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Experimental Study of Concrete Beams Reinforced with Uniaxial and Biaxial Geogrids.

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Abstract: This paper illustrates the behavior of concrete beams reinforced with uniaxial and biaxial geogrids. The use of geogrids in concrete setup a new dimension for employing geo-synthetics in structural engineering. Geogrids are being used in providing stabilization, confinement, and reinforcement of asphalt concrete layers, further to reduce reflective cracking in pavement applications. The purpose of examining the behavior of geogrids in structural members gives opportunity to observe benefit and feasibility of using geogrids in thin concrete layers. 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.
Keywords: Concrete, Geogrids, Uniaxial Geogrid, Biaxial Geogrid, Flexural strength.

Introduction:

Geogrid is one of the constituent materials classified under geo-synthetics manufactured from the polymers such as polyester, polypropylene, and polyethylene. Uniaxial geogrids are fundamentally used in grade separation appliances for instance steep slope and retaining walls while biaxial geogrids are used in roadways to take vibrations. Geosynthetics is being used as a stabilization and reinforcement element in distinct infrastructure and heavy civil works[1]. Newly, the use of geogrids as reinforcing material are widen towards pavement system, especially reinforcing constituent in asphalt layers and stabilizing medium in unbound layers[2] and as interlayers in overlay applications[3]. Applying geogrids as interlayers to reduce reflective cracking in asphalt overlays of jointed plain concrete pavements (JPCP) has become widely used[4].The direct use of geogrids as reinforcing element along plain cement concrete in thin sections where installation of steel reinforcement is not possible due to durability and constructability limitations[5]. Such drawbacks consists difficulty of placing the reinforcing steel bars in thin segments, for instance concrete overlays, architectural works, domes and ultra thin white toppings, further concerns of steel corrosion and extensive time for construction. Therefore there is a need to find out alternate material to replace steel bars.

In considering rib direction and aperture shape there are three varieties of geogrid used for reinforcement: Uniaxial, Biaxial, (Fig. 1, 2). Uniaxial geogrids possess great tensile strength in their unidirectional ribs, where as biaxial geogrid ribs owns tensile strength in both the directions(x and y directions). 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 objective of this investigation is to find out the flexural behaviour of plain cement concrete beams when reinforced with uniaxial, biaxial geogrids and number of layers they have been used. Figuring out such behaviour helps in knowing the potential of using geogrids in structural members. The flexural behaviour is evaluated for normal strength (40) concrete beams subjected to two point bending loading. Experimental investigation consists of testing 8 plain cement concrete beams reinforced with uniaxial and biaxial geogrids in 2 and 3 layers each type under two point bending load and 2 normal concrete beams reinforced with 2 numbers of 10mm dia steel bar 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.

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 reinforcement. The full details of experimental investigation and equipment used in testing geogrid concrete beams are summarized below.

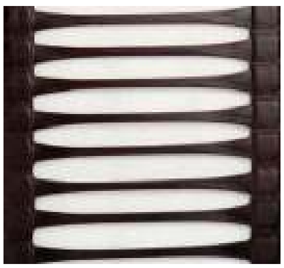


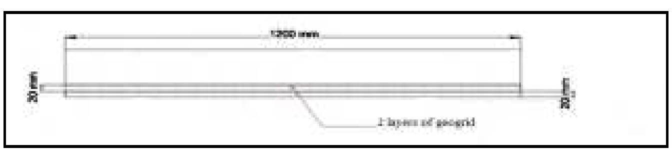
Figure. 1 Uniaxial Geogrid

Figure .2 Biaxial Geogrid

Experimental Program:

All the beams reinforced with different types of geogrid or steel bars had a cross section of 100mm wide and 150mm thick and a span of 1200mm. loading details and specimen dimensions are shown in Fig.3. PCC mixture used in this study is normal strength with a target strength of 40MPa.

Eight geogrid reinforced beams are fabricated: two beams reinforced with two layers of uniaxial geogrid, two beams reinforced with three layers of uniaxial geogrid, two beams reinforced with two layers of biaxial geogrid, two beams reinforced with three layers of biaxial geogrid. All the geogrids are placed in tension zone itself. Two control beams reinforced with two numbers of 10mm dia steel bars in tension zone and two numbers of 8mm dia steel bars in compression zone. 6 mm stirrups are used at 100mm spacing.



(a)

(b)

Figure 3. (a) Beam Reinforced with Two Layers of Geogrid, (b) Beam Reinforced with Three Layers of Geogrid.

Material Specifications:

The plain cement concrete mix was prepared using Portland cement, 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. The cement to fine aggregate to coarse aggregate by mass was 1:2.134:3.89 with a water cement ratio of 0.4. The concrete mixture is designed for obtaining target strength of 40MPa in 28 days. The properties of fine aggregates, coarse aggregate and super plasticizer are illustrated in table 1, table 2, and table 3.

Table1. Properties of Coarse Aggregate

Property	Coarse aggregate
Specific gravity	2.74
Fineness modulus	6.44
Bulk density(kg/m^3)	1500
Water absoption	0.8%

Table 2. Properties of Fine Aggregate

Property	Coarse aggregate
Specific gravity	2.65
Fineness modulus	2.4
Bulk density(kg/m^3)	1700
Water absoption	1%

Table 3. Properties of Super Plasticizer

Property	Super Plasticizer
Specific gravity	1.18
Solid dosage in %	40

Testing of Beams :

The beams were testing under two point bending loading. In this case there is constant maximum moment and zero shear force actiong 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 2 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 1000KN 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 is depth of beam.

Results and discussion

Flexural Strength of Geogrid and Control Beam:

All the beams of size 100mm x 150mm x 1200mm with different types of geogrid and different layers of geogrid have been tested under two point bending loading in flexure testing machine. Flexural strength of each beam is plotted in bar graph as shown in figure 4.

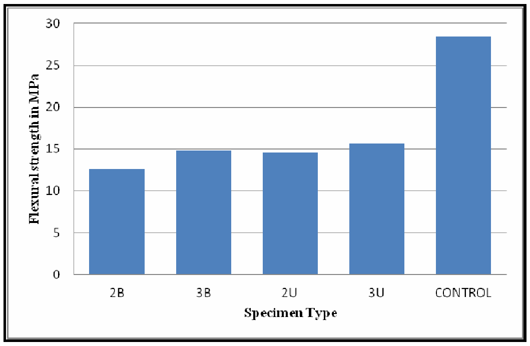


Figure 4. Flexural Strength Of Geogrid And Control Beams

Load vs Vertical Behaviour of Geogrid beams and Control beams:

Figure 5,6 shows load vs displacement curve for beams reinforced with different types of geogrids with two and three layers. A special type of load vs deflection behaviour is observed because of using geogrids as reinforcing material. The geogrids used for reinforcing will remain passive till it gets stressed. Next the first crack, 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. So, the beam reinforced with geogrid can take further load.

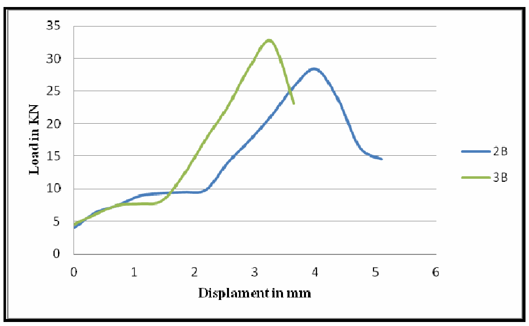


Figure 5. Load Vs Displacement Curve for Beams Reinforced with Biaxail Geogrids

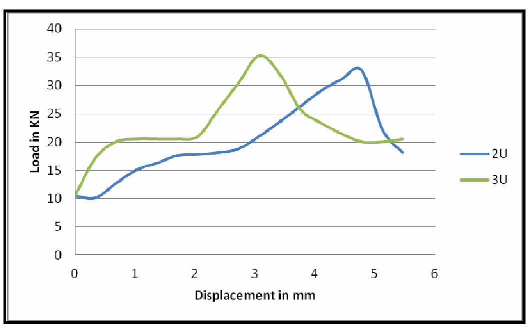


Figure 6. Load Vs Displacement Curve for Beams Reinforced with Uniaxial Geogrids

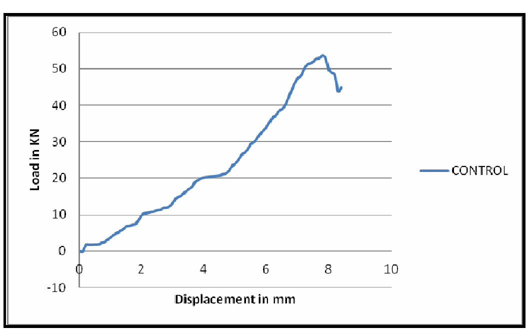
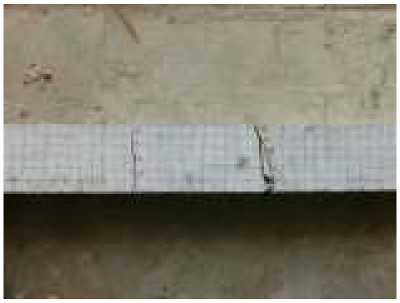


Figure 7. Load vs displacement curve for control beam

Crack Patterns:

The crack patterns for all the geogrid beams and control beams are shown in the figure 8. 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.



a)

(b)

(c)

(d)

(e)

Figure 7. Crack Patterns (a) 2B, (b) 3B, (c) 2U, (d) 3U, (e) Control

Conclusions:

An experimental investigation has been carried out to study the behaviour of plain cement concrete beams reinforced with two and three layers of uniaxial geogrid and biaxial geogrids. From flexure tests it has been found out that geogrids can take tensile forces when these are kept in plain cement concrete beams. The total experimental investigation can be summarized as follows.

1) Various reasons could have been caused for the failure of concrete first in geogrid concrete beams followed by failure of geogrids.
2) Both Uniaxial and biaxial geogrids provide post cracking and ductile behaviour like steel in beams.
3) The type of geogrids and number of layers used in geogrids play a major role in flexure behaviour of beams.
4) Uniaxial geogrids gives better postpeak flexural behaviour compared to biaxial geogrid.
5) Flexural strength is more when three layers of uniaxial geogrids are used in plain cement concrete beams.
6) only flexural cracks are formed for all the beams reinforced with geogrids.

Nomenclature:

2U: Beam reinforced with two layers of uniaxial geogrids.
3U: Beam reinforced with three layers of uniaxial geogrids.
2B: Beam reinforced with two layers of biaxial geogrids.
3B: Beam reinforced with three layers of biaxial geogrids.
Control: Beam reinforced with steel bars.

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