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Flexural Behavior of Geo-Grid Reinforced Concrete Beams

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Abstract: Geogrids are manufactured from polymers. Thepresent paper deals with the experimental investigation on concrete beams reinforced with geo grid in uniaxial and biaxial directions. The use of geogrid in concrete sets anew dimension for employing geo-synthetics in structural engineering. Geogridsare being used in providing stabilization, confinement, and reinforcement of asphalt concrete layers, further to reduce reflective cracking in pavement applications. The objective of study is to assess the feasibility and benefit of using geogrid in thin concrete overlays.The experimental investigation consists of casting and testing 6 geo-grid concrete beams and 1 control beams subjected to 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- deflection behavior and flexural strength. Test result indicate that geogrid can be used an alternative material for steel in structural members.
Keywords: Portland cement concrete (PCC); Flexural behavior; Uniaxial Geogrids; Biaxial Geogrid; load vs displacement moment vs curvature

I. INTRODUCTION

Geo-grid are classified under geo-synthetics, geogrid is one of the constituent materials classified under geo-synthetics, manufactured from the polymers such as polypropylene, polyethylene and polyester. These geo-grids are classified as either uni-axial or bi-axial. Uni-axial geo-grids are principally used in grade separation applications such as retaining walls and steep slopes while bi-axial geo-grids are used mainly in roadway applications. The effective use of geo-grid as reinforcing material with plain cement concrete in thin sections where steel reinforcement is not possible is studied by Tang et al.[1] and Meskiand Chehab[2].Geo-synthetics have long been used as reinforcement and stabilization element in various heavy civil infrastructure works(Maxwell et al.2005)[3], particularly as it relates to geotechnical engineering. More recently, the use of geogrid as reinforcement element has expanded into pavement systems, particularly as stabilizing media in unbound layers, reinforcing element in asphalt layers (Webster 1993; Yu 2009)[4-5], and as interlayer in overlay applications (Tang et al.2008b)[6]. Using Geogrids as interlayers to mitigate reflective cracking in asphalt overlayers of jointed plain concrete pavement(JPCP) has become widely used (Khoadaii and Fallah 2009)[7]. The flexural behaviour of Lightweight oil palm shells concrete slab reinforced with geo-grid has been studied and found with increase in the layers of geo-grid the flexural strength has been enhanced[8]. The geo-grid encasement in the columns is studied and the confining effect of geo-grid on the mechanical properties of concrete specimens with steel fibre under compression and flexure. The flexural and shear behaviour of geo-grid confined reinforced concrete beams with steel fibre reinforced concrete is studied [9-11]. Little research, however, has been performed on their use as reinforcement in thin Portland Cement Concrete (PCC) members and overlays (Tang et al. 2008a) in pavement and other structures where steel reinforcement cannot be placed due to constructability and durability limitations.Such limitations include physical constraints of placing the reinforcing steel bars in thin sections, such as architectural elements, concrete overlay, and ultra thin white-toppings, in addition to extensive time for construction and concerns of steel corrosion. Therefore, the need arise or alternatives to replace the reinforcing steel bars, including the fibers reinforced polymer (FRP) composites that have been extensively investigated as a viable alternative

In considering rib direction and aperture shape there are two varieties of Geogrids used for reinforcement.Uniaxial, Biaxial,(Fig. 1 & 2).Uniaxial geogrid possess grate tensile strength in their unidirectional ribs, where as Biaxial geogrid ribs owns tensile strength in both the directions(x and y directins).Experiments operated in biaxial geogrids[1] shown that they cannot maintain a unvarying tensile strength when subjected to tension in distinct directions, especially for subgrade reinforcement and stabilization applications.

The present investigation on focuson the flexural behavior of plain cement concrete beams when reinforced with uniaxial, biaxial Geogrids and number of layers they have been used. For this M_{25} grade concrete beamsare selected to under go two point bending loading. Experimental investigation consists of 6 plain cement concrete beams reinforced with uniaxial and biaxial Geogrids in 1&2 and3 layers each type under two point bending load and 1normal concrete beams reinforced with 2 numbers of 10mm dia steel bars in tension zone and 2 numbers of 8mm dia steel bars in compression zone. In geogrid beams all the geogrids are placed in tension zone.

II. EXPERIMENTAL INVESTIGATION

Two point bending test has been carried out to observe the effect of geogrid on plain cement simply supported concrete beams as an alternative material instead of steel reinforcemen

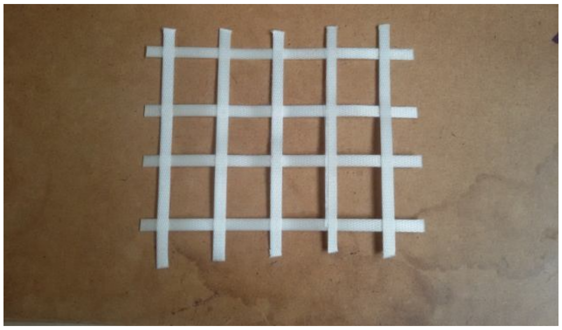

Figure.1 Uniaxial GeogridFigure.2 Biaxial Geogrid

III. EXPERIMENTAL PROGRAM

Beamsof size1350mm length with 120mm wide and 180mm thick casted with M_{25} grade are used. PCC mixture used in this study is normal strength with a target strength of 25 MPa. Six geogrid reinforced beams are fabricated : one beam reinforced with one layer of uniaxial geogrid, and one beam reinforced with two layers of uniaxial geogrid, and one beam reinforced with three layers of uniaxial geogrid, & one beam reinforced with one layer of biaxial geogrid, and one beam reinforced with two layers of biaxial geogrid, and one beam reinforced with three layers of biaxial geogrid.All the Geogrids are placed in tension zone itself. One control beam reinforced with two numbers of 10mm dia steel bars in tension zone and two numbers 8mm dia steel bars in compression zone.6 mm stirrups are used at 120mm spacing.

Table.1Geogrid and control beams

S.no	No. of beams	No .of layers	Description
1	1	1 layer biaxial geo-grid	1B
2	1	2 layer biaxial geo-grid	2B
3	1	3 layer biaxial geo-grid	3B
4	1	1 layer uniaxial geo-grid	1U
5	1	2 layer uniaxial geo-grid	2U
6	1	3 layer uniaxial geo-grid	3U
7	1	Control beam	Control beam

A. *Materials used*

The following are the materials used in the current experimental investigation

1) *Cement:* OPC obtained from the local crushing plants. It has a specific gravity of 2.762. 53 grade (ZUARI brand) conforming to code IS: 12269-1987 having specific gravity ofcement 3.13 was used.
2) *Coarse Aggregate:* The coarse aggregate used in this work was of 20mm down nominal size. The granitecrushed angular shaped coarse aggregate was used
3) *Fine Aggregate:* In the present investigations, Tungabhadra river sand available inkurnoolthe local market was used as fineaggregate and has a specific gravity of 2.632 and conforming to grading zone -2.
4) *Geo-grid :* The uni-axial geo-grid with tensile strength of 60 KN/m is used, the geo-grid is made polyester.
5) *Geo-grid:* The biaxial geo-grid with tensile strength of 40 KN/m is used, the geo-grid is made polypropylene

B. 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 is applied at points dividing the length into three equal parts plates are used under the loads to distribute the load over the width of the beam. The testing equipment is a universal testing machine of 100KN capacity. Flexural strength of beams are calculated by using this formula

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

Where F is ultimate load, L is distance between the supports, $L_i$is distance between loads, b is width of beam and d depth of beam

IV. RESULTS AND DISCUSSION

Flexural Strength of Geogrid and control Beam

All the beams of size 120x180x1350mm with different types of geogrid and different layers of geogrid have been tested under two point bending in flexure testingusig UTM of 100 tans capacity machine. Flexural strength of each beam is plotted in bar graph shown in figure

Table.2 Flexural strength of geogrid and control beams

Table.1 flexural strength S.NO	Flexural strength in Mpa		
	Uni-axial Geo-grid	Biaxial geogrid	Control beam
1	4.7	4.4	18.64
2	6.50	5.00	
3	8.49	7.6	

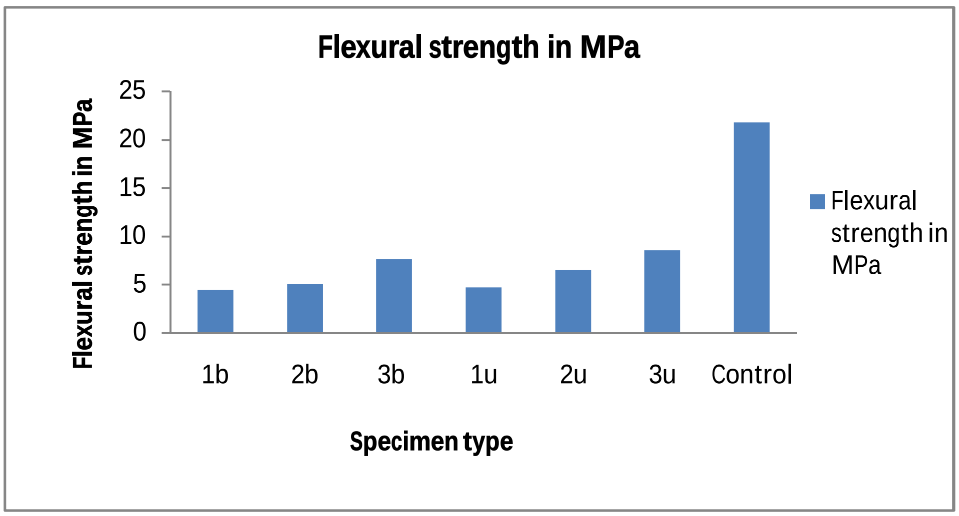

Figure.3 Flexural Strength of GeogridAnd Control beams

A. Load vs Displacement

Load vs Displacement curve for beams reinforced with different types of Geogridswith one & two and three layers. A special type of load vs deflection behavior is observed because of using Geogrids as reinforcing material. The geogrids used for reinforcing will remain passive till it get stressed. Next the first crack, all the tensile forces may gets transferred to the geogrid installed in beams. After concrete failure the total load will be directly transferred to the geogrid.So, beam reinforced with geogrid can take further load

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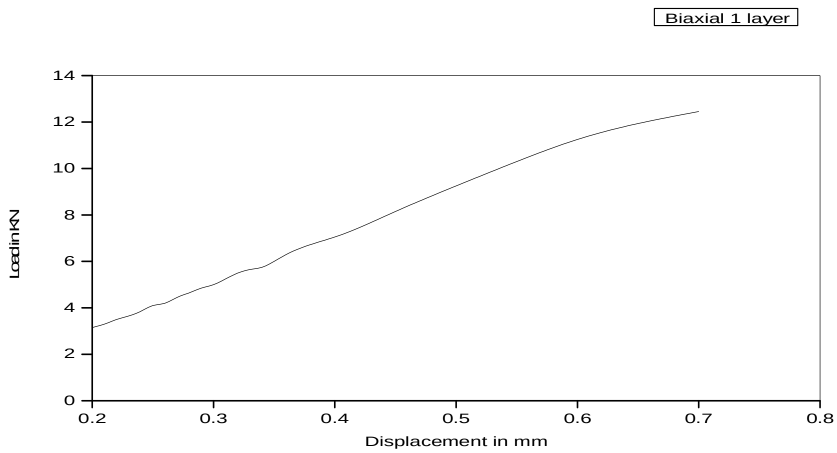

Figure.4 Loadvs Displacement Curve for Beams Reinforced with BiaxailGeogrid one layer

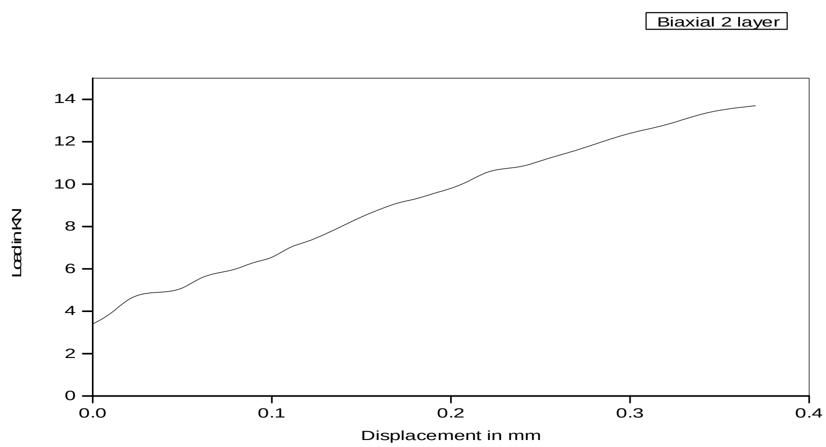

Figure. 5 Load vs Displacement Curve for Beams Reinforced with BiaxailGeogrid two layer

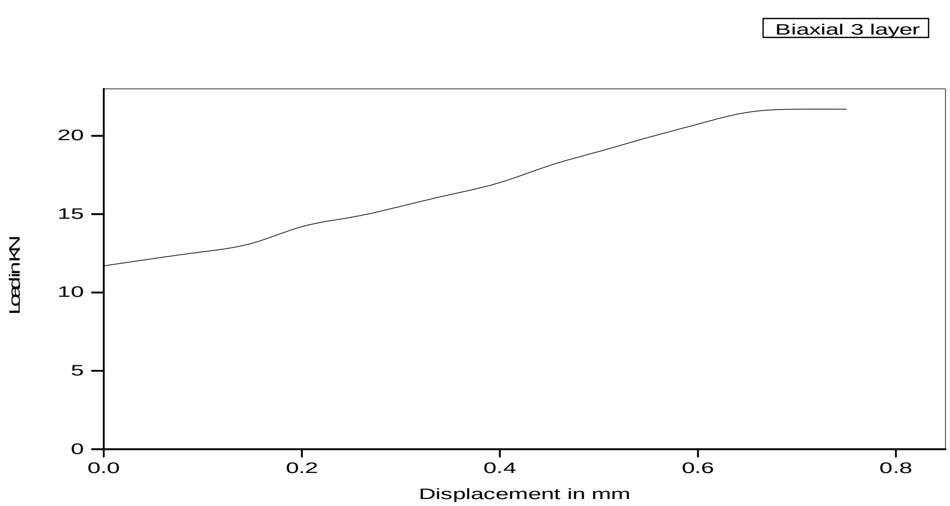

Figure.6 Loadvs Displacement Curve for Beams Reinforced with Biaxial Geogrid three layer

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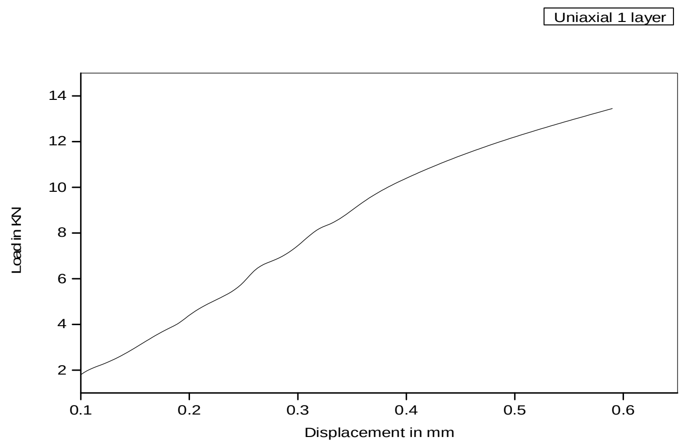

Figure.7 LoadvsDsplacement Curve Beams Reinforced with Uniaxial Geogrid one layer

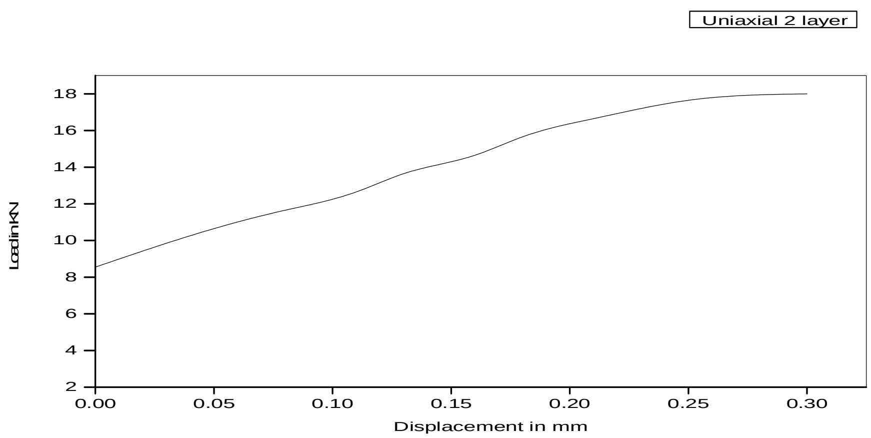

Figure.8 Loadvs Displacement Curve Beams Reinforced with Uniaxial Geogrid two layer

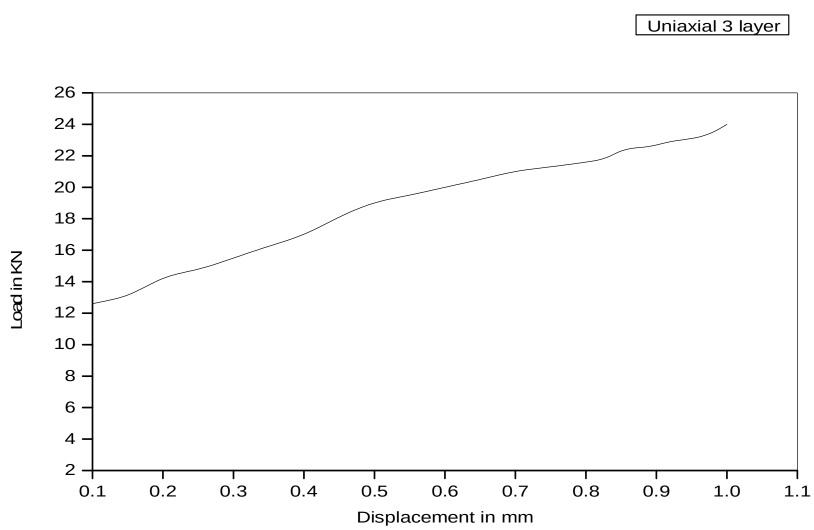

Figure.9 Loadvs Displacement Curve Beams Reinforced with Uniaxial Geogrid three layer

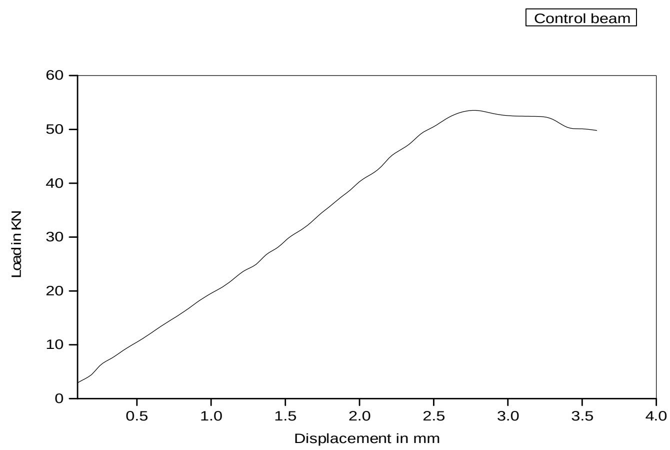

Figure.10 Load vs Displacement Curve for Control beam

B. moment vs curvature

Moment Curvature Graphs are drawn below from load and deflection values

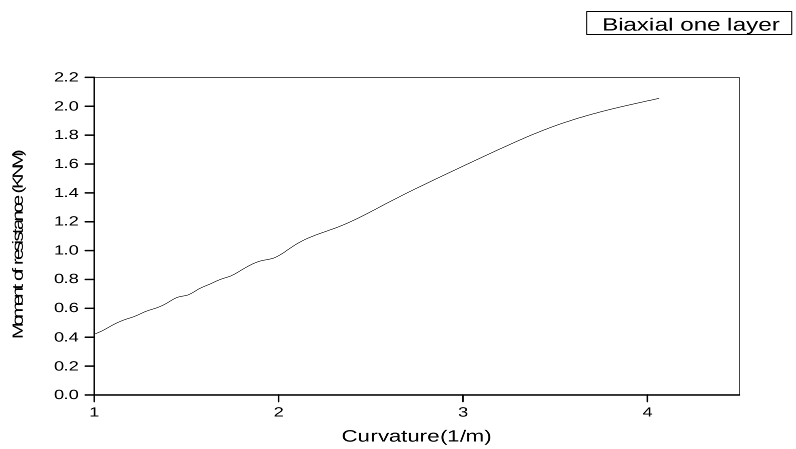

Figure.11 Momentvs Curvature for Beams Reinforced with BiaxialGeogrid one layer

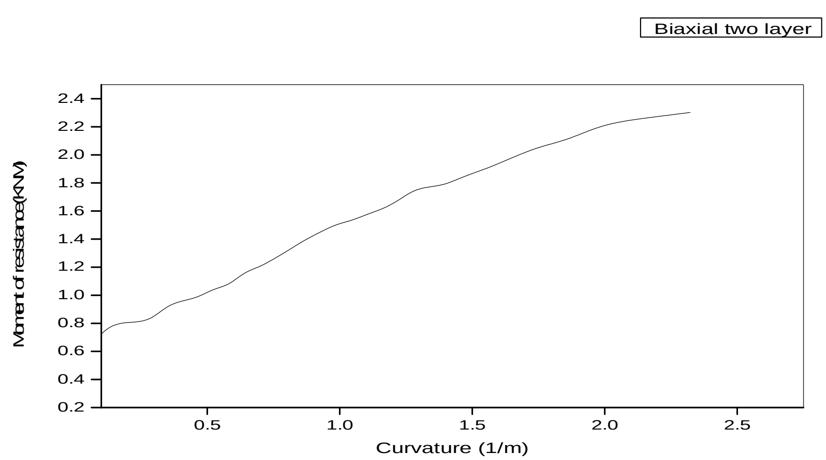

Figure.12 Moment vs Curvature for Beams Reinforced with Biaxial Geogrid two layer

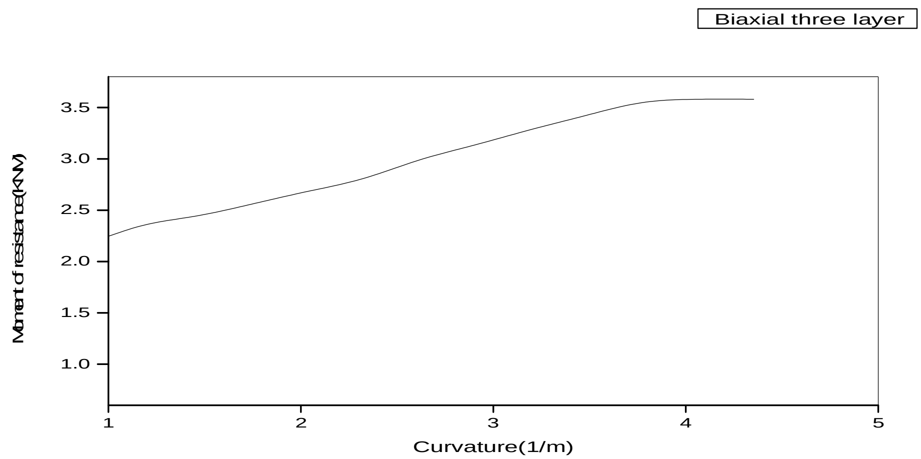

Figure.13 Momentvs Curvature for Beams Reinforced with Biaxial Geogrid three layer

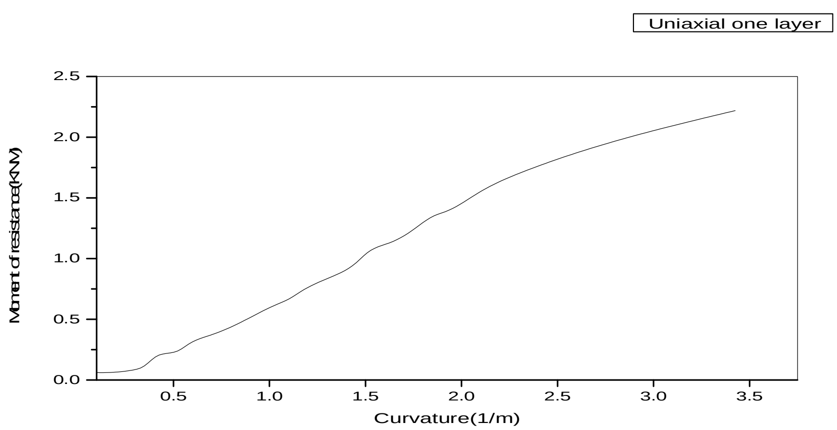

Figure.14 Momentvs Curvature Beams Reinforced with Uniaxial Geogrid one layer

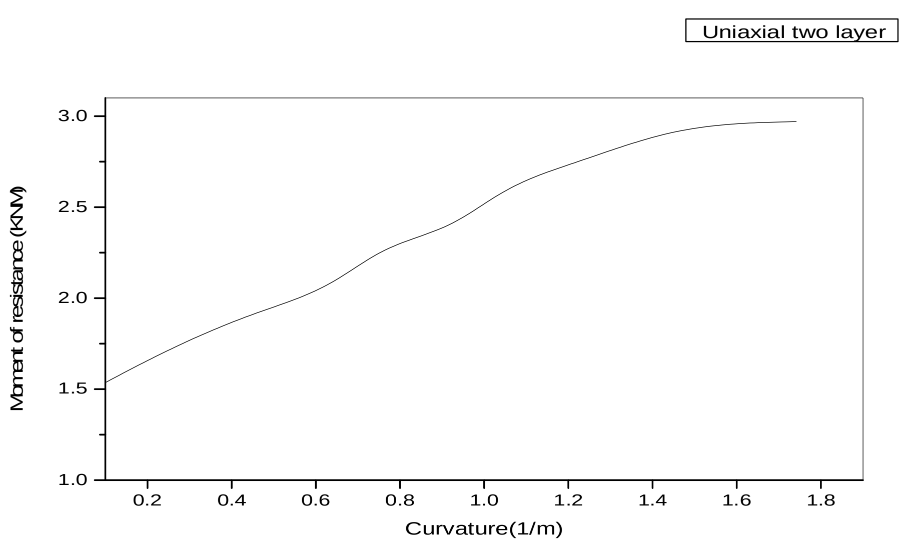

Figure.15 Moment vs Curvature Beams Reinforced with Uniaxial Geogrid two layer

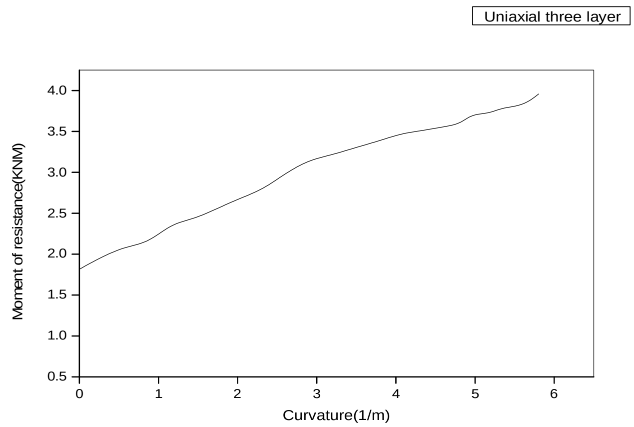

Figure.16 Momentvs Curvature Beams Reinforced with Uniaxial Geogrid three layer

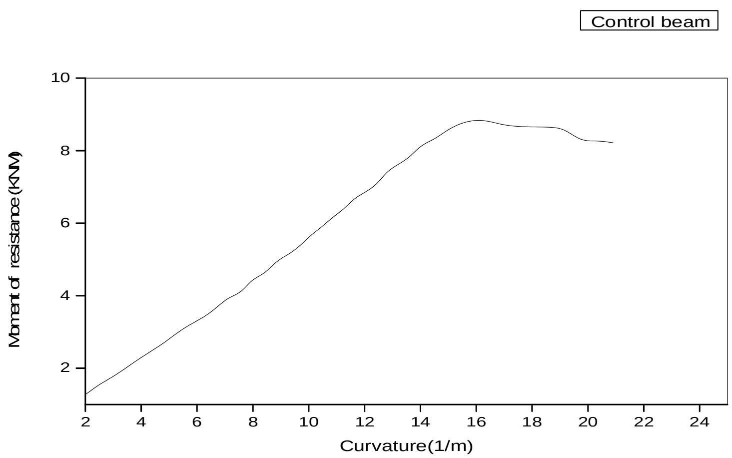

Figure. 17 Moment vs. Curvature for Control beam

C. Crack patterns

The crack patterns for all the geogrid beams and control beams are shown in the figure .In geogrid beams cracks appeared only in the middle section i.e, only Flexural cracks are formed and no shear cracks are formed. In control beam both flexural and shear cracks are formed

Figure.18 Beams Reinforced with UniaxialGeogridsFigure.19 Beams Reinforced with Biaxial Geogrid

Figure.20 Control Beam

V. CONCLUSIONS

From flexure tests it has been found out that Geogrids can take tensile force when these are kept in plain cement concrete beams.From the flexural test conducted on beams the following conclusions are listed

A. Various reasons could have been caused for the failure of concrete first in geogrid concrete beams followed by failure of Geogrids.
B. Flexural strength is more when three layers of uniaxial Geogrids are when compared to biaxial geo-grid reinforced concrete beams
C. Both Uniaxial and Biaxial Geogrids provide post cracking and ductile behavior like steel in beams.
D. The type of Geogrids and number of layers used in Geogrids play a major role in flexure behavior of beams
E. Uniaxial Geogrids gives better post peak flexural behavior compared to biaxial geogrid.
F. Only flexural cracks are formed for all the beams reinforced with Geogrids.

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