International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.12, December 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

A COMPLETE STUDY ON BEHAVIOUR OF CONCRETE COLUMNS BY USING BIAXIAL GEOGRID ENCASEMENT

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ABSTRACT

A new reinforced system is introduced to be used in concrete columns. This new reinforcement named Geogrid reinforced steel columns (GRSC), is a little satisfactory alternative to the rebar cage used in traditional reinforced concrete, for faster and easier construction.

Geogrids are an alternative tool in transportation and civil construction. They allow engineers to build where it otherwise would not be possible or would be cost prohibitive using traditional material. It is structured polymeric material usually made from polyethylene compounds.

To extend the use of geogrid in civil engineering as a structural component in concrete in axial load member, with the strength comparison to traditional rebar system and geogrid encased system was done. Test results have shown that the axial load carrying capacity of specimens reinforced with two different cases geogrid encased columns. The geogrid reinforced steel columns are given strength 5 percent less strength with compare to traditional rebar system by using geogrid (50 kN/m tensile strength). Axial load-displacement relations for the test column and stresses in member was observed in Finite element analysis (ANSYS12.0).

INTRODUCTION

Reinforced concrete (RC) has been used in construction of different structures for centuries. Reinforced concrete is defined as concrete which is a mixture of cement, sand, gravel, water, and some optional other admixtures, combined with a reinforcement system, which is usually steel. Concrete is strong in compression but weak in tension, therefore may result in cracking and failure under large tensile stresses. Steel has high tensile capacity and can be used in areas with high tensile stresses to compensate for the low tensile strength of concrete.

The combination of concrete, a relatively cheap material with high compressive strength, and steel, a material with high tensile strength, has made reinforced concrete a popular construction material for structural and non-structural members. Historically, steel in the form of rebar has been used as longitudinal and transverse reinforcement. Other forms of steel reinforcement systems, such as tubular and composite sections have been introduced in recent decades.

Reinforced concrete columns are used to transfer the load of the structure to its foundations. These are reinforced by means of main longitudinal bars to resist compression and/or bending and transverse steel (ties) to resist the bursting forces.

The column or strut is a vertical compression member, the effective length of which exceeds three times its lateral dimension. A column may be classified based on different criteria such as shape of cross section, slenderness ratio, type of loading, pattern of lateral reinforcement.

The function of longitudinal reinforcement is to prevent sudden brittle failure, to reduce the effect of creep and shrinkage due to sustained loading, to impart necessary ductility to the column and to hold the transverse reinforcement. The function of transverse reinforcement (ties) is to prevent buckling of individual bars, to resist diagonal tension due to transverse shear, to prevent longitudinal reinforcement in position and to delay sudden collapse and impart necessary ductility.

The failure of any other part (beam or slab) of a structure may not cause so serious damage as that caused by the failure of a column. It can endanger even the whole structure. As such the columns must be analysed in all aspects namely strength, stability and serviceability point of view. Hence columns are most important part of any kind of structures.

EXPERIMENTAL PROGRAM

The three types of specimens were constructed and tested up to failure monotonic axial load. The strength and displacement and effect of reinforcement with rebar and polypropylene geogrid strength of the column were investigated.

The results fromtraditional rebar, GRSC and GRC specimen with different amount of transverse and longitudinal steel were compared. The specimens were 700mm high and had 230mm X 230mm cross-sections with 40 mm clear cover the reinforcement .The specimen specification are provided in Table 3.1.

The characteristic concrete compressive strength for tested specimen M20 grade concrete was used.Table 3.2 illustrates the mixture properties as well as the concrete mechanical properties for the tested specimens.

The used polypropylene and highdensity polyethylene geogrid with opening size (25x25) mm with tensile strength 50kN/m.

Details of tested column specimen

Group	Column Designation	Column specimens dimension (mm)			Slenderness ratio h/D
		Length (mm)	Breadth (mm)	Height (mm)	
C1	Traditional rebar columns	230	230	700	3.04
C2	Geogrid reinforced steel columns	230	230	700	3.04
C3	Geogrid reinforced columns	230	230	700	3.04

Mixture properties of concrete M20 (1:1.63:3.32)

Grade	w/c	Cement(kg/m^3)	Fineaggregate (kg/m^3)	Coarse aggregate (kg/m^3)
M20	0.5	360	586.8	1195.2

The average measured compressive concrete cube strengthwas 18 MPa on the day of testing. The specimens and cubeswere taken out of the moulds one day after casting and cured insidewater tank for 7 days and then placed outside at room temperatureuntil the testing date. Geogrid reinforcement was made out of polypropylene or polyethylene. The openings on the steel tubeswere cut out by punching.

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ISSN: 2319-8354

The load Vs displacement relationshipsfor the reinforcements were obtained from the compressive test. The measured average yield and ultimate stresses for the geogrid was 50kN/m. The 415 Mpalongitudinal bars, and 250 MPa for the transverse barsused in the rebar reinforced specimens, respectively.

The experimental work was conducted utilizing the universal testing machine 1000kN. All specimens were tested up to failure under monotonic loads. The specimens were subjected to axial vertical load applied at the specimens to achieve a constant stress distribution at the concrete cross section. The load was applied vertically at the centre of the specimens. When the load was applied to the entire section, the contribution by the concrete core to the total axial force was constant along the height of the column. Further, the bond strength had no influence on the structural behaviour of the column. The columns were tested under compression load (fig 3.2).

Figure : 3.1

Casting of geogrid reinforced column with MS shuttering moulds

Figure : 3.2

Test setup

ANALYTICAL MODELING

The finite element model in ANSYS (SAS 2003) there are multiple tasksthat have to be completed for the model to run properly. Models can be created usingcommand prompt line input or the Graphical User Interface (GUI). For this model, theGUI was utilized to create the model. This section describes the different tasks andentries into used to create the FE calibration model.

Element Types

Table 4.1 -Element Type for Working Model

Material Type	ANSYS Element
Concrete	Solid 65
Steel reinforcement and geogrid	Link 8

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ISSN: 2319-8354

Real constants

The real constants for this model for this model are shown in Table 4.2 .Note that individual elements contain differential real constants. Real Constant Set 1 is used for the Solid65 element. It requires real constants for rebar assuming a smeared model. Values can be entered for Material Number, Volume Ratio, and Orientation Angles. The material number refers to the type of material for the reinforcement. The volume ratio refers to the ratio of steel to concrete in the element. The orientation angles refer to the orientation of the reinforcement in the smeared model. ANSYS (SAS 2003) allows the user to enter three rebar materials in theconcrete. Each material corresponds to x, y, and z directions in the element (Figure 1.5).

Table 4.2 Real Constants for Calibration Model

Real constant set	Element type		Constants		
			Real Constants for Rebar 1	Real Constants for Rebar 2	Real Constants for Rebar 3
1	Solid 65	Material Number	0	0	0
		Volume Ratio	0	0	0
		Orientation Angle	0	0	0
		Orientation Angle	0	0	0
2	Link8	Cross-sectional Area(mm^2)	50.24		
		Initial Strain (in. /in.)	0		
3	Link8	Cross-sectional Area(mm^2)	28.26		
		Initial Strain (in. /in.)	0		
4	Link8	Cross-sectional Area(mm^2)	10.66		
		Initial Strain (in. /in.)	0		

Material Properties

Parameters needed to define the material models can be found in Table 4.3., there are multiple parts of the material model for each element.

International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.12, December 2018
www.ijarse.com
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Table 4.3 - Material Models for the Calibration Model

Material ModelNumber	Element type	Material Properties	
1	Solid 65	Linear Isotropic	
		EX	22360
		PRXY	0.2
2	Link 8	EX	200000
		PRXY	0.3
3	Link 8	EX	2500
		PRXY	0.18

Meshing

To obtain good results from the Solid65 element, the use of a rectangular mesh isrecommended. Therefore, the mesh was set up such that square or rectangular elements were created (Figure 4.5). The volume sweep command was used to mesh the steel rebar, geogrid and support. This properly sets the width and length of elements in the specimen to beconsistent with the elements and nodes in the concrete portions of the model.
The overall mesh of the concrete, steel, geogrid and support volumes see fig (4.1&4.2) is shown in Figure. The necessary element divisions are noted. The meshing of the reinforcement is aspecial case compared to the volumes. No mesh of the reinforcement is needed becauseIndividual elements were created in the modeling through the nodes created by the meshof the concrete volume. However, the necessary mesh attributes as described above needto be set before each section of the reinforcement is created.

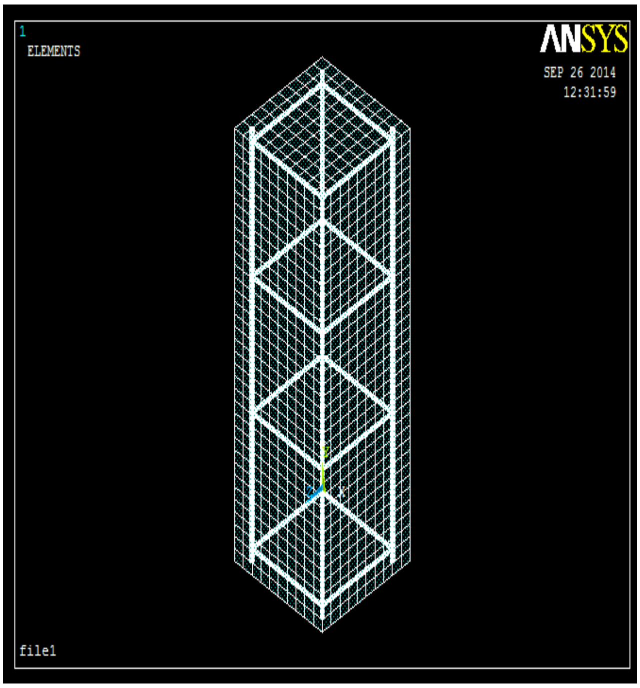

Figure 4.1 -Meshing of the concrete and rebar material

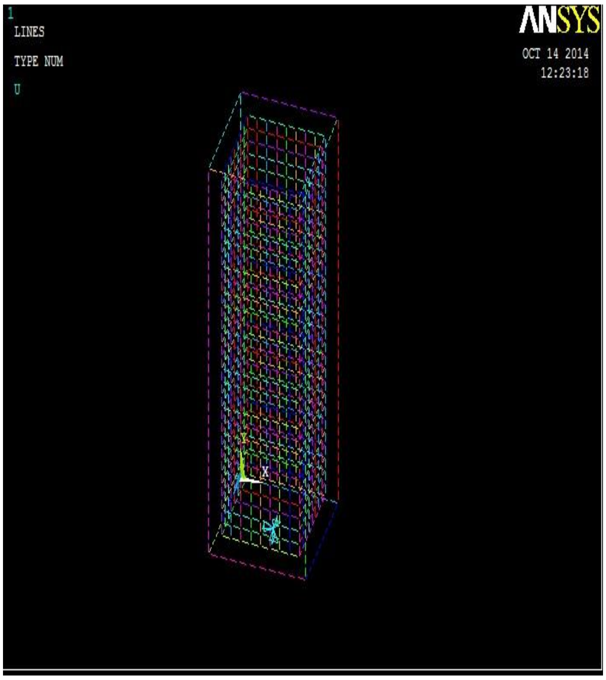

Fig 4.2-Meshing of concrete and geogrid

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Volume No.07, Issue No.12, December 2018
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IJARSE
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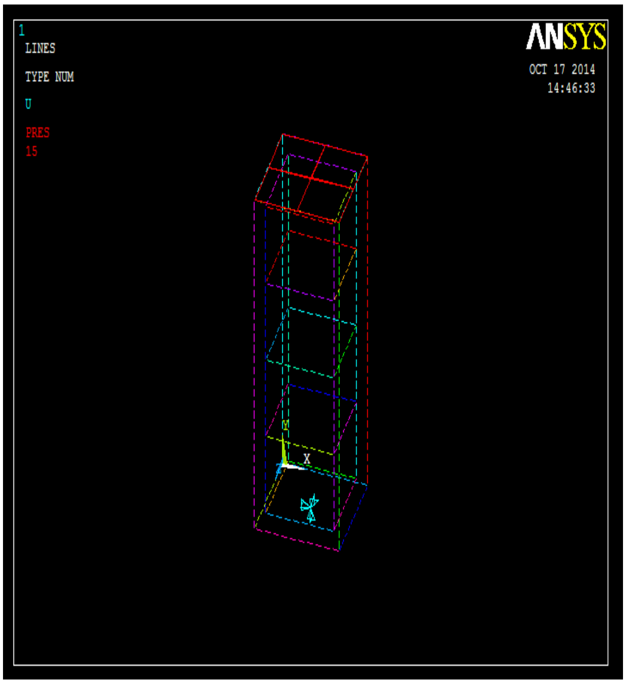
Numbering Control

The command merge items merges separate entities that have the same location. Theseitems will then be merged into single entities. Caution must be taken when mergingentities in a model that has already been meshed because the order in which mergingoccurs is significant. Merging key points before nodes can result in some of the nodesbecoming “orphaned”; that is, the nodes lose their association with the solid model. Theorphaned nodes can cause certain operations (such as boundary condition transfers,surface load transfers, and so on) to fail. Care must be taken to always merge in the orderthat the entities appear. All precautions were taken to ensure that everything was mergedin the proper order. Also, the lowest number was retained during merging.

Loads and Boundary Conditions

Displacement boundary conditions are needed to constrain the model to get a uniquesolution. To ensure that the model acts the same way as the experimental column,boundary conditions need to be applied one end is fixed and the other end was loadings exist axially.The symmetry boundary conditions were set first. The boundary conditions for planes of symmetry are shown in (Figure 4.3 and 4.4).



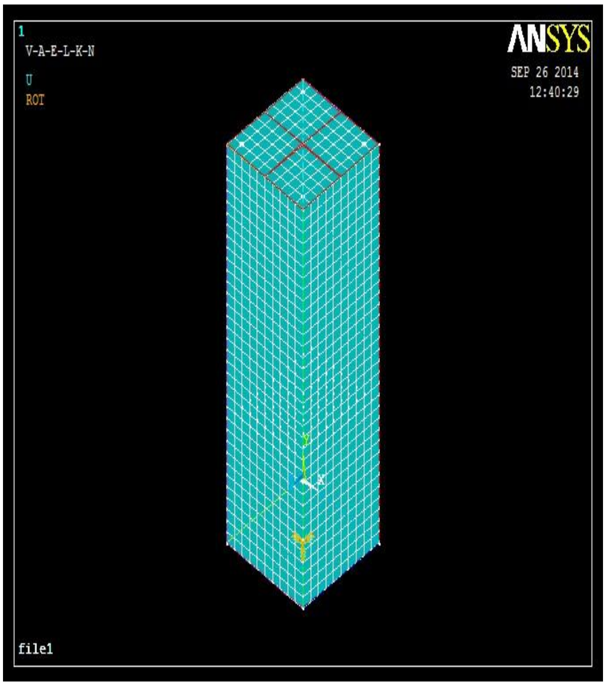


Figure 4.3 -Boundary conditions for plane of symmetry **Figure 4.4**-Boundary condition and pressure direction

Analysis Type

The finite element model for this analysis is a simple beam under transverse loading. Forthe purposes of this model, the Static analysis type is utilized.The Restart command is utilized to restart an analysis after the initial run or loadstep has been completed. The use of the restart option will be detailed in the analysisportion of the discussion.

The Sol‟ n Controls command dictates the use of a linear or non-linear solution forthe finite element model. Typical commands utilized in a nonlinear static analysis areshown in (Table 4.5).

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ISSN: 2319-8354

Table 4.5 -Commands Used to Control Nonlinear Analysis

Time at the end of load step automatic time stepping number of sub steps	15
	On
	1
Max no.of sub steps Min no.of sub steps Write items to result file	2
	1
	All solution items
Frequency	Write every sub step

RESULTS AND DISCUSSION

The all three types specimens Traditional rebar column (C1),Geogrid reinforced steel column (C2) and Geogrid reinforced column (C3) was very different in strength see table(5.1). A representative axial load-displacement is measured, Typically the specimens behaved elastically without cracking until the peak strength was almost reached .Suddenly the axial strength dropped about 1/2 of the peak strength.

Measured load-displacement values

Group	Column Designation	Column specimens dimension (mm)			First cracking (kN)	Peak strength (kN)	Displacement (mm)
		Length (mm)	Breadth (mm)	Height (mm)			
C1	Traditional rebar columns	230	230	700	560	785.8	8.9
C2	Geogrid reinforced steel columns	230	230	700	520	746.3	7.84
C3	Geogrid reinforced columns	230	230	700	515	559.05	7.47

International Journal of Advance Research in Science and Engineering
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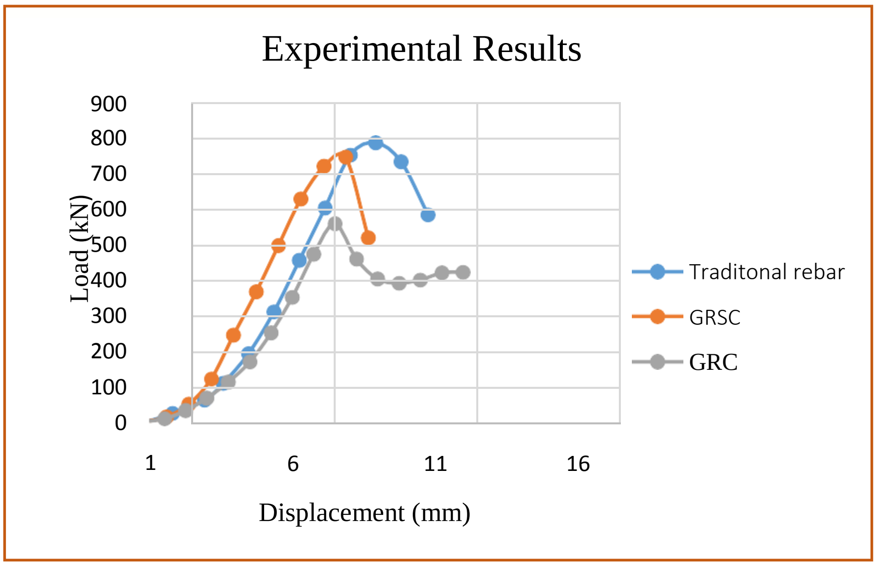
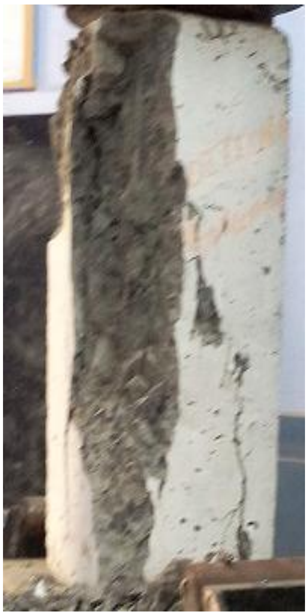
www.ijarse.com
IJARSE
ISSN: 2319-8354



Load –Displacement curves



C1 **C2** **C3**

Fig 5.1.1 C1-Traditional rebar columns

C2-Geogrid reinforced steel columns

C3-Geogrid reinforced columns

The specimens behaved elastically without cracking until the peak strength was almost reached. The cracking usually started suddenly near the corners either the top or bottom of specimens.

CONCLUSION

From the experimental and practical investigations carried out in the study, the following major findings can be arrived at

1. A new geogrid reinforcement termed GRSC is proposed for longitudinal reinforced members GRSC is an anticipated to be an alternative to the existing reinforcement systems andlower construction cost as it eliminates the labour cost associated with cutting, bending and tying reinforcing ties.
2. The columns with rebar gives the better confinement than the geogrid, this may be due to low tensile and compressive strength of geogrid.
3. The test results shows that the load carrying capacity of columns with geogrid and longitudinal steel reinforcement is 5% less than the load carrying capacity with traditional rebar reinforcement, so the GRSC shows a little reduction of its strength.
4. The strength reduction of two models GRSC and GRC compared withtraditional rebarspecimens give 5% and 29% respectively.
5. From FEM analysis it is observed that the failure stresses at the interface in traditional system with GRSC and GRC systems was compared, and found that the stresses in traditional reinforcement is more.
6. A result of analytical work, the stresses developed steel in traditional rebar column - 86.47N/mm^2(compression),Geogrideinforced steel columns- 81.53N/mm^2(compression) and geogrid reinforced columns-2.37N/mm^2(tension) respectively. From the above result can conclude that compression stress in GRCS is more compared to GRS.
7. This research shows that in second case with increasing the tensile strength of geogrid grade, the confinement of the concrete compressive strength of the column specimen will increase.

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