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STRENGTHENING OF CONCRETE BEAM BY REINFORCING WITH GEOSYNTHETIC MATERIALS

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Abstract — *In the polymeric products Geosynthetics play a wide range of applications and presently used for solving the civil engineering problems. This research reveals that the use of Geocells and Geogrids in concrete beam. Geocells are three dimensional fabricated material of ultrasonically-welded High Density Polyethylene (HDPE) strips and easy to transport. Geogrid has notable application in constructions due to good in tension and has a higher capacity to transfer load over a large area. The Flexural test were carried out up to failure of concrete beams. An experimental program was performed and compared with analytical solution to predict the Flexural strength of concrete beam reinforced with Geocells and Geogrids. A total of 18 beams, with (120mm × 150mm) rectangular cross section and of span 1200 mm were cast and tested. In the first case, R.C.C under reinforced beams were strengthened with Geocells ,the beam is subjected to static loading and tested. In second case, R.C.C under reinforced beams were strengthened with Geogrid.*

Keywords- *Cement concrete Reinforced Beam, Geocell, Geogrid, Flexural Strength.*

I. INTRODUCTION

Geosynthetics is the term used to describe a range of generally polymeric products used to solve civil engineering problems. The term is generally regarded to encompass six main product categories: Geotextiles, Geogrids, Geonets, Geomembranes, Geosynthetics clay liners, Geofoam and Geocomposites.

Geosynthetics are available in a wide range of forms and materials, each to suit a slightly different end use. These products have a wide range of applications and are currently used in many civil, geotechnical, transportation, hydraulic, and private development applications including roads, airfields, railroads, and embankments, retaining structures, reservoirs, canals, dams, erosion control, sediment control, landfill liners, landfill covers, mining, aquaculture and agriculture.

II. MATERIALS USED

2.1 GEOCELL

Cellular Confinement Systems are popularly known as “Geocells”. Geocells are strong, lightweight, three dimensional systems fabricated from ultrasonically-welded High Density Polyethylene (HDPE) strips that are expandable on-site to form a honeycomb-like structure. The composite forms a rigid to semi-rigid structure. They are easily transported as flat strips welded width-wise at regular intervals, and logistics for large quantities is not a problem; Geocells are easy to install and do not require skilled labour. They can be installed in any weather condition; The in-fill has essentially to be non-cohesion material, however the material could be recycled material. It helps to reduce carbon foot-print, since carbon black is an essential ingredient of the HDPE.

Fig 1 Geo Cell

2.2 GEOGRID:

Geogrid is one of the polymeric materials classified under geo-synthetics manufactured from the polymers such as polyester, polypropylene, and polyethylene. Uniaxial geogrids are used for the grade separation appliances in steep slope and retaining walls while biaxial geogrids are used in roadways to take vibrations

Fig 2 Geogrid

III. LITERATURE REVIEW

Gourav Dhane et al (2015) Studied that when the structure is constructed over loose or weak soil. The reason behind is lack of strength, and associated deformability. Geocell is a Soil reinforcement technique which is proved to be a versatile method in terms of its cost effectiveness for the improvement of the strength of soft soils. It is the latest form of reinforcement which is both economical and durable in long term. It increases the strength and stiffness property of the soft soil. The overall mechanism and applications of geocell in the field of civil engineering. the structure should be safe against any type of failure and second is that structure should be economical as far as possible

Ghosh S.K et. al (2014) , This paper illustrates the behavior of concrete beams reinforced with uniaxial and biaxial geogrids. Geogrids are being used in providing stabilization, confinement, and reinforcement of asphalt concrete layers, further to reduce reflective cracking in pavement applications. It gives opportunity to observe benefit and feasibility of using geogrids in thin concrete layers. The two point bending test on geogrid beams reveals that strength of geogrid and number of layers plays a crucial role in enhancing load–deformation behavior and flexural strength.

N.B.Parmar et al (2016) described the founding of different research paper published so far worldwide on use of Geocell in road construction. Geocells are placed at sub base, in-filled with soil material, and compacted. The cellular structures of the geocells provide lateral and vertical confinement and tensioned membrane effect, thereby increasing the bearing capacity and providing a wider stress distribution. As a result, rutting or permanent deformations under traffic loading can be reduced. So it is necessity to improve strength, erosion control, and durability of shoulder for safety of road users for that we use geocell material at sub base or base layer of shoulder for giving better strength and it is also economical.

Suman shakthi et al (2015) considered that ground improvement is an essential condition to build any civil engineering structure in these type of soil as they are found to have low bearing capacity and uneven settlement among other drawbacks. Geosynthetics are being widely used as soil reinforcement to improve the quality of soil owing to their ease of operation and overall cost. Geocell is the most advanced form of geosynthetics. The soil particles can be trapped inside these cells providing an overall confinement to the soil structures. layer and improves it properties regarding support of civil engineering. The efficiency of geocell in improvement of bearing capacity of foundation when the soil is reinforced with geocell.

Daniel Torrealva et. al (2012), reviewed that the paper presents an empirical approach for the assessment of the flexural behavior and flexural strength of adobe masonry, considering the effect of Geogrid reinforcement. The approach is based on the analysis of experimental results of bending tests of adobe walls reinforced and non-reinforced with Geogrids. Analytical models for the flexural behavior were initially based on the constitutive laws of the individual materials. Then, they have been simplified and updated so they agree with experimental moment-curvature relationships.

Ir. Zakaria Che Muda et. al (2012), aimed to study the flexural strength and deflection behavior of concrete slab casted with oil palm shells (OPS) as aggregates and reinforced with Geogrid. Effects of oil palm shells content and amount of Geogrid layers in concrete slab towards the enhancement of flexural strength and deflection were monitored. Data from test results shows that increment in oil palm shells content will reduce the flexural strength of slab while increment in amount of Geogrid can increase the flexural strength.

SUMMARY OF LITRATURE REVIEW

Various literatures regarding the utilization of Geocells and Geogrids in concrete and similar works were collected and reviewed.

From the above literature review we have observed the following results:

- The axial load carrying capacity of Geogrid reinforced steel columns with traditional rebar column is less in strength and the behaviour of columns are similar.
- The ultimate deflection of slab samples with double layers of geogrid is higher than the single layer of geogrid.
- The load and deflection behaviour of concrete beam is observed that the geogrids used for reinforcing will remain passive till it get stressed. The crack shows all the tensile forces may gets transferred to the geogrid installed in beam. After concrete failure the total load will be directly transferred to the geogrid.
- The flexural strength of geogrid is increased compared with the flexural strength of oil palm shells content
- The bearing capacity of geocell-reinforcement increases and decreases the settlement of the foundation bed .
- The deformation of given load cycle decreased as the confining pressure increased. The observed benefit of geocell was maximum at the lowest confining pressure; after which it decreased as the confining pressure increased.

IV. MIX DESIGN

4.1 MATERIAL PROPERTY

Table 1 Concrete Mix Design

S. No	Concrete Mix Design Quantities	
1	Grade of concrete	M40
2	Type of exposure	Mild
3	Sp. Gravity of cement	3.15
4	Fine Aggregate	2.5
5	Coarse aggregate (20mm)	2.6
6	Maximum Water Cement Ratio	0.40

Table 2 Result of mix proportions

Cement (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	Water (lit/m^3)
450	759	1004.64	180
1	1.686	2.232	0.40

Table 3 Test Matrix

S No	Conventional RCC Beam	Flexural Test	
		RCC beam Reinforced with Geocell	RCC Beam Reinforced with Geogrid
14 Days	3 Nos	3 Nos	3 Nos
28 Days	3 Nos	3 Nos	3 Nos
TOTAL	**18 Beams**		

V. TESTING OF BEAMS:

The beams were testing under two point bending loading. In this case there is constant maximum moment and zero shear force acting in the section between the loads. Between the supports and loads linearly varying moment acts. Spacing between the supports is 1000mm and the load is applied at points dividing the length into three equal parts as in figure.

plates are used under the loads to distribute the load over the width of the beam. The testing equipment is a loading frame of 50 ton capacity. Flexural strength of beams are calculated by using this formula

$$F = \frac{PL}{BD^2}$$

Where P is ultimate load, L is distance between the supports, B is width of beam and D is depth of beam

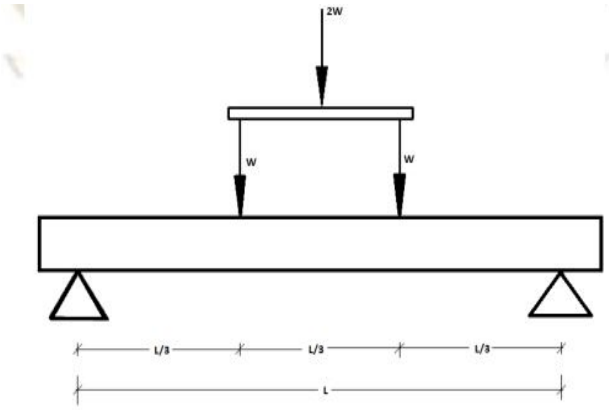

Fig 3 Two point loading

5.1 FORMWORK WITH BEAM SPECIMEN

The reinforcement cages were placed in the moulds and cover between cage and form provided was 25 mm. The concrete was placed into the mould immediately after mixing and well compacted. They are cured in water for 28 days. After 28 days of curing the specimen was dried in air and white washed.

Fig 4 Formwork with Beam Specimen

5.2 EXTERNAL WRAPPING BY WHITE CEMENT

After 28 days of curing the specimen was dried in air. And the specimen was externally wrapped by white cement before the testing of beams. It shows the clear crack formation of the specimen

Fig 5 External Wrapping by white cement

5.3 CRACK PATTERN

The reinforced concrete beams are tested with geocell and geogrid after 14 days of testing and 28days of testing. The minor crack has been observed in the reinforced concrete beam with geocell and geogrid.The deflection also been lesser compared to the conventional concrete beam

5.4 REINFORCEMENT DETAILS

Tension reinforcement = 2-Nos 10mm dia bar

Compression reinforcement = 2-Nos 10mm dia bar

Stirrups = 8mm dia bar 150mm c/c

VI. EXPERIMENTAL STUDY

For determining the flexural strength of concrete beam using Geocell and Geogrids. The ultimate load carrying capacity of beams for 14 days and 28 days curing results as follows.

6.1 COMPARISION OF TEST RESULTS BY TABLE

Beam	**Plain Cement Concrete Beams**	**Beam Reinforced with Geocell**	**Beam Reinforced with Geogrid**
	Load in KN		
B-1	35	36	62
B-2	48	44	68
B-3	52	53	69
Avg load	**45**	**44**	**66**

Table 4 Test Result on 14 days curing

Beam	**Plain Cement Concrete Beams**	**Beam Reinforced with Geocell**	**Beam Reinforced with Geogrid**
	Load in KN		
B-4	83	89	107
B-5	69	98	116
B-6	72	107	116
Avg load	**75**	**98**	**113**

Table 5 Test Result on 28 days curing

6.2 COMPARISON OF TEST RESULTS BY CHART

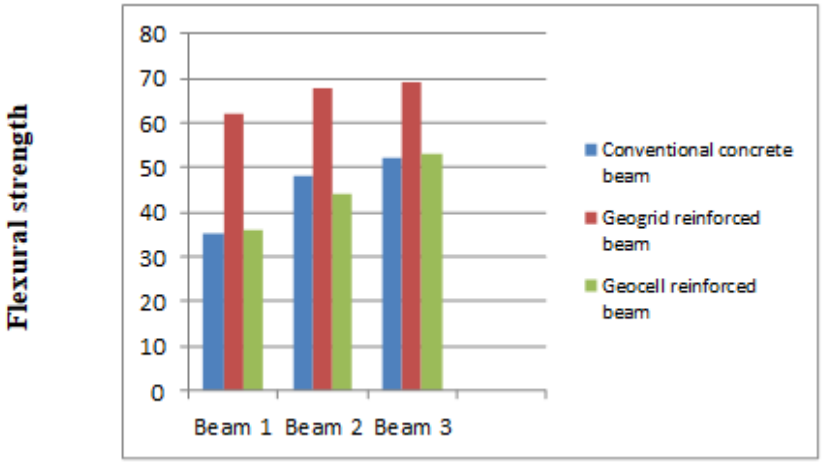

Fig 6 14 Days Testing results

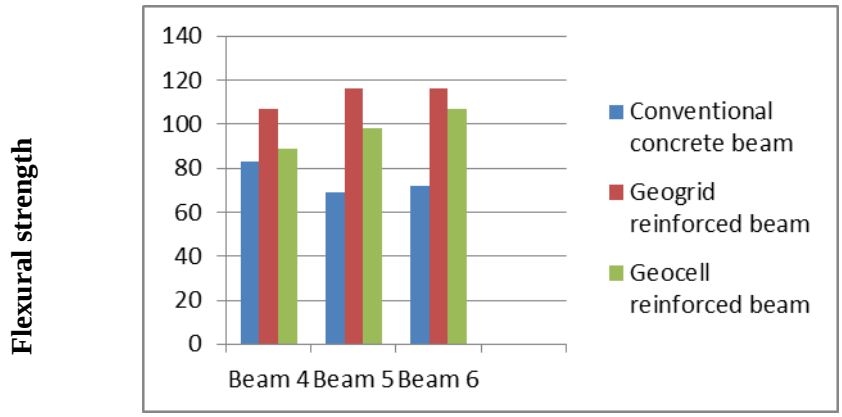

Fig 28 Days Testing results

VII. CONCLUSION

Due to several advantages of Geosynthetics materials, it is used for structural repair and strengthening. The use of Geosynthetics has becoming popular. Geocell and geogrid reinforcement of concrete is applied in several new and technically challenging applications, some of which tested the boundaries of the current knowledge and understandings the functioning of these systems. Geocell was achieved by studying the constitutive behaviour of the infill and membrane material and their interaction, as well as the influence of multiple cells on the composite structure. Geogrid is a matrix structured materials with intersection of perpendicular ribs, based on the longitudinal and transverse arrangement of the ribs. This paper was undertaken to investigate the potential benefits of using reinforcement to improve the flexural strength, reduce the deformation on structures and utilize the Geosynthetics. It makes a comparative study between the load carrying capacity of an RCC beam and other beam with Geosynthetics bonded. An experiment study will carry out to study the change in the structural behavior of R.C.C. beams Reinforced with Geosynthetics, to enhance the Flexural capacity of the beams. Therefore to reduce or to minimize these deficiencies, Geosynthetics materials such Geocells and Geogrids are excellent solution in this situation.

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