Comparative Study and Analysis of PCC Beam and Reinforced Concrete Beam using Geogrid

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Abstract

This paper describes the comparative study of the behavior of the geogrid reinforced concrete beam and non-reinforced concrete beams. The application of geogrid in concrete pavement ameliorates better strength, durability, and eco-friendly. The purpose of this paper is to reduce the utilization of concrete in this rapidly urbanizing world by introducing smart materials such as "Geogrid" in the road pavement which can be eco-friendly and durable without compensating its strength. The experimental investigation consisting of comparison of testing 2 beams reinforced with geogrid and 1 beam of conventional plain cement concrete (PCC) beam under two point loading testing apparatus. The result from testing confirms that the geogrid beams have more flexural strength and bond strength in comparison to PCC beams. In this project ANSYS is used to analyze the deflection of all beams by applying design load. The finite element program ANSYS has been used to study the Strengthened behavior of a beam. ANSYS 14.5 software is used to analysis the beam to develop finite element model. ANSYS 14.5 is used to analyze deformation occurs in beam. Concrete is molded in solid element where geogrid is molded in line element. Analysis is carried out by using a computer software program ANSYS with a three dimensional linear 8-noded hexahedral element.

Keywords: ANSYS software, deflection, Failure, Flexural strength, geogrid, Plain cement concrete (PCC)

I. INTRODUCTION

At the present scenario, in India there is the rapid growth of urbanization and the vehicular traffic is increasing day by day. Due to this the load on the road pavement is increasing which causes a need of increasing the depth of pavement to resist the load. In such cases for the increase of depth of pavement it increases the concentration of cement and concrete which thereafter increases the emission of carbon dioxide which is further harmful for the environment and human life. On Contrary to such cases, if any new advance material basically known as "smart materials" is entertained in road pavement which has more strength, economical and increases the lifespan of the road pavement can eliminate the cost of material and reduces the emission of harmful gases. There are many smart materials ex bamboo, steel fiber, geogrid and geotextile which can increase the strength and durability but out of them geogrid has more ability to sustain the load and proved to be economical. A geogrid is geosynthetic material used to reinforce soils and similar materials. Geogrids are commonly used to reinforce retaining walls, as well as sub-bases or sub-soils below roads or structures. Geogrids are mainly made from poly - metric materials, typically polypropylene (PP), high density polyethylene (HDPE) and polyester (PET). Geogrids are manufactured as either 1-biaxial or 2- uniaxial. Biaxial geogrids are those that exhibit the same strength in both the machine and cross machine directions while uniaxial geogrids exhibit the primary strength in the machine direction with enough strength. Geogrids are used in base reinforcement, earth retaining wall construction including veneer stabilization, the segmental retaining wall market, embankment reinforcement and pile cap platforms. Biaxial geogrids are primarily used in base reinforcement applications, while the uniaxial geogrids are often used in the other markets. Geogrid is economical and their m Geogrids helps to promotes soil stabilization to a better extent. It increases higher load bearing capacity. Geogrid is a good remedy to retain soil from erosion and thereby improves stability. Geogrids have high durability due to this the maintance cost is reduced.

The main objective of this paper to study the flexural behaviour of beam reinforced with geogrid over plan cement concrete beam (PCC). A comparative study between a PCC beam and a Geogrid beam will be analyzed based on the test result observation can be drawn out about how much a geogrid beam is effective to PCC beams. To achieve the objective of this paper

according to the IS 516 the two point testing apparatus properly known as "flexural testing machine" is used which gives the test result of flexural behaviour of PCC as well as beam reinforced with geogrid.

II. MATERIAL SPECIFICATION

For the testing of the beam using two point apparatus the beam is casted using

1) The plain cement concrete mix was prepared using Portland cement of 53 grade, natural sand as fine aggregate and crushed blue granite as coarse aggregate. The maximum size of coarse aggregate is limited to 20mm.Super plasticizer was used to improve the workability of concrete and water cement ratio maintain as 0.45.
2) Geogrid

There are 3 types of Geogrid:

1) Uniaxial
2) Biaxial
3) Triaxial

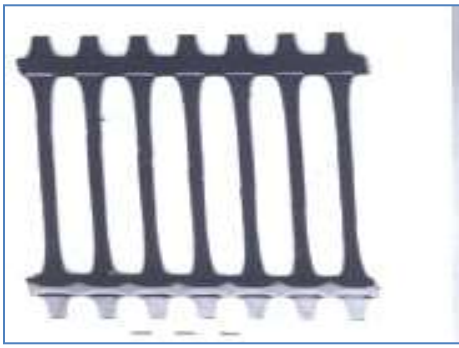

Fig. 1: Uniaxial geogrid

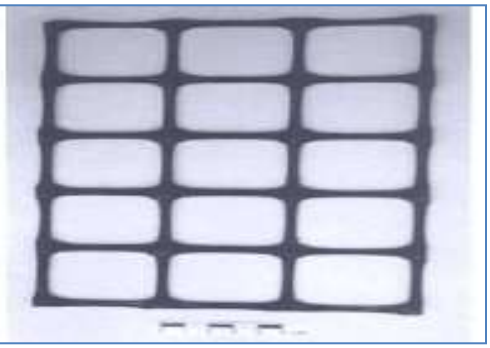

Fig. 2: Biaxial Geogrid

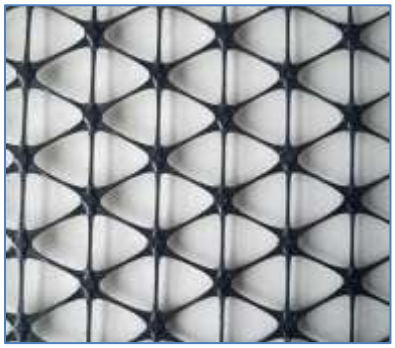

Fig. 3: Triaxial Geogrid

Uniaxial geogrids are basically used in grade separator appliances for instant steep slopes and retaining wall while Bi axial geogrids are used in roadway to take vibrations. Triaxial geogrids are used in road construction where the soil under the road is sandy or loose.

In this research paper the biaxial geogrids are used because this paper concerns only about road pavement. Selection of grade of geogrid is based upon design and loading condition

III. DESIGN

The beams which are reinforced with geogrid in that beam geogrids are laid in two layers in tension zone with a spacing of 20mm as shown in fig.5 and 6 and each layer should be vibrated using table vibrator. Beam 1 is of plain cement concrete beam and in beam 2 150KN grade of geogrid is introduce where in beam 3 200KN of geogrid is introduce. There are 3 specimens for each type of beam. Take cover of 10 mm from all 4 sides in both layers as shown in fig. 4 and 5. While lying of the geogrids the Machine direction (MD) ribs should be laid parallel to the longitudinal direction of the beam. The geogrids used in beam 2 and beam 3 is of different grades. For every beam type two beam specimens is casted one for 7 days and 28 days respectively.

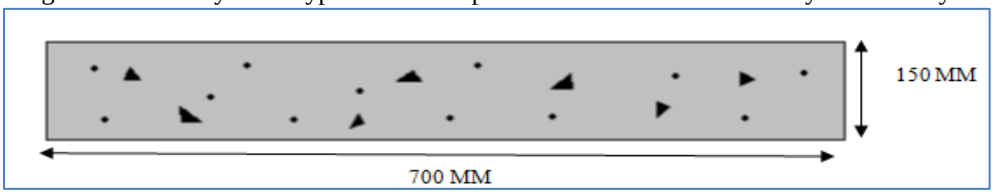

Fig. 4: Conventional PCC Beam (Beam 1)

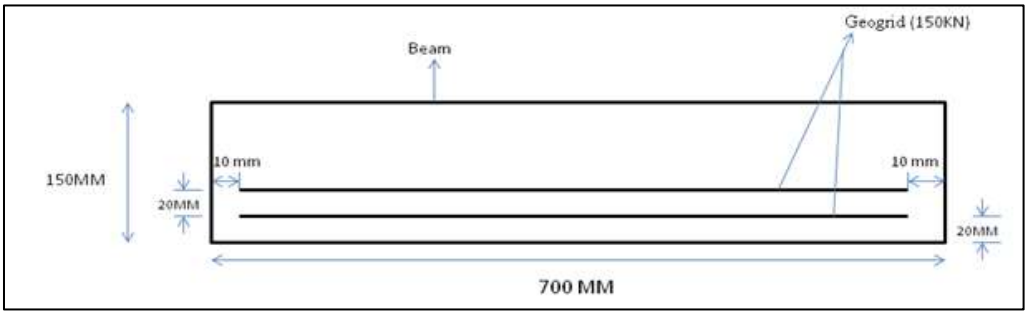

Fig. 5: 150kN Grade Geogrid Reinforce Beam (Beam 2)

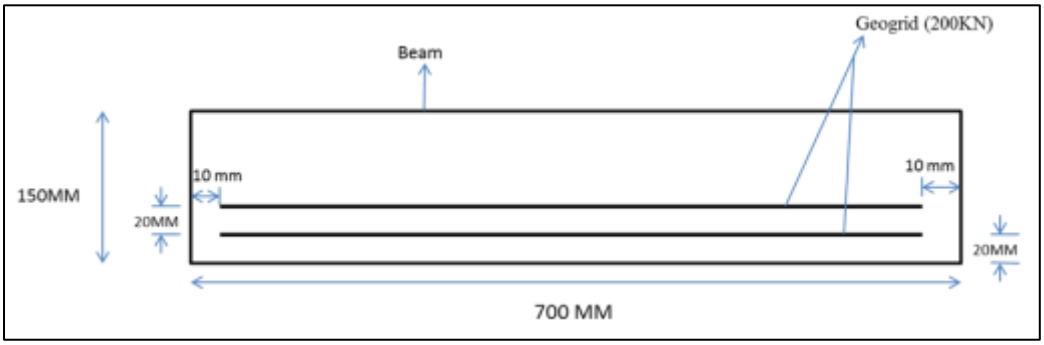

Fig. 6: 200 kN Grade Geogrid reinforced beam (Beam 3)

For calculating the flexural strength the following formula is used

$$fb = \frac{Pl}{bd^2}$$

Where
fb= flexural strength in MPa
P = load at which beam fail in KN
l = total length of beam in mm
b = width of beam member in mm
d = depth of beam member in mm

Note: - while placing geogrid beam in flexural testing machine one thing should check that the beam should place properly as geogrid place in tension zone it should be place in bottom only while placing the beam as shown in fig 7.

IV. METHODOLOGY

To examine the results the experiment is conducted by casting 3type of beams, out off which one is PCC beam and other 2 beam are reinforced with biaxial geogrid with 150KN grade of geogrid and 200KN grade of geogrid in beam 2 and beam 3 respectively. Geogrid use in both beam are of different grade. Beams are casted for 7 days and for 28 days respectively and there is 3 specimens for each type of beam that means total 18 beams are required to cast for perform this experiment. Geogrid use in both beam are of different grade. The size of all beams is 700x150x150mm as per IS 516.The concrete mix used in the beams should be same for all 3 beams and it should gain the characteristic strength of 40 MPa.

Fig. 7: Casting of Beam reinforced with Geogrid

V. CRACK PATTERN

For determining load carrying capacity of beam, 3 beams of 7 days and 28 days were casted and tested in the flexural testing machine as per specification of IS standard 516. After completion of curing periods of 7 days and 28 days, beams were taken out to determine its flexural strength. While testing the beam in flexural testing machine load is gradually increases on beam which causes failure of beam and cracks over beam. That cracks have particular pattern which shows that beam was properly casted or not. The beam is divided in 3 regions of 200mm each. During the testing of beam if flexural cracks are developed in middle region as shown in fig. 8 and beam gets broken from the middle region then it is shown that the beam is strong enough to carry ultimate load. But if beam is not broken from middle region then it is shown that the beam is not able to carry enough load for which it design.

Fig. 8: Flexural Cracks in Beam

VI. RESULT

After testing of all 18 beams in which 3 specimen for each type of beams are of 7 days and 28 day. In every beam one common thing is notice in all beams that are cracks occurs in all beam are occurs in middle portion. It shows that all beams are able to carry enough ultimate loads.

Following results are come under observation.

Table – 1

7 day PCC beam

	LOAD IN kN	*FLEXURAL STRESS IN MPa*
SPECIMEN 1	*17.5*	*3.63*
SPECIMEN 2	*18*	*3.73*
SPECIMEN 3	*18.5*	*3.83*
AVERAGE	*18*	*3.73*

Table – 2

7 days 150 kN grade geogrid beam

	LOAD IN kN	*FLEXURAL STRESS IN MPa*
SPECIMEN 1	*18*	*3.73*
SPECIMEN 2	*18.5*	*3.83*
SPECIMEN 3	*19*	*3.94*
AVERAGE	*18.5*	*3.83*

Table – 3

7 days 200 kN grade geogrid beam

	LOAD IN kN	*FLEXURAL STRESS IN MPa*
SPECIMEN 1	*20.5*	*4.25*
SPECIMEN 2	*21*	*4.35*
SPECIMEN 3	*21.5*	*4.46*
AVEARGE	*21*	*4.35*

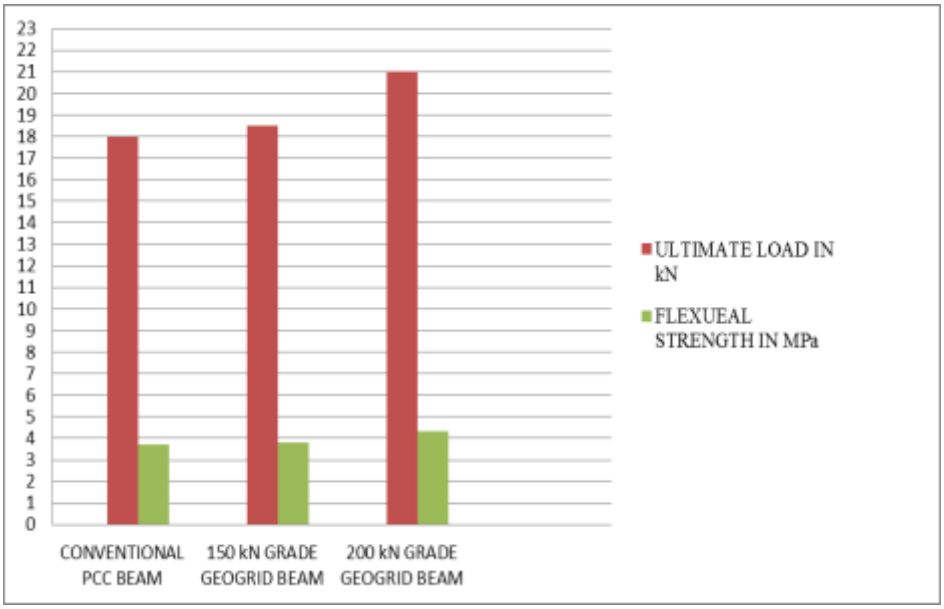

Fig. 9: 7 –Days Testing Results of Beam

Table – 4
28 Days PCC Beam

	LOAD IN kN	*FLEXURAL STRESS IN MPa*
SPECIMEN 1	*19.5*	*4.05*
SPECIMEN 2	*20*	*4.15*
SPECIMEN 3	*20.5*	*4.25*
AVERAGE	*20*	*4.15*

Table – 5
28 Days 150 kN Grade Geogrid Beam

	LOAD IN kN	*FLEXURAL STRESS IN MPa*
SPECIMEN 1	*22*	*4.56*
SPECIMEN 2	*22.5*	*4.67*
SPECIMEN 3	*23.5*	*4.87*
AVERAGE	*22.67*	*4.7*

Table – 6
28 Days 200 kN Grade Geogrid Beam

	LOAD IN kN	*FLEXURAL STRESS IN MPa*
SPECIMEN 1	*24*	*4.97*
SPECIMEN 2	*24.5*	*5.08*
SPECIMEN 3	*25*	*5.18*
AVERAGE	*24.5*	*5.07*

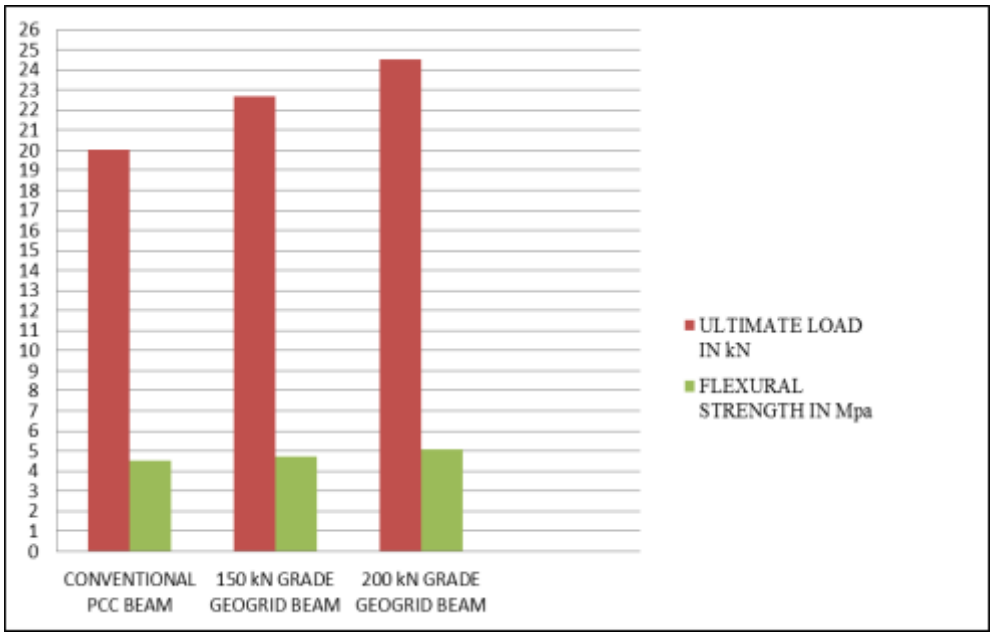

Fig. 10: 28- Days Testing Results of Beam

VII. ANALYSIS

For analysis of deflection in beams finite element model (FEM) software ANSYS is used. FEM supports all types of advanced analysis such as dynamic, static, linear and non-linear supported by ANSYS. ANSYS suited for Civil engineering project such high-rise buildings, bridges, seismic calculations, offshore structures, power plants, soil mechanics, dams and tunnels.

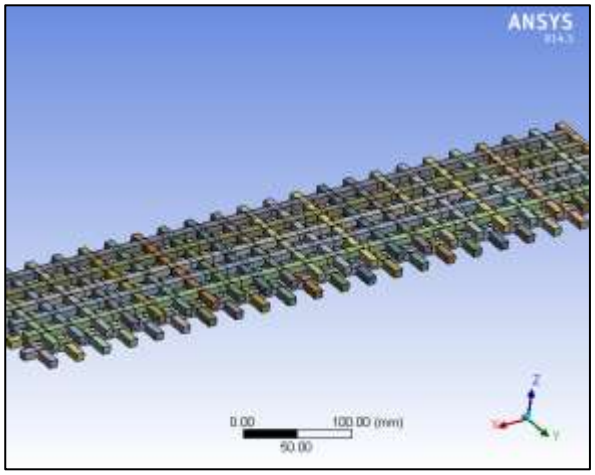

Fig. 11: Line body of Geogrid

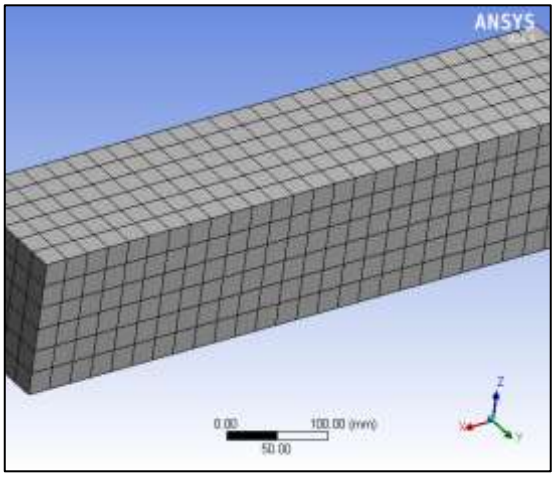

Fig. 12: Meshing of Beam

While preparing model Geogrid is moulded in line body as shown in fig. 11 and concrete is moulded in solid body as shown in fig. 12. Meshing is done in mechanical environment. The size of meshing element is 25 mm. loading taken while analyzing is average loading value of each type of beam.

Steps for analyzing the beam by ANSYS

1) Preparing model
2) Applying boundary condition and loading
3) Result

Results of Deformation of 7 Day and 28 Days Curing Beam

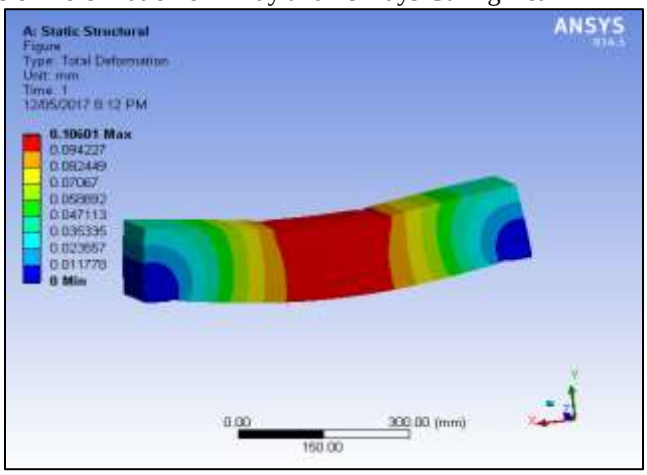

Fig. 13: Deflection of 7 Days Conventional PCC Beam

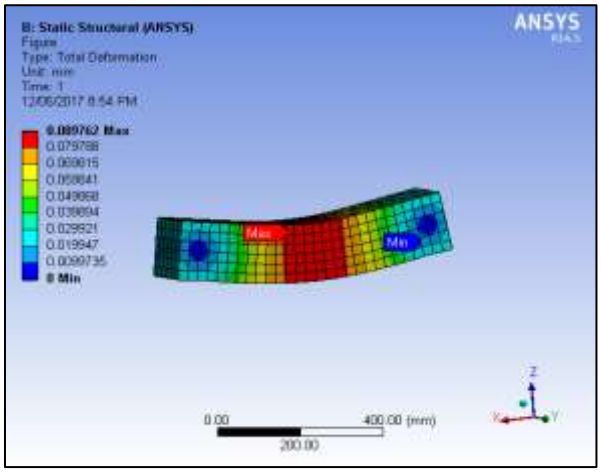

Fig. 14: Deflection of 7 Days 150 kN Grade Geogrid Beam

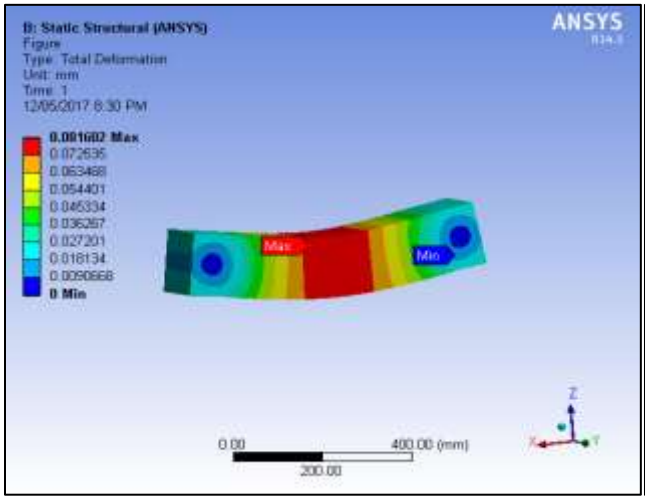

Fig. 15: Deflection of 7 Days 200 kN Grade Geogrid Beam

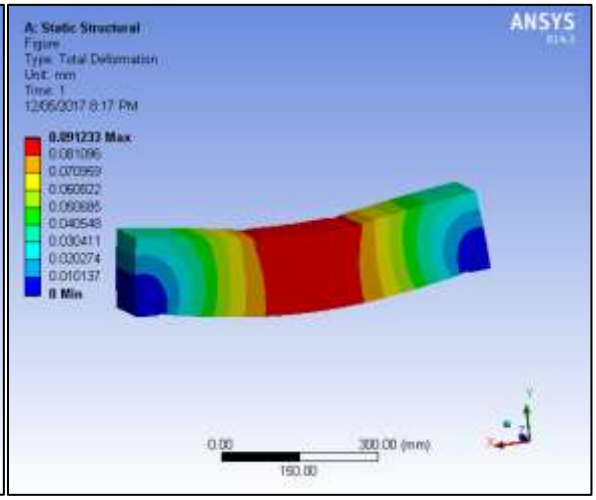

Fig. 16: Deflection of 28 days Conventional PCC beam

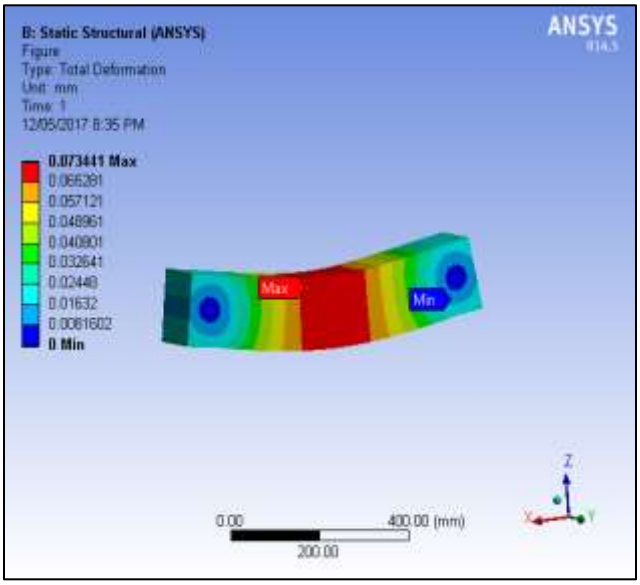

Fig. 17: Deflection of 28 Days 150 kN Grade Geogrid Beam

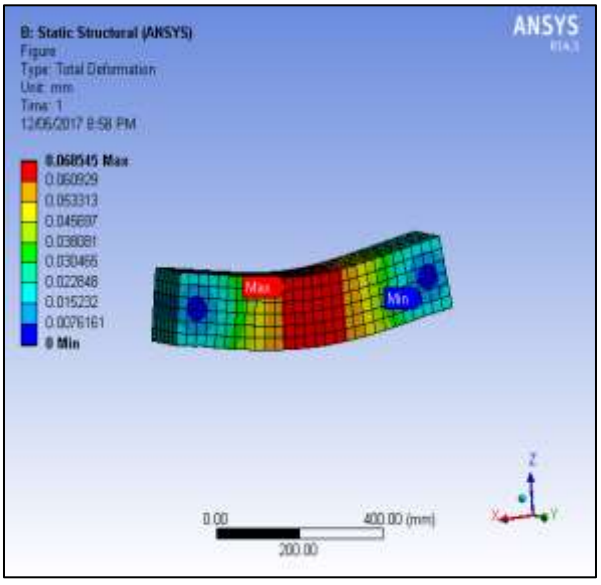

Fig. 18: Deflection of 28 Days 200 kN Grade Geogrid Beam

Table – 7
Deflection of 7 days and 28 days beam

		Conventional PCC Beam	*150 kN Grade Geogrid Reinforced Beam*	*200 kN Grade Geogrid Reinforced Beam*
1	*7 days Deflection value in mm*	*0.1060*	*0.089*	*0.0816*
2	*28 days Deflection value in mm*	*0.091*	*0.073*	*0.068*

VIII. CONCLUSION

An experimental comparison has been carried out to study the behaviour of plain cement concrete beams reinforced with various grades of biaxial geogrids over conventional plain cement concrete beam. After performing flexure test it has been found out that the load carrying capacity of geogrid reinforced beam is more as compared to conventional PCC beam. Following points summarized the experimental study: -

1) After failure of the conventional plain cement concrete beam it is separated in two parts while the beam which is reinforced with geogrid bind the concrete even after the failure of the beam as geogrid have more strength, durability and more elasticity.
2) As the number of layers of geogrids is increased, the strength of beam will also increase.
3) According to the graphical representation fig 9 and 10 as the grade of geogrid is increased, the strength of beam increases accordingly to the grade of geogrid.
4) With the use of geogrid in the plain cement concrete beam the Flexural strength of beam will show the remarkable improvement.
5) The formation of crack width is reduced as the grade of geogrid is increased.
6) In analysis deflection in 200 KN grade geogrid beam and 150 KN grade geogrid beam is less than conventional PCC beam in both 7 day and 28 days curing of beam as shown in table no.7.
7) Which shows geogrid also help to reduce the deflection and strengthen the beam.

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