The State-of-the-Art Report on use of Strengthening of RCC Structure by Reinforcing with Steel Bars and Geosynthetic Material

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Abstract **- The aim of the present study is to investigate the use of geogrid and geonet as a strengthening material to reinforced structures like beams and slabs. The purpose of this paper is to check if we can reduce the utilization of steel in this rapidly developing world by introducing smart materials such as geogrid and geonet in the reinforcement which can be durable without compensating its strength. Geogrids have been investigated by a limited number of studies as a potential alternative to steel reinforcement for Ordinary Portland cement (PCC) concrete, especially in situations where using steel reinforcement may not be suitable due to constructability and durability limitations. Geonet's design function is completely within the drainage area where they are used to convey liquids of all types. By introducing it to a reinforced structure we can check its functional ability as a reinforcing material. A total of 15 beams with (1000 mm x 150 mm x 200mm) rectangular cross section and 15 slabs (750 mm x 750 mm x 75 mm) were casted and tested. From total of 15 beams and slabs 3 were control specimens, respectively. With the rest 6 beams and 6 slabs, geogrid and geonet were bonded at bottom of the steel cages of beams and slabs individually. Also, geogrid and geonet were bonded at both bottom and top of the reinforcing steel cage of other 6 beams and slabs individually.**

Index Terms **- Geogrid, Geonet, Beams, Slabs, Smart materials, Ordinary Portland Cement, Steel reinforcement.**

1.INTRODUCTION

Geosynthetics are synthetic products generally used to stabilize terrain and are also widely used to resolve civil engineering problems. These polymeric products are mainly of eight categories: geotextiles, geogrids, geonets, geomembranes, geosynthetic clay liners, geofoam, geocells and geocomposites. The prefix of Geosynthetics, "geo", directly suggests whose application has to do with soil, rock, and earth. Geo-synthetics are manufactured from the polymers such as polyester, polypropylene, and polyethylene. Most applications of geosynthetics are in civil, marine, transportation, geotechnical, environmental, hydraulics and other development engineering such as roads, railroads, embankments, canals, retaining walls etc. In this project we are focusing on the use of two of these geosynthetic materials, geogrid and geonet. These products promise a wide area of development in construction and other fields. Geosynthetics are available worldwide and the activity is robust and steadily growing.

2.NEED OF THE STUDY

1. The wide functional ability of geogrids and geonets can be useful for strengthening concrete structures like beams and slabs.
2. To use smart materials and discover their properties that can help us with replacing steel reinforcement.
3. To increase the flexural strength of concrete structures by utilising geosynthetics in modern construction.
4. To study the wide-area usage of these materials as they are rarely used in reinforced structures.

3.MATERIALS USED

3.1 Geogrid

Geogrid is one of the constituent materials classified under geosynthetics manufactured from the polymers such as Polyester, polypropylene, and polyethylene. Geogrid is a flexible mesh that generally used to create a reinforced coherent mass behind the retaining wall by stabilizing the soil. The stability of the soil depends greatly on the friction angle it contains. The friction angle is often referred to as the shear strength of the soil. Geogrids are plastics having grid-like configuration with large apertures between individual ribs. The geogrids used is this project have an aperture of 38 mm x 38 mm which was provided to us by MACCAFFERI. MACGRID EG used are high modulus polypropylene geogrids, produced by an extrusion process characterized by tensile resistance both in longitudinal and in the transverse direction.

Figure 1. Geogrid

3.2 Geonet

A geonet is a geosynthetic material similar in structure to a geogrid, consisting of integrally connected parallel sets of ribs overlying similar sets at various angles for in-plane drainage of liquids or gases. Geonets are often laminated with geotextiles on one or both surfaces and are then referred to as drainage geocomposites. When the ribs are opened, relatively large apertures are formed into a netlike configuration. Their design function is completely within the drainage area where they are used to convey liquids of all types. The primary function of a geonet is to convey liquid within the plane of its structure, the in-plane hydraulic flow rate, or transmissivity, is of paramount importance. However, other features, which may influence this value over the service lifetime of the geonet, are also of importance. Thus, a few physical, mechanical, endurance, and environmental properties will also be mentioned. The geonet we used was MACDRAIN N1471 which was provided by MACCAFERRI company.

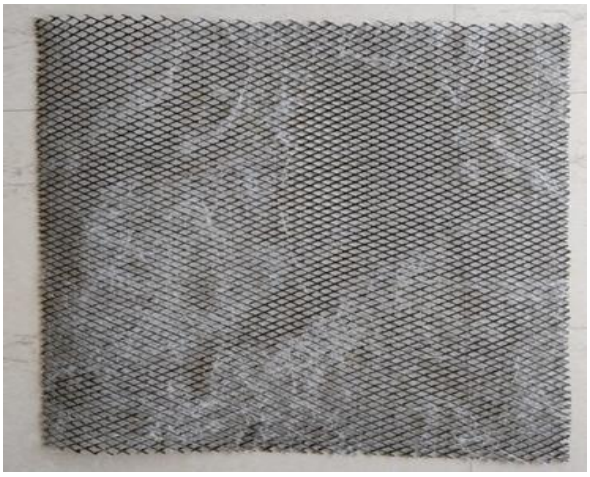

Figure 2. Geonet

4.LITERATURE REVIEW

Aluri Anil Kumar et. al (2015), introduced to be used in concrete columns. This new reinforcement named Geogrid reinforced steel columns (GRSC), is a little satisfactory alternative to the rebar cage used in traditional reinforced concrete, for faster and easier construction. It is structured polymeric material usually made from polyethylene compounds.

S. Ramakrishnan (2018) In this paper illustrates the behaviour of reinforced concrete (RC) beam with biaxial geogrid as an extra reinforcement. The intention of examining the behaviour of geogrids in structural members gives chance to observe benefit and possibility of using geogrid in thin concrete layer. In this investigation consists of 1 control beams (CB) and 5 geogrid reinforced concrete beams (GB) with changeable geogrid layer from 1 to 5. These beams were subjected to slowly increased two-point load until failure occurred. The first crack load, ultimate load carrying capacity and behaviour was observed till fall down occurred.

P. Maheswar Reddy, J. Ravi Kumar (April 2018). This paper related to the experimental investigation on concrete beams reinforced with geogrid in uniaxial and biaxial directions. The use of geogrid in concrete sets a new dimension for employing geo-synthetics in structural engineering. Geogrids are being used in given that stabilization, confinement, and reinforcement of asphalt concrete layers, further, to decrease reflective cracking in pavement applications.

Sivakamasundari, Daniel, and Kumar (2017) have performed an experimental study to investigate the flexural behaviour of biaxial geo-grid with and without steel fibres to know the possibility of biaxial geo-grid and steel fibre as a substitute for shear reinforcement. The experimental test shows that the significant improvement in the flexural strength, stiffness degradation, energy dissipation capacity, displacement ductility, and the ultimate load with its corresponding deflection. The present research work had focused on Geo-grid proportioned concrete elements basic tests and they are compared with regular controlled specimens.

Venkatappa.Get. al (1997), the testing required for hydraulic applications is presented in detail. The work is carried out on design of needle punched fabrics for a hydraulic application is described. A case study on use of edge drains for rural roads is presented. The work in progress on nature fiber geotextiles with jute and coir is included.

Saranyadevi M (2016) A total 18 beams, with (150mm ×100mm) rectangular cross section and of span 1200 mm were casted and tested. From totally 18 beams nine were used for 7 Days curing and remaining nine was used for 28 Days curing. In first set of 6 R.C.C. Under reinforced beams were strengthened with Geogrid in 1 layer from tension face which is parallel to beam axis subjected to static loading tested until failure. In 2 set of R.C.C. Under reinforced beams were externally wrapped with Geotextile fabric. The remaining 6 beams were used as a control specimen. A Finite Element (FEM) model has been developed using ANSYS 14.5 to analysis beams. The finite element program ANSYS has been used to study the Strengthened behaviour of a beam. The concrete was modelled using solid 65 elements.

Sandeep Kumar (June 2014), The tests were conducted in a steel tank of I20x90x90 cm size. A square mild steel plate of size 20x20 cm having a thickness of 2 cm was used as a test footing. The sand was filled in the tank keeping the uniform density of 1.6 g/cc throughout the filling procedure. According to code provisions, the effect of Geogrid and Geonet does not play any role after the depth exceeds 1.5 times the width of footing or test plate. In our study, we kept the layers of Geogrids and geonets at various depths and check the behaviour of test plate. As the depth of Geogrid and Geonet increases, the load carrying capacity of footing increases up to a certain depth and then it goes decreasing. In this study, the load carrying capacity of footings v\hen Geogrids and Geonets are used separately has been compared. The comparison is done with the help of graphs also.

Xiaochao Tang, Isaac Higgins, and Mohamad N. Jlilati (September 2018) This study aims to investigate the flexural behaviour of simply supported concrete beams reinforced by geogrids, which would aid in assessing the potential use of geogrids for concrete structures such as overlays and other thin sections. Another objective of this study is to examine the potential benefits of embedding geogrids in PCC, and to investigate the mechanism and effectiveness of geogrid reinforcement in PCC.

Shobana S.et. al (2015), illustrated the behaviour of concrete beams reinforced with uniaxial and biaxial geogrids. The experimental investigation consists of testing 8 geogrid concrete beams and 2 control beams under two-point bending. 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 behaviour and flexural strength. Test results indicate that geogrid can be used as an alternative material for steel in structural members.

Ajit K. Kakade, Prof. K. S. Patil (2019) In this paper an additional material for steel reinforcement of the beam is suggested. This paper assesses the experimental studies of concrete beam and slab with geogrid reinforcement. The beams and slabs were tested for 7 days and 28 days of curing period. Beams and slabs are tested without geogrid and with conventional reinforcement in the interval of 7 days and 28 days, respectively. Rest of the beams and slabs are tested with single layer geogrid and double layer geogrid. And these results are compared with each other based on their achieved strength.

5.SUMMARY LITERATURE REVIEW

Several literature reviews were studied and analysed regarding the use of Geosynthetics in different structural elements, mainly in beams and slabs. As Geosynthetics are categorised accordingly, we studied the use of Geogrid and Geonets in concrete.

- It is observed that beams generally fail because of flexural failure without any warning. This occurs due to several reasons such as inadequate reinforcement, corrosion in steel bars, excessive loads, and construction defects.

- After failure of the beam, it might separate in two parts whereas a beam reinforced with Geogrid or Geonet bonded with the steel reinforcement bind the concrete even after the failure of the beam as Geogrid and Geonet have more strength, durability, and elasticity.
- The flexural strength of slabs can be increased by using Geogrid and Geonet in steel reinforced slabs.
- We can also notice reduction in slab deflection by using Geogrids and Geonets.
- As the number of layers of Geogrid and Geonet is increased, the strength of beam and slab will also increase.
- Therefore, use of Geogrid and Geonet can lower the defects in various structural elements making it an exceptional solution for such situations.

6.MIX DESIGN

6.1Material Property

Table 1. Concrete mix design

Sr. no.	Concrete Mix Design Quantities	
1	Grade of concrete	M20
2	Type of exposure	Mild
3	Sp. Gravity of Cement	3.15
4	Coarse Aggregate (12 mm)	2.865
5	Coarse Aggregate (20 mm)	2.868
6	Maximum Water Cement Ratio	0.55

Table 2. Result of mix proportion

Cement (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	Water (lit/m^3)
451	1016	1591	190
1	2.27	3.55	0.55

7.FORMWORK

The formwork of size for beam is 1000 mm×200 mm×150 mm internally and for slab its size is 750 mm×750 mm×75 mm. The reinforcement cages were placed in the moulds and cover between cage and form provided was 15 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 whitewashed.

Figure 3. Formwork of Beam

Figure 4. Formwork of slab

7.1Reinforcement Details

For Beams:

Compression reinforcement = 2 No. of 8 mm diameter bar

Tension reinforcement = 3 No. of 8 mm diameter bar

Stirrups = 7 No. of 6 mm diameter bar 150mm c/c

For Slabs:

Reinforcement = 5 No. of 8 mm diameter bars on both sides

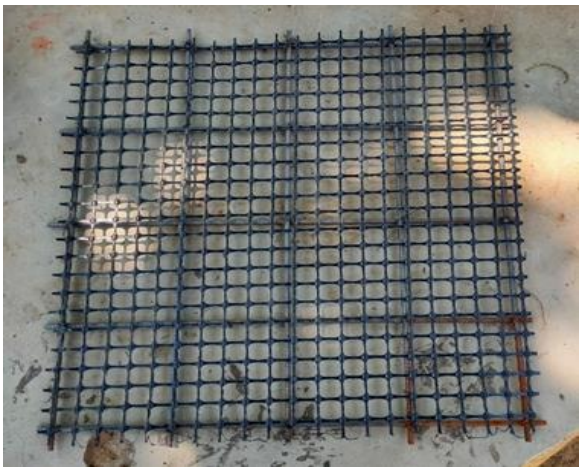

Figure 5. Steel reinforcement for slab

Figure 6. Steel reinforcement for Beam

7.2 Placement of Geosynthetic Materials

- Steel reinforcing cage to be placed with 15 mm cover on each side, top and bottom.
- The geogrid and geonet must be bonded at bottom of the steel cages of 6 beams and slabs individually.
- Also, geogrid and geonet must be bonded at both bottom and top of the reinforcing steel cage of other 6 beams and beams individually.

Figure 7. Steel reinforcement in Slab bonded with geosynthetics.

Figure 8. Steel reinforcement in Beam bonded with geosynthetics.

8.EXPERIMENTAL STUDY

To determine the properties of Geogrid and Geonet when used in structural elements such as beams and slabs reinforced with steel several tests must be conducted, after 28 days of curing, Two-point loading on beam and Sandbag loading on slab.

9.CONCLUSION

Although Geogrids and Geonets are mostly used in soil reinforcement, retaining walls, as well as subbases or subsoils below roads or structures, Limited research exists on the benefits of using geogrids and geonets to reinforce Ordinary Portland Cement concrete structural and non-structural members. This study investigated on how Geonet and Geogrid can be beneficial as smart materials in many construction areas and how it can enhance the properties of these structural elements. Following is the main conclusion on this study:

1. The use of geogrid and geonet reinforced with steel bars in different structural elements i.e., is beam, slab is suitable and shows high strength as compared to the specimen which reinforced with only steel bars.
2. Using the geogrids and geonet as a strengthening material with steel bars enhanced the flexure strength of beam and slab. Even increasing the layer of Geogrid and Geonet prominently increases the bending strength of beam and slab.
3. Geogrid, geonet strengthening technique reduced the slab deflection at ultimate load.
4. It also suggests a significant improvement in terms of post cracking ductility and load carrying capacity compared to plain concrete and steel reinforced concrete.

5. Steel, Geogrid ad Geonet show similar behaviour. This also suggests that Geogrids and Geonets can certainly replace steel as a flexural reinforcement. However, the amount and type of Geogrid and Geonet must be investigated first.

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