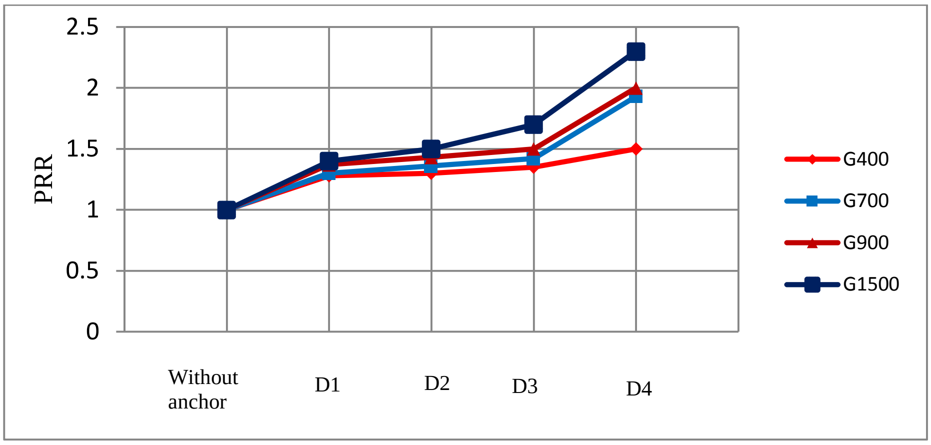

Fig.7. Variation of PRR with anchor density under 5kPa

5 Conclusion

- Pullout resistance increases with increase in overburden pressures
- Pullout resistance increases as the tensile strength increases
- G1500 geotextile shows maximum value of pullout resistance in all overburden pressures
- Geotextiles shows maximum value when an anchor of length 200mm is used
- Pullout resistance increases with increase in anchor densities
- Pullout resistance shows maximum value with an anchor density of 80 anchors/m^2
- Pullout resistance of G1500 anchored coir geotextile is 2.3 times greater than unanchored geotextile
- PRR value is minimum for G400 geotextile and its value is 1.5 under an overburden pressure of 5kPa
- G700 and G900 shows a PRR value of 1.8 and 2.0 respectively under 5kPa .

References

1. Abdi, M.R., Zandeih : Experimental and numerical analysis of large scale pull out tests conducted on clays reinforced with geogrids encapsulated with coarse material. Geotextiles and Geomembranes, Volume 42, pages 494-504(2014).
2. Abramento, M. and Whittle, A.J.: Analysis of pullout tests for planar reinforcement in soil. Journal of Geotechnical Engineering ASCE , pages 476–492 (1995).Alfaro, M.C., Hayashi, S., Miura, N.: Pullout interaction mechanism of geogrid strip reinforcement. Geosynthetics International ,Volume.4, pages 679–698 (1995).
3. ASTM D6706-03(2013): Standard test method for measuring geosynthetic pullout resistance in soil
4. Balunaini ,U, Prezzi, M, Salgado, R. : Pullout Response of uniaxial geogrid in tire shred–sand mixtures. Geotechnical and Geological Engineering, Volume 32, pages 505-523 (2014).
5. Mosallanezhad,M , Taghavi , S.S.H., Hataf, N. , Alfaro,M.C.: Experimental and numerical studies of the performance of the new reinforcement system under pull-out conditions. Geotextiles and Geomembranes, Volume. 44, pages 70-80 (2016).
6. Subaida,E.A., Chandrakaran , S. and Sankar,N.: Experimental investigations on tensile and pullout behaviour of woven coir geotextile. Geotextiles and Geomembranes Volume. 26, pages 384-392 (2008).