iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 Issue: IV Month of publication: April 2020

DOI:

www.ijraset.com

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Experimental Investigation on Application of Geogrid in Concrete to Improve its Flexural Strength

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Abstract: This paper deals with the experimental investigation on using geogrid in concrete for improving its flexural strength. Concrete is the most important and widely used construction material in the world. The production of large quantities of concrete requires extensive amount of natural resources. Over the last several decades, researches have been focusing on improving the strength of concrete by inclusion of manufactured product. This study investigates the application of geogrid in beam to increase its flexural strength. The flexural strength of the RCC beam and RCC beam with geogrid reinforcement is studied. The work involves testing of RCC beams reinforced with geogrid at varying positions and conventional RCC beams. The four - point flexural bending test on the beam is done to compare the flexural strength of geogrid reinforced RCC beam with conventional RCC beam. It is observed that geogrid increases the flexural strength of the beam and also reduces the cracks formed.
Keywords: Concrete, beam, Geogrid, Biaxial Geogrid, Flexural strength

I. INTRODUCTION

Geo-grids are geo-synthetic material made from polymers such as polypropylene, polyethylene or polyester and are used widely in Civil Engineering applications to provide tensile reinforcement of soil. They are in the form of open grids so that soil can strike through the apertures and the two materials interlock together to give composite behaviour. They are used in the construction of retaining walls, steep slopes, roadway bases and foundations.

Geo-grid is one of the constituent materials classified under geosynthetics manufactured from the polymers such as polyester, polypropylene, and polyethylene.

There are three types of geogrid used. They are uniaxial geogrid, biaxial geogrid and triaxial geogrid. Uniaxial geogrids are fundamentally used in grade separation applications for instance steep slope and retaining walls while biaxial geo-grids are used in roadways to take vibrations.

These geogrid have varying tensile strength due to the material used for making them, the tensile strength can be found out by laboratory test [7]. Geo-synthetics are being used as a stabilization and reinforcement element in distinct infrastructure and heavy civil works. The principle function of geogrids is as reinforcement. This area, as with many other geosynthetics, is very active, with a number of different products, materials, configurations, etc., making up today's geogrid market.

The usage of geogrid as reinforcement in the PCC beams has shown good results as studied in [1]. Different types of geogrid gives varying strength according to their types and number of layers reinforced as in [3],[4].

It is seen from [5] that the use of geosynthetics increases the flexural strength of the beam. When the beam is reinforced particularly with uniaxial geogrid it gives effective increase in flexural strength [2].

The flexural strength of the beam can effectively increased by using steel fibre [8], [9]. Reference [6] shows that the geogrid confined beams show good increase in the flexural strength of the beam.

Though many studies proves the advantages of introducing geogrid in concrete beams, this work aims to study the flexural behaviour of conventional Reinforced cement concrete (RCC) beam over RCC beam reinforced with biaxial geogrid at varying positions.

A comparative study between conventional RCC beam and RCC beam reinforced with biaxial geogrid has been carried out to find the difference in their flexural strength. To achieve this four-point bending test was performed according to the IS 516: 1959 using flexural testing machine. The study also focused on examination of deflection characteristics and cracking pattern of RCC beam with and without geogrid.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue IV Apr 2020- Available at www.ijraset.com

II. MATERIALS USED

A. Cement

Ordinary Portland Cement of grade 43 conforming to IS 8112: 2003 was used. Table 1 lists the properties of cement.

Table 1 Cement Properties

PROPERTY	RESULT
Specific Gravity	3.22
Fineness	3.91%
Consistency	30%
Initial Setting Time	45 minutes
Final Setting Time	417 minutes

B. Fine Aggregate

Well graded sand with specific gravity of 2.59 and conforming to Zone I as per IS 383:1970 was used.

C. Coarse Aggregate

Granite crushed angular coarse aggregate of nominal size 20mm, with specific gravity of 2.74 was used.

D. Geogrid

Biaxial type of geogrid having a tensile strength of 30 KN/m was used. Table 2 shows the properties of the geogrid used.

Table 2 Properties of Geogrid

PROPERTY	RESULT
Aperture size in cm	2.3 x 2
Aperture shape	Rectangular
Weight in g/m^2	690
Tensile strength	30kN/m

The work involved casting of six beams that included two conventional RCC beams, two numbers of two-layer geogrid reinforced RCC beam (with reinforcement in the tension zone) and two numbers of geogrid confined RCC beams. Each type of beam was tested for its 7 days and 28 days flexural strength. M_{40} grade concrete was designed according to IS 10262: 2009. The concrete was prepared for 100 mm slump. Superplasticizer was used to increase the workability of the concrete. Cube test was done to check whether the mix design attained the required compressive strength or not.

The size of the beam was 1000mm in length, 150mm in width and 150mmdepth.

III. METHODOLOGY

Figure 1 Casting of beams

IV. FLEXURAL TEST

Flexure tests are generally used to determine the flexural modulus or flexural strength of a material. A flexure test is more affordable than a tensile test and the test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to the top of the material through either one or two points of contact (upper loading span) until the sample breaks. The maximum recorded force is the flexural strength of that sample.

Unlike a compression test or tensile test, a flexure test does not measure fundamental material properties. When a specimen is placed under flexural loading all three fundamental stresses are present: tensile, compressive and shear and so the flexural properties of a specimen are the result of the combined effect of all three stresses as well as (though to a lesser extent) the geometry of the specimen and the rate the load is applied. Flexural strength is defined as the maximum stress at the outermost fibre on either the compression or tension side of the specimen.

Flexural modulus is calculated from the slope of the stress vs strain curve. These two values can be used to evaluate the ability of the sample to withstand flexure or bending forces. The two most common types of flexure test are three - point and four - point flexure bending tests. A three - point bending test consists of the sample placed horizontally upon two points and the force applied to the top of the sample through a single point so that the sample is bent in the shape of a “V”. A four - point bending test is roughly the same except that instead of the force applied through a single point on top, it is applied through two points so that the sample experiences contact at four different points and is bent more in the shape of a “U”.

Figure 2 Testing of beam

The three- point flexure test is ideal for the testing of a specific location of the sample, whereas, the four point flexure test is more suited towards the testing of a large section of the sample, which highlights the defects of the sample better than a three - point bending test. A bend test is similar to a flexure test in the type of hardware and test procedure involved. Bend tests are used with ductile materials whereas flexural tests are used with brittle materials. Flexural strength can be found using the formula,

$$\sigma = \frac{3 \text{ X } F \text{ X } (L - L_i)}{2bd^2} \qquad (1)$$

Where,

F = ultimate strength of beam in KN
L = distance between the support in mm
L_i = distance between the loads in mm
b = Breadth of the beam in mm
d = depth of the beam in mm

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V. RESULT AND DISCUSSION

The flexural testing of the beam was done according to IS 516: 1959. Using Equation 1, the flexural strength of three types of beams was found and is reported in Table 3 and 4. It was observed that the flexural strength of the beam increased with when was reinforced with geogrid. For both the cases of geogrid reinforcement, the flexural strength did not vary much.

Table 3 Flexural Strength of beam (7th day test)

TYPE OF BEAM	ULTIMATE LOAD IN KN	FLEXURAL STRENGTH N/mm^2
Conventional RCC Beam	8	2.13
Two-layer geogrid reinforced RCC beam	9	2.4
Geogrid confined RCC bream.	10	2.66

Table 4 Flexural Strength of beam (28th day test)

TYPE OF BEAM	ULTIMATE LOAD IN KN	FLEXURAL STRENGTH N/mm^2
Conventional RCC Beam	17	4.53
Two-layer geogrid reinforced RCC beam	19	5.06
Geogrid confined RCC bream.	20	5.33

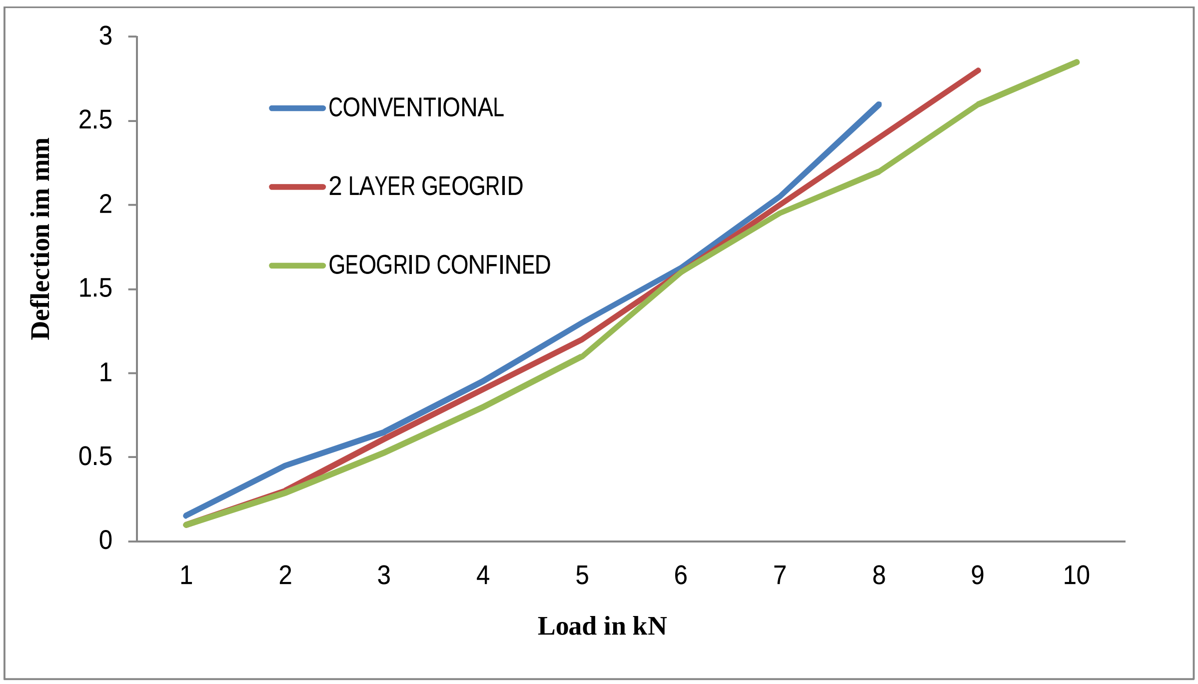

Figure 3 Graph for comparison of 7th day flexural strength

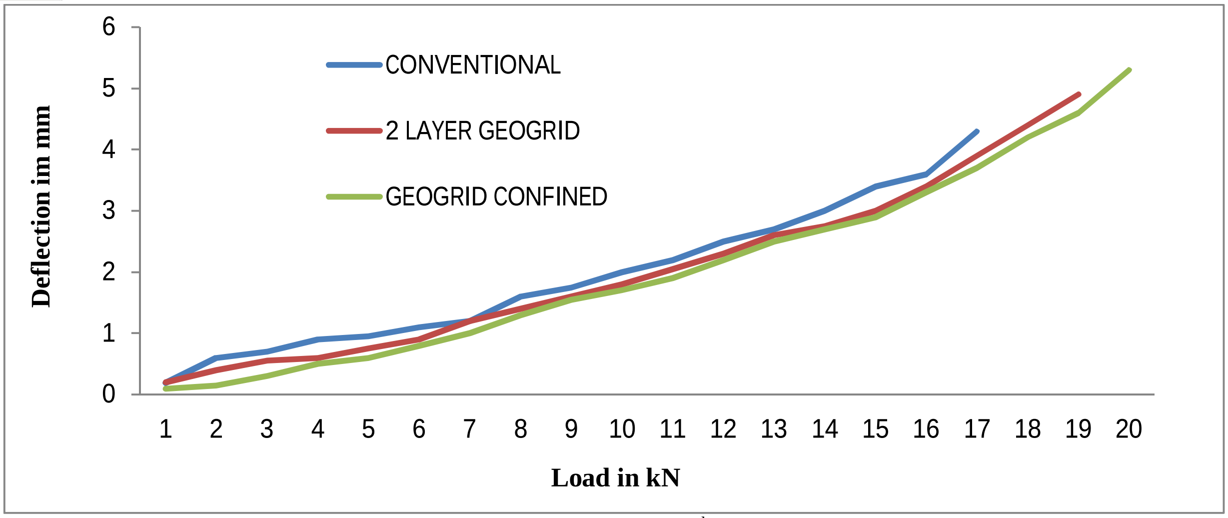

Figure 4 Graph for comparison of 28th day flexural strength

The deflection characteristics of all the three types of beam were studied from the graph of Load vs Deflection as shown in Figure 3 and 4. It was observed that introduction of geogrid resulted in the reduction of deflection in the beams in addition to its strength improvement. The geogrid confined RCC beam proved to be the best from the point of view of deflection reduction, whereas the strength characteristics of both the types of geogrid reinforced RCC beam were more or less the same.

The crack pattern of the conventional RCC beam and the geogrid reinforced RCC beams are shown in Figure 5, 6 and 7. It was found that the conventional beam has a greater number of cracks when compared to the other beams. While comparing two-layer geogrid reinforced RCC beam and geogrid confined RCC beam, the geogrid confined beam has lesser number of cracks with the depth of propagation of crack being small.

Figure 5 Cracked pattern of conventional beam

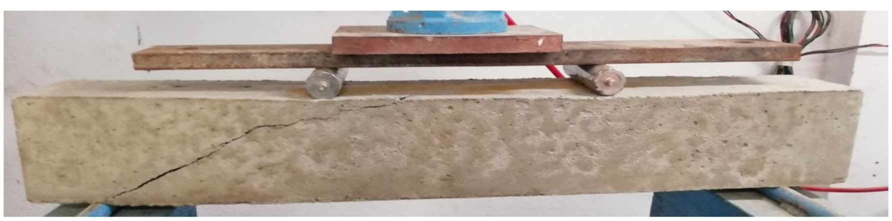

Figure 6 Cracked pattern of two layer geogrid reinforced beam

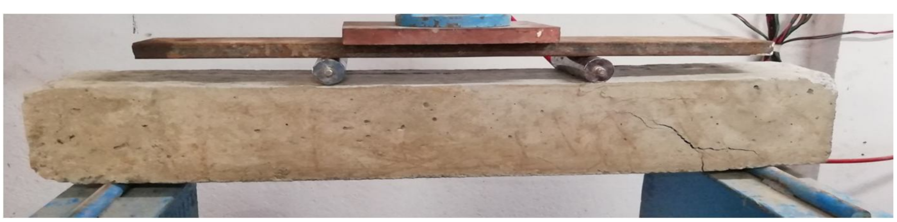

Figure 7 Cracked pattern of geogrid confined beam

VI. CONCLUSION

Based on the investigation carried out on the conventional RCC beam and geogrid reinforced RCC beams, the following conclusions were arrived at.

A. The flexural strength of the geogrid reinforced RCC beam is more when compared to conventional RCC beam.
B. The flexural strength of geogrid confined RCC beam and the two-layer geogrid reinforced RCC beam are almost the same.
C. The geogrid reinforced RCC beam has lesser deflection as compared to conventional RCC beam.
D. The number cracks formed in geogrid reinforced RCC beam is less than conventional RCC beam.
E. The geogrid confined RCC beam has the least number of cracks as compared to other cases. Also, the cracks propagate to a shallower depth in this case.

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