Determination of Pullout Strength of Geogrid in Sandy Soil

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Abstract*: Geogrid reinforcement of soil has been successfully used for many years in a wide variety of applications. This paper presents data obtained from a series of laboratory tests performed on the geogrid. The tests were conducted to determine the mechanical property including the tensile strength of the geogrid and its corresponding pullout test. Tests were performed to find out the effect of width of geogrid on the pullout resistance. It was found that the pull-out resistance of geogrid is a function of the relative density of the soil, the length and the width of geogrid specimen. A mechanism of soil-geogrid interaction is described and used to explain the results of' the pull-out tests. A significant finding is that the selection of geogrid specimen dimensions for laboratory pullout tests must take into account the strain to failure of the soil and the stiffness of the geogrid in order to properly represent the maximum pull-out stress that will be available in field applications.

Keywords: Polymer Geogrid , Pull out resistance, Tension test, Anchorage Ratio.

I. INTRODUCTION

A. Geogrids

Geosynthetics are synthetic products used to stabilize terrain. They are generally polymeric products used to solve civil engineering problems. The polymeric nature of the products makes them suitable for use in the ground where high levels of durability are required. Geosynthetics are available in a wide range of forms and materials. These products have a wide range of applications and are currently used in many civil, geotechnical, transportation, geoenvironmental, hydraulic, and private development applications including roads, airfields, railroads, embankments, retaining structures, reservoirs, canals, dams, erosion control, sediment control, landfill liners, landfill covers, mining, aquaculture and agriculture.

II. LITERATURE

Bergado, D. T et al (1994)predicted the pullout resistance of polymer-grid reinforcement, in which they proposed that the influence of bearing member rigidity and spacing ratio (S/D) are explicitly expressed in the hyperbolic model. They also proposed a new bearingcapacity equation for calculating the maximum pullout force.Wilson-Fahmy, R.F et al (1994) studied the anchorage behaviourby increasing use of polymeric geogrids in reinforced soil walls and steep slopes. They concluded that the presence of open structural nature of geogrids, improved the performance from other sheet-like reinforcing materials such as metallic strips and geotextiles.

Functions

Geotextiles are commonly used to improve soils over which roads, embankments, pipelines, and earth retaining structures are built. There are several types of geotextile material, including open-mesh, warp-knitted, and closed fabric or non-woven textiles. Different geotextile materials are specified for various characteristics, such as separation, filtration, drainage, reinforcement, sealing, and protection.

III. MATERIALS

TABLE 1
Geotechnical Properties of Sand

Specific Gravity	Sieve Analysis Test		Compaction Test		Classification of Soil
G	C_u	C_c	Υ_{dmax}	OMC	Sp
2.6	2.72	0.98	2.08	9	
-	-	-	g/cc	%	

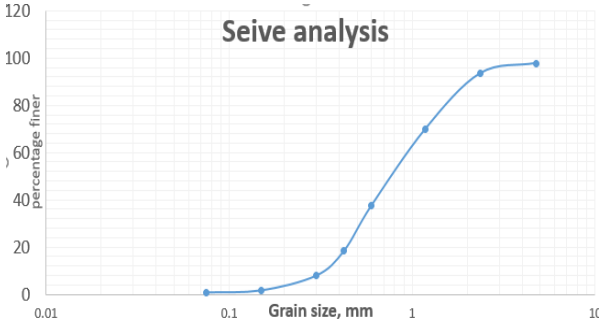

Fig.1 Grain size distribution curve of the soil sample

RELATIVE DENSITY:

The required sand sample was taken and test is performed to density of cohesion less, free-draining soils using a vibrating table. The relative density of a soil is the ratio, expressed as a percentage, of the difference between the maximum index void ratio and the field void ratio of a cohesion less, free-draining soil; to the difference between its maximum and minimum index void ratios. Relative density and percent compaction are commonly used for evaluating the state of

Revised Manuscript Received on February 05, 2020

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compactness of a given soil mass. The engineering properties, such as shear strength,compressibility, and permeability, of a given soil depend on the level of compaction.

The fibre container was filled with the sand and then placed in a vibrator. After the sand being densely compacted, it was weighed and the readings were duly noted. Their corresponding values were solved to obtain the e_{max} and e_{min}.

γ_{min}= W / V = 1.74 g/cm^3

γ_{max}= W / V = 2.08g

To find out e_{max} and e_{min}

emax = (2.62 x 1 / 1.74) – 1 = 0.50

emin = (2.62 x 1 / 2.08) – 1 = 0.25

Pullout Test onGeogridof Width 8cmLoose State (8cmWide)For Anchorage Ratio 2

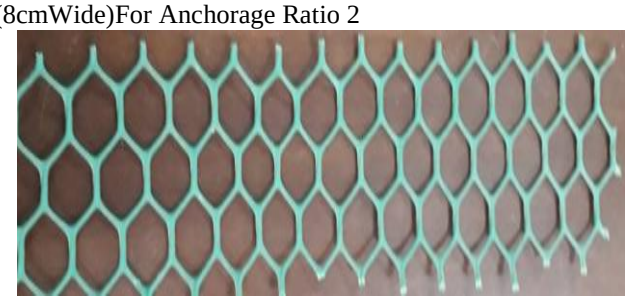

Fig.2Geogridsample

Geogrid of 8cm Wide and 45cm Length

TENSION TEST ON GEOGRID :

Fig. 3 Geogrid - Before Load Application

Fig. 4Geogrid at failure

TABLE II PROPERTIES OF GEOGRID

The physical properties		
Property	Data	
Mesh type	Square	
Standard color	Green	
Polymer type	HDPE	
Packaging	Rolls	
Dimensional Properties		
Property	Unit	Data
Aperture size	mm	34*34
Mass per unit area	g/m^2	429
Rib thickness	mm	2.8
Junction thickness	mm	5
Longitudinal rib width *lw*	mm	3.1
Transverse rib width *tw*	mm	3.1
Roll width	m	1.2
Roll length	m	30
The Mechanical Properties		
Peak Tensile Strength	kN/m	1.92
Elastic modules	GPa	0.32
Upper yield strength	MPa	--------
Lower yield strength	MPa	--------
Tensile strength	MPa	1
Fracture percentage elongation	%	-98.0
Percentage elongation at maximum load	%	1.5
Total percentage elongation	%	8.5

The tensile strength was found to be 1.92 kN/m during its peak. The dimensional properties such as rib thickness, junction thickness, longitudinal and transverse rib width of geogrid play important role in the mechanical properties such as tensile and elastic modulus.

IV. METHODOLOGY

A. Pullout Test

Good properties of various geogrids and geonets as well as the possibility of connecting them with other geotextiles cause that the geomaterials are widely used in road construction and civil engineering. The increasing application of geotextile materials induces a need of more careful examination of soil – reinforcement interaction mechanisms. Technical and economical effects of geotextiles (e.g. simplicity of use and lower transportation costs, respectively) are strongly related to the proper exploitation of physical and mechanical properties of the materials itself as well as the soil-reinforcement system. The appropriate determination of the value of force required for pulling out the geogrid from the soil is of the significant importance for reinforced soil structures. The effects expected are dependent on the sufficient anchoring of the reinforcing material in the soil. A source of essential information regarding the behaviour of the soil-reinforcement system can be pullout tests. A standard testing procedure for determination of the geotextile-soil interaction properties has not been established until now.

Fig. 5 Experimental setup for pullout test

V. RESULTS AND DISCUSSIONS

The load per unit width and the displacement relationship of the geogrid placed in the sand of varying states such as loose, medium dense and dense state was estimated comparatively along with the geogrids of different size – 8cm, 10 cm and 15cm respectively. The results obtained is discussed below.

For 8cm Wide Geogrid

Pullout Resistance With Respect To Anchorage Ratio 2

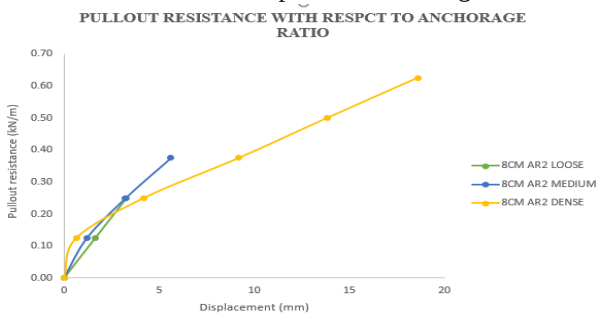

Fig. 6 Comparison with respect to various states of sand

The geogrid at medium dense state showed 52% when the anchorage ratio is 2. At 0.63 mm of displacement in the dense state, the resistance was found to be tripled.

Pullout Resistance With Respect To Anchorage Ratio 1

The resistance at medium dense state was found to be 152%. With respect to dense state, the percentage increase was almost twice compared to loose and medium dese state, i.e.,200 % pullout resistance.

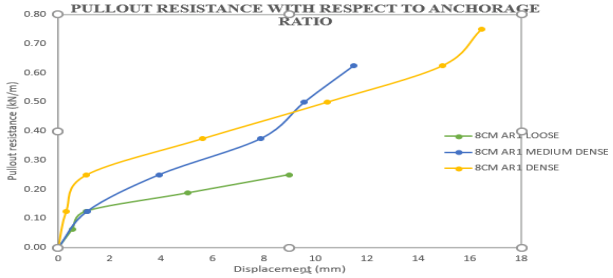

Fig. 7 Comparison with respect to various states of sand

Pullout Resistance With Respect To Anchorage Ratio 0

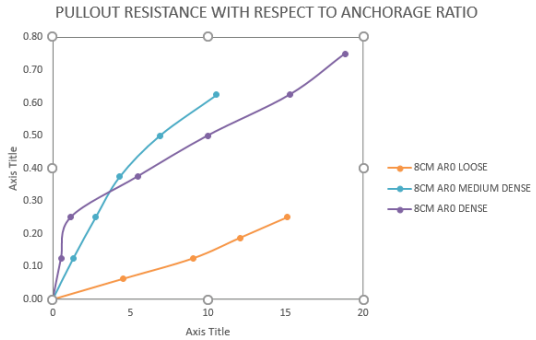

Fig. 8 Comparison with respect to various states of sand

For 10cm Wide Geogrid .

PulloutResistance With Respect To Anchorage Ratio 1

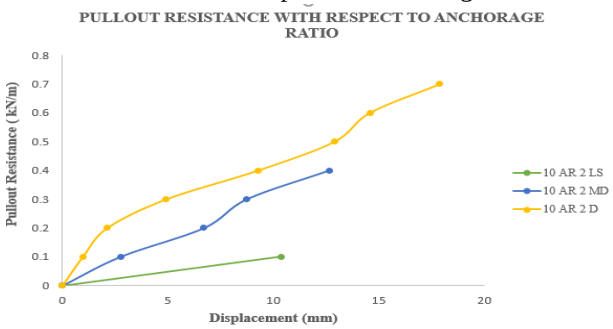

Fig. 9 Comparison with respect to various states of sand

Initially, the geogrid showed 300 % at medium dense state. On calculating the pullout resistance for dense sand, the geogrid showed twice the increase in its resistance i.e., 600%. So it can be said that, pullout resistance increases with respect to it corresponding variation in the state of the sand.

Pullout Resistance With Respect To Anchorage Ratio 1

The pullout resistance for the medium sand from the above fig.37 is found to be 300%. Further, the resistance for the dense sand was calculated to be 500%. This indicates that, on increasing the density of the soil with respect to e_{max} and e_{min} values, a significant increase in the pullout resistance can be observed.

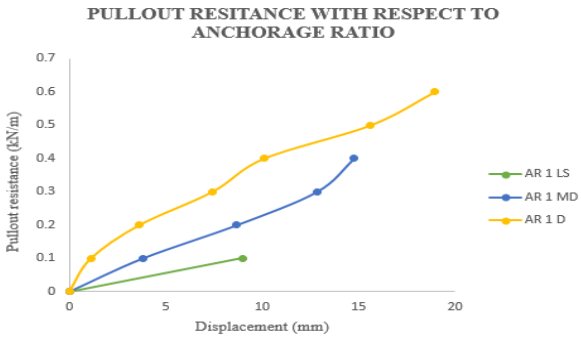

Fig.10 Comparison with respect to various states of sand

Pullout Resistance With Respect To Anchorage Ratio 0

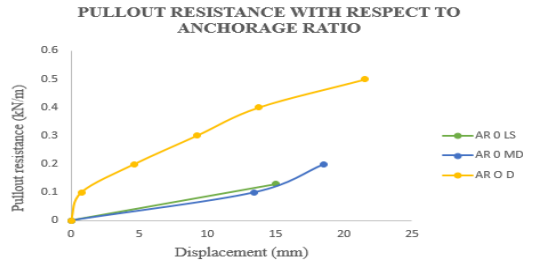

Fig. 11Comparison with respect to various states of sand For 15cm Wide Geogrid

Pullout Resistance With Respect To Anchorage Ratio 2

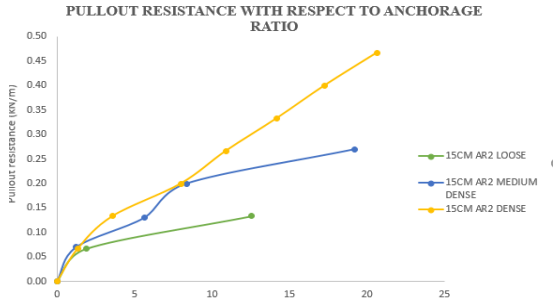

Fig. 12 Comparison with respect to various states of sand

Initially, the geogrid showed 107.6% % at medium dense state. On calculating the pullout resistance for dense sand, the geogrid showed twice the increase in its resistance i.e.,, 261.5%. So it can be said that, pullout resistance increases with respect to it corresponding variation in the state of the sand.

Pullout Resistance With Respect To Anchorage Ratio 1

The resistance at medium dense state was found to be 285.7%. With respect to dense state, the percentage increase was almost twice compared to loose and medium dense state, i.e.,571.4 % pullout resistance.

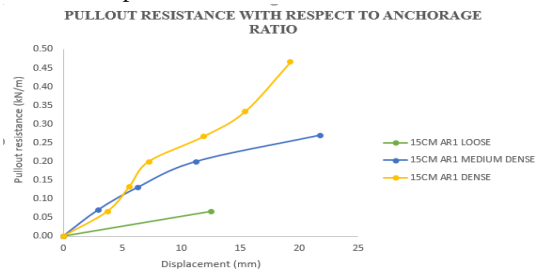

Fig. 13 Comparison with respect to various states of sand

Pullout Resistance With Respect To Anchorage Ratio 0

The pullout resistance for the medium sand is found to be 285.7%. Further, the resistance for the dense sand was calculated to be 571.4%. This indicates that, on increasing the density of the soil with respect to emax and emin values, a significant increase in the pullout resistance can be observed.

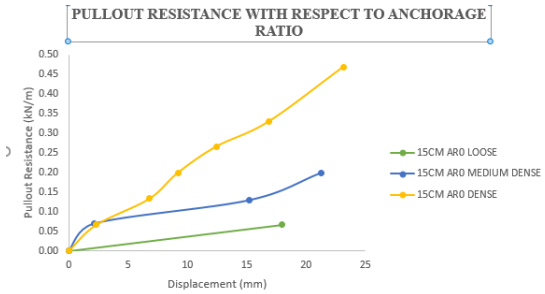

Fig.14 Comparison with respect to various states of sand

Study Between same Anchorage ratio and Different Width of Geogrids

At Loose State -Anchorage ratio 2

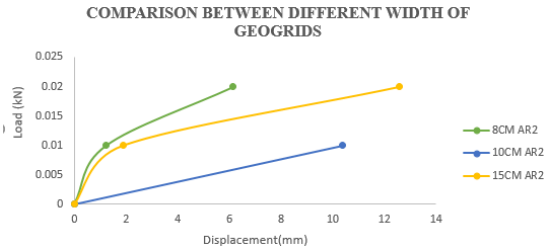

Fig.15 Comparison with respect to different widths of geogrid

When geogrids of same anchorage ratio 2 and different width is taken into consideration, it can be seen that the geogrid with 15cm width shows more load carrying capacity than the 8cm and 10cm, while the 10cm wide geogrid shows comparatively better results than 8cm. The geogrid with 15cm width shows twice the increase in load carrying capacity than the 8cm and 10cm wide geogrid.

Anchorage Ratio 1

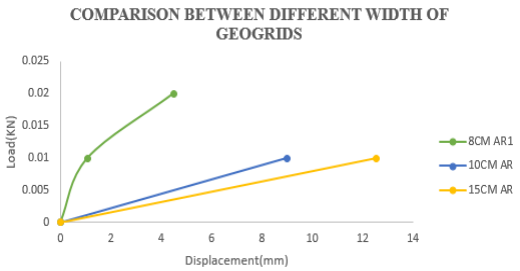

Fig.16 Comparison with respect to different widths of geogrid

On comparing the load carrying capacity of the geogrids at various widths, it can be seen that the 15cm wide geogrid has more capacity to withstand the failures of the sand when compared to 8cm and 10cm. There is a steady increase in the load carrying capacity of 15cm wide geogrid which is deemed suitable for the soil reinforcements.

Anchorage Ratio 0

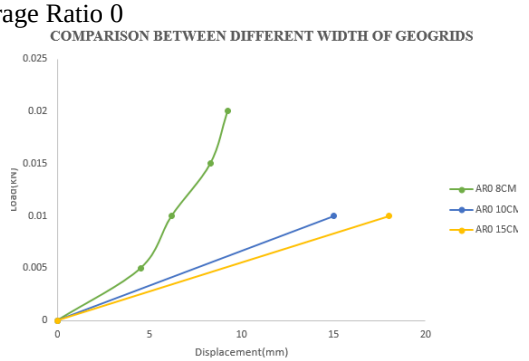

Fig. 17 Comparison with respect to different widths of geogrid

At anchorage ratio, the 8cm wide geogrid shows maximum load carrying capacity at 0.02 kN of load whereas the 10cm and 15cm wide geogrid shows comparatively lesser load carrying capacity.

Medium Dense State - Anchorage Ratio 2

When the sand was at medium dense state and anchorage ratio being 2, 33.3% of loadcarrying capacity was found for

10cm wide geogrid. The load was attained at 0.04 kN for 10 and 15 cm geogrid. This means that the behavioural changes of 10cm and 15cm does not have huge change in the load carrying capacity. Both has the capacity to carry the same load.

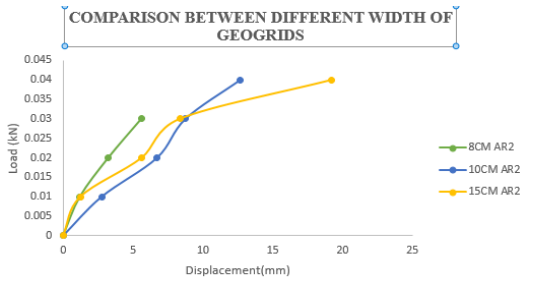

Fig.18 Comparison with respect to different widths of geogrid

Anchorage ratio 1

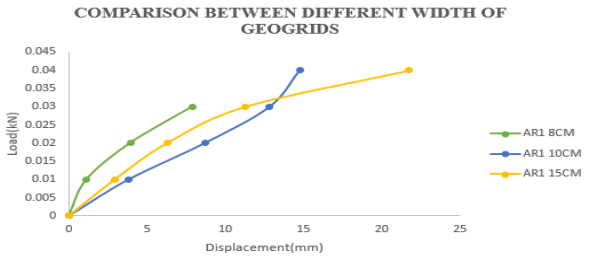

Fig.19 Comparison with respect to different widths of geogrid

Whereas, for 8cm wide geogrid, the load carrying capacity is 0.03 kN. This indicates that, at AR1 ,

the geogrids of higher width can be used for soil reinforcement as they have high load carrying capacity.

Both 10cm and 15cm have the load carrying capacities of 0.04kN with a steady increase.

Anchorage Ratio 0

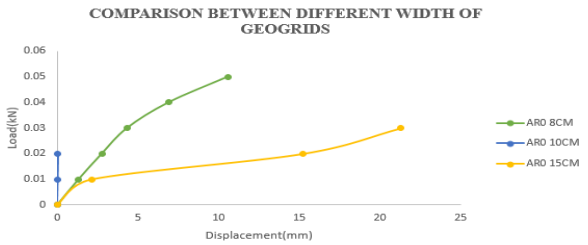

Fig.20 Comparison with respect to different widths of geogrid

When the 10cm wide geogrid was placed at Anchorage ratio 0 in the soil, failure of geogrid occurred and hence it can be seen in the fig. 48.

At Dense State -Anchorage Ratio 2

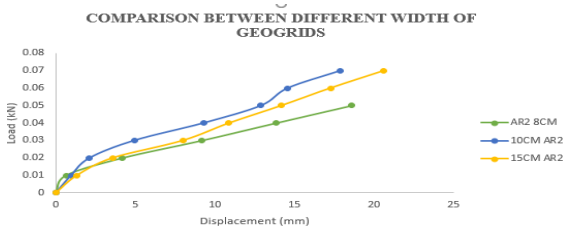

Fig.21 Comparison with respect to different widths of geogrid

At dense state, when the anchorage ratio was 2, all the 3 types of georgrids showed immense load carrying capacity meaning that, the best suitable anchorage ratio being 2 and the advisable state of sand being dense.

Anchorage Ratio 1

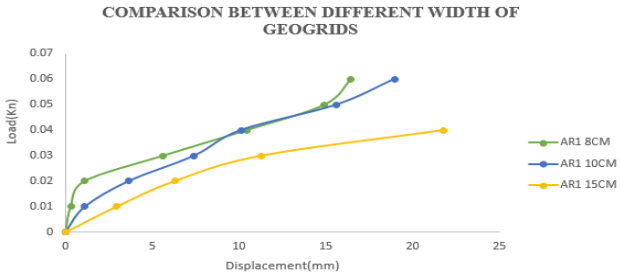

Fig. 22 Comparison with respect to different widths of geogrid

Anchorage Ratio 0

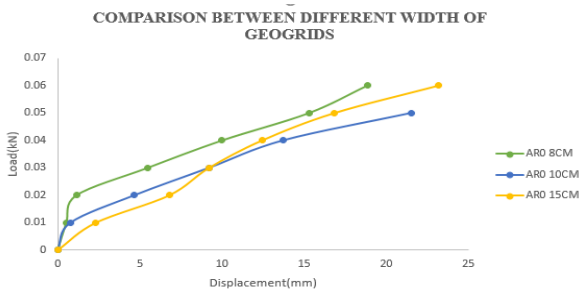

Fig. 23 Comparison with respect to different widths of geogrid

VI. CONCLUSIONS

On performing tensile strength test on the geogrid specimen, the following conclusions maybe drawn:

1. The geogrid PMP CE 131 have tensile strength comparatively lesser than other type of geogrids. But, on large scale use of the geogrids at the construction site, it can redeemed to be useful.

2. The effect of tensile strength (stiffness) is more significant than elastic modulus when geogrids are used as reinforcement in the soil.

A soil-geogrid interaction mechanism has been described and used to explain the results of the pullout tests.

1. In the field, the embedded area of geogrid is likely to be large enough that stretching will cause the pullout stress to approach some minimum value, as demonstrated by the pullout tests reported. Thus, if laboratory tests are performed on specimens too small to include this effect, the pullout stress will be over predicted, which will lead to unsafe design. This is most likely to happen with stiff geogrid material in a dilatant soil.

2.The significance of the results of this study is that when conducting laboratory pullout tests, the relationship between the pullout resistance and displacement is to be observed and the load carrying capacity of the geogrid is to be taken into account when choosing the size of the geogrid specimen.

3.While using geogrid specimens with greater width, the load carrying capacity and the pullout resistance of the

geogrid was found to be higher than general.

4.When the anchorage ratio is maximum, the resistance between the sand and the geogrid was greater at ratio 2 than anchorage ratio 1 and 0. And hence, on providing suitable anchorage ratio to the soil, the reinforcement can be redeemed safe to avoid soil failures.

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