International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 7, Issue 4, April 2018, ISSN: 2278 -7798

STUDY OF GEO-GRID CONFINED 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.

IndexTerms: Geo-Grid,Rein forced concrete beams Materials &properties,

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 geo-synthetics manufactured from the polymers such as polyester, polypropylene, and polyethylene. Uni-axial geo-grids are fundamentally used in grade separation appliances for instance steep slope and retaining walls while biaxial geo-grids are used in roadways to take vibrations. Geo-synthetics is being used as a stabilization and reinforcement element in distinct infrastructure and heavy civil works.

Now a days, the use of geo-grids as reinforcing material are widen towards pavement system, especially reinforcing constituent in asphalt layers and stabilizing medium in unbound layers and as inter layers in overlay applications. Applying geo-grids as inter layers to reduce reflective cracking in asphalt overlays of jointed plain concrete pavements has become widely used. Geo-synthetics have long been used as reinforcement and stabilization elements in various heavy civil and infrastructure work particularly as it relates to geotechnical engineering. More recently, the use of geo-grids as reinforcement elements has expanded into pavement systems, particularly as stabilizing media in unbound layers, reinforcing elements in asphalt layers and as inter layers in overlay applications. Using geo-grids as inter layers to mitigate reflective cracking in asphalt overlays of jointed plain concrete pavements has become widely used.

1.1 FUNCTIONS OF GEO-GRID

The function of a geo-grid will perform as reinforcement. Depending on the application under consideration either a uni-axial (strength in one direction) or biaxial (strength in all directions) geo-grid will be required.

1.2 PURPOSE OF GEO-GRID

The correct use of a geo-grid can offer many benefits to a scheme such as increasing the speed of construction, and reducing the quantity of soil that needs to be exported from imported to a site. Common uses of geo-grids include increasing the amount of usable land on a site by enabling construction of steep slopes or walls, enabling construction of a road over poor ground conditions or decreasing the thickness of fill required to construct a road.

1.3 MANUFACTURING OF GEO-GRIDS

Currently there are three categories of geo-grids available, The first categories geo-grids are commonly referred to as 'punched and drawn' geo-grids. A sheet of either high density polyethylene (HDPE) or Polypropylene has holes punched into it in a regular pattern and the sheet is then 'drawn' or 'stretched' into the finished product. The drawing is done under controlled conditions of temperature and strain rates to avoid fracture whilst allowing ductile flow of the molecular chains. This operation aligns the molecular chains in the direction of drawing to convert low-strength polymer into high-strength grids.

The second category of geo-grids is 'coated yarn' types. They are in fact technical textiles in the form of grids and use bundles of fibres (most commonly Polyester) as the reinforcing component that are then coated to provide protection during installation and in service. The grid structure is formed by knitting or intertwining the transverse and longitudinal bundles of fibers.

The third category of geo-grids is made by laser or ultrasonically welding together polyester or polypropylene rods in a grid like pattern.The different methods of manufacture create products that look and feel quite different. It therefore follows that the different forms of geo-grid will work with the soil to perform the reinforcing function in differing ways.There have been numerous studies on the performance of geo-grids. These have concluded that whilst there are a number of mechanisms which enable a geo-grid to function, the principal and most effective mechanism is lateral restraint or confinement of the compacted fill that is interlocked within the grid.The best type of geo-grid for mobilizing this mechanism is punched and drawn.

1.4 SPECIFICATIONS OF GEO-GRIDS

Geo-grids will either be uni-axial or biaxial and can be specified either by a number performance properties (e.g. tensile strength, junction efficiency).

The key attributes to consider in selecting a geo-grid are the height and thickness of the rib, the aperture area, the tensile loads at 2%strain, the open area percentage, the quality of the raw material used, whether the product is full traceability, and whether it has been manufactured under a certified ISO 9001 system.

Types of geo-grids

1.Uni-axial

2.Bi-axial

3.Tri-axial

Fig1.1 Different types of geo-grids

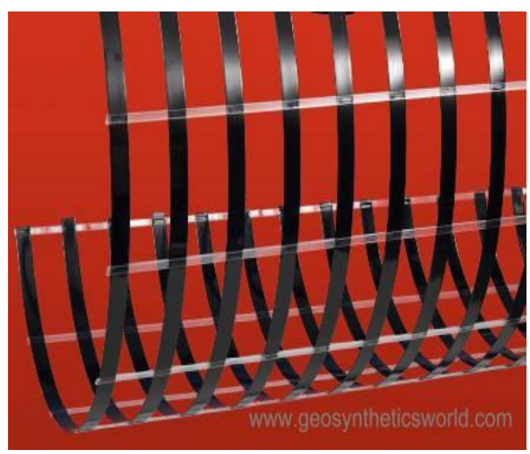

Fig1.2 Uni-axial geo-grid

Fig1.3 Bi-axial geo-grid

II. MATERIALS & PROPERTIES

Different type of materials used in this work are cement, steel fibers, super plasticizer, water. Physical and chemical properties of materials used in this investigation are mentioned below.

2.1.CEMENT:

In this work ULTRATECH cement of Ordinary Portland Cement (OPC) 53 grade was used for all concrete mixes .The various tests conducted once ment are initial and final setting time, specific gravity, fineness and compressive strength etc.

1.2. STEEL FIBERS:

Steel fibres are filaments of wire, deformed and cut to lengths, for reinforcement of concrete, mortar and other composite materials. It is a cold drawn wire fibre with corrugated and flatted shape. Short fibers used in concrete can be characterized in different ways. First according to the fiber material natural organic (such as cellulose, sisal, jute, bamboo, etc.) natural mineral (such as asbestos, rock-wool, etc.) man-made (such as steel, titanium, glass, carbon, polymers or synthetic, etc).Second, ac-cording to their physical/chemical properties density, surface roughness, chemical stability, non-reactivity with the cement matrix, fire resistance or flammability, etc. Third according to their mechanical properties such as tensile strength, elastic modulus, stiffness, ductility, elongation to failure, surface adhesion property, etc. Moreover, once a fiber has been selected, an infinite combination of geometric properties related to its cross sectional shape, length, diameter or equivalent diameter,

Properties	Test Results
Initial setting time	48 min
Final setting time	300 min
Fineness (%)	4.0
Compressive strength	56 N/mm^2
Soundness	1mm
Specific gravity	3.12
Consistency	32%

Table1.1: Physical Properties of Cement

and surface deformation can be selected. The cross section of the fiber can be circular, rectangular, diamond, square, triangular, flat, polygonal, or any substantially polygonal shape. To develop better bond between the fiber and the matrix the fiber can be modified along its length by roughening its surface or by inducing mechanical deformations. Thus fibers can be smooth, in-dented, deformed, crimped, coiled, twisted, with end hooks, paddles, buttons, or other anchorage. In some fibers the surface Is etched or plasma treated to improve bond at the microscopic level Some other types of closed-loop steel fibers such as ring, annulus, or clip type fibers have also been used and shown to significantly enhance the toughness of concrete in compression; however, work on these fibers did not advance beyond the research level.

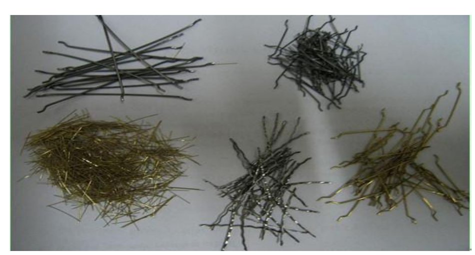

Fig 2.1: Different types of Steel Fibres

Steel fibre with hooked ends is made using high-quality low-carbon steel wire. A kind of high-performance steel fibre, with the characteristics of the high tensile strength, good toughness, low prices, etc. The product is widely used in concrete strengthening.

2.3. AGGREGATES:

Aggregates are the important ingredient materials in concrete. They impart bulk volume to the concrete and reduce the shrinkage effect. They occupy 70 to 80 percent of the total volume of concrete.

2.3.1 Fine Aggregate: Locally available sand collected from River Tungabhadra was used. The following tests are conducted on fine aggregate according to IS: 383-1987.

Tests on fine Aggregate:-

- Sieve Analysis of Fine Aggregate
- Specific Gravity of Fine Aggregate

S.No	Sample Description	Weightin gms
1	Weight of Dry and Empty pycnometer	W1 = 428
2	weight of pycnometer + Sand	W2 = 929
3	weight of pycnometer + Sand + Water	W3 = 1616
4	weight of pycnometer + water	W4 =1303
5	weight of Oven Dry Aggregate Sample	W5 = 500

Table: 3.1 Specific Gravity of Fine Aggregate

S. No	Properties	Results
1	Bulk density, kg/m^3	1618
2	Specific gravity	2.66
3	Fineness modulus	3.10

Specific Gravity of

$$\text{Fine Aggregate} = \frac{W_5}{((W_2 - W_1) - (W_3 - W_4))}$$

$$= \frac{500}{((929 - 428) - (1616 - 1303))}$$

=2.66

The Specific Gravity of Fine Aggregate is 2.66

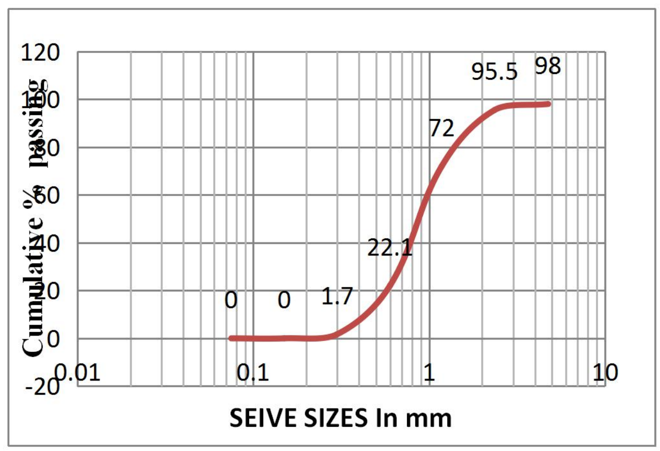

Fig 2.2: Grain size distribution curve for river sand.

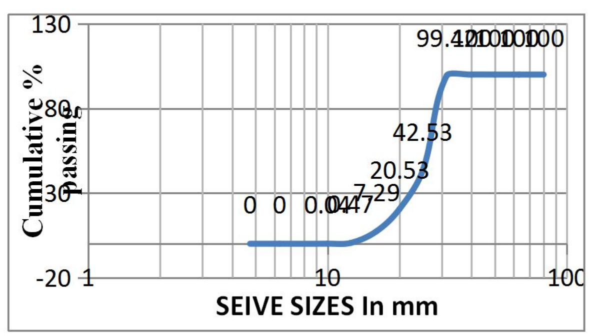

Fig 2.3: Grain size distribution curve for coarse Aggregate.

III. EXPERIMENTAL PROGRAMME

Experimental investigation has been carried out with a reference mix of M25 grade concrete which was designed as perIS10262-2009. Two concrete mixes were prepared. One is control mix with M25 and another withaddition of 1% steel fiber of M25 grade.

3.1 MIX PROPORTIONS:

In this investigation concrete mix design (M25) was designed based on IS10262-2009.This code presents a generally applicable method for selecting mixture proportion forM(25)strength concrete and optimizing this mixture proportion on basis of trial batches. The mix proportion is designed with 75mm slump.

Unit of Batch	Cement (kg/m^3)	FA(Kg)	CA(Kg)	Water(kg/m^3)
Cubic meter content	419.14	643.125	1151.8556	197
Ratio of ingredients	1	1.53	2.748	0.47

4.2 SPECIMEN SIZE:

Experimental programme consists of casting of cubes of size 150×150mm×150mm to determine compressive strength and Beams of size 120mmX180mmX1350mm to study the behaviour of

geo-grid confined beams. After curing the

surfaces of the beam specimens are dried and white washed to study the crack pattern of beam specimens.

3.3.PROPERTIES OF FRESH CONCRETE

The workability of fresh concrete is a composite property which includes the diverse requirements of stability, mobility, compactability, placeability and finish ability.

There are different methods for measuring the workability. Each of them measures only a particular aspect of it and there is really no unique test which measures workability of concrete in its totality. In the present work, workability of concrete mixes were determined using compaction factor.

3.3.1 COMPACTION FACTOR TEST

Compaction factor test is a measure of workability which is that property of concrete that determines the amount of work required to produce full compaction. The test consists essentially of applying a standard amount of work to standard quantity of concrete and measuring the resulting compaction

The various reinforcement details that are used in project work are shown below:

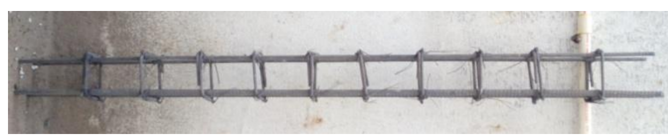

Fig 4.1 : Type A reinforcement cage used for representation purpose.

Fig 4.2 : Type B reinforcement cage used in the project work.

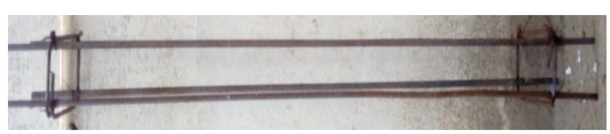

Fig 4.3 : Type C reinforcement cage used in the project work.

In the type A reinforcement cage the stirrups are provided as per the code IS 456-2000.

In the type B reinforcement cage the stirrups are provided at a distance double the distance provided in the type A.

In the type C reinforcement cage the stirrups are provided at the end to support the longitudinal reinforcement. This stirrups does not have any effect in controlling the shear as they are provided after clear span of the beam specimen.

Fig4.4: Confinement of geo-grid to reinforcement cage.

IV. RESULTS

Based on the behaviour of geo-grid confined beams, and steel fibre reinforced concrete beams reinforced with flexural reinforcement and the following results are listed.

4.1 LOAD-DISPLACEMENT BEHAVIOUR AND CRACK PATTERN:

The load vs displacement behaviour of the tested beam specimens are shown in below figures. The displacement and load carrying capacity has been increased in beam confined with geo-grid. The peak load is more in the geo-grid confined with steel fibre reinforced concrete beams. The peak load is high in geo-grid confined beams with steel fibre reinforced concrete beams in each category of beams A,B&C.

The crack pattern was studied to analyse the failure of beams the crack pattern in the geo-grid confined beams of Type A is flexural in the middle one third span only that is under the application of load.

The cracks at the time of failure of control beam and steel fibre reinforced concrete beam is combined shear and flexural failure , the failure load in steel fibre reinforced concrete is more than the control beam. The number of cracks in the steel fibre reinforced beam are less where as the cracks developed geo-grid confined beam is a single crack formed exactly under the application of load.

The crack pattern in the Type B beams are combined shear and flexural failure in control beam and steel fibre reinforced concrete beams where as the cracks in the geo-grid confined beams are flexural failure these shows that the confinement of geo-grid enhanced the shear carrying capacity of the beams. The cracks pattern in the Type C beams are completely shear failure the cracks developed are inclined from the point of application of load and propagated towards the support.

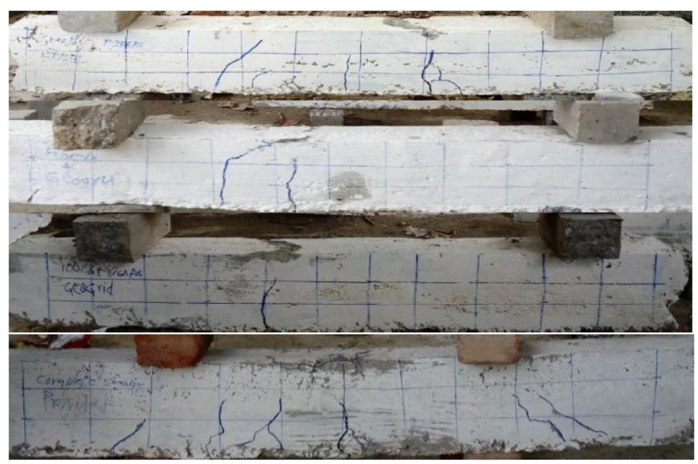

Fig 4.1 : Crack Pattern of Type A beam specimens

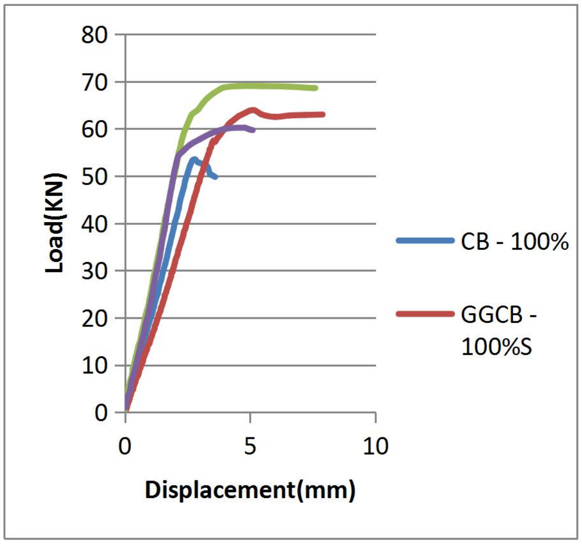

Fig4.2 : Load vs Displacement curves of type B beam specimens.

Fig 4.3 : Crack Pattern of Type B beam specimens.

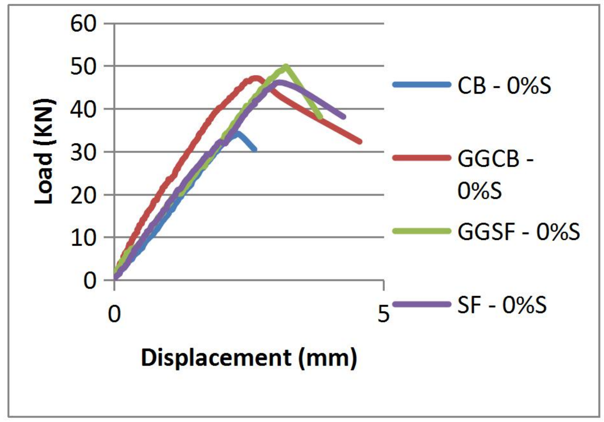

Fig 44: Load vs Displacement curves of type C beam specimens.

V.CONCLUSION

Based on the results obtained from the beam flexure tests presented in this paper, the benefits of geo-grid confinement as an alternative confining reinforcement the following conclusions are drawn.

- The effect of geo-grid confinement contributes to increase the strength of beams and to attain flexural failure with minimum shear reinforcement.
- The highest load is 69.5 for geo-grid confined with steel fiber reinforced concrete and the lowest load is for type C control beam 34.1.
- The combined shear and flexure of the control beam is changed to the flexural failure in the beam with 100% stirrups (type A) and with 50% stirrups (type B) with increased load carrying capacity in case of geo-grid confined beams.
- The shear failure of the beams specimens without shear reinforcement(type C) is not eliminated but the load at failure in geo-grid confined beams and geo-grid with steel fiber reinforced concrete has been increased.

- The increase in the strength geo-grid confined beam is 20% to that of conventional beam, the increase in the strength of geo-grid confined with steel fiber reinforced concrete is 29.9%, and that of steel fibers is 14% in beam with 100% stirrups (type A) beam specimens.

- The strength of geo-grid confined beam with type B reinforcement is slightly more that of the conventional control with type A shear reinforcement.
- The size of coarse aggregate should be less than the aperture size of geo-grid.

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