Experimental investigation on compressive behavior of light weight aggregate concrete under uniaxial load

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ABSTRACT

Fifteen wall section specimens of dimension 400 × 300 × 100 mm were casted using rectilinear steel hoops with light weight aggregate concrete. There are three sets of specimens namely type A, type B and type C. Each type consists of five specimens, the specimens were compressed under uniaxial load. The comparison of confinement effects and compressive strength between type A, type B and type C specimens were deeply studied in this paper. The main reinforcement of 12mm diameter is common to all three types of specimen. The varying hoops diameter for type A, type B and type C were 6mm, 8mm, 10mm respectively. The variation of the hoop volumetric ratio (Psv) of type-A and type-B and type C were 0.25%, 0.12%, 0.08%, 0.05%, 0.02% and 0.45%, 0.29%, 0.01%, 0.09%, 0.04% and 1.00%, 0.35%, 0.23%, 0.14%, 0.071% respectively. The concrete and steel grades used were M-20 and Fe-415 respectively. The properties of fresh light weight concrete were confirmed by slump test, flow test and compaction test. The numerical simulation of confined light weight concrete with wall section was carried out using ANSYS® finite element software. From both the numerical and experimental results, it has been observed that as the volumetric ratio and diameter of hoops increases, the strength and ductility of wall section increases noticeably and also the ultimate load bearing capacity of column increases.

KEYWORDS: Light-weight aggregate Concrete, Confinement, Ductility, Volumetric Ratio, Wall Section.

1. INTRODUCTION

Light weight aggregate concrete is an old construction material. The property of lower density is making difference between light weight aggregate concrete and normal concrete. Pumice stone is natural light weight aggregate, which are formed due to sudden cooling of volcanic matters. Pumice available as rock form, in order to use pumice as light weight aggregate size should be made artificial work. Some of the part of structures such as patrician walls does not need more load carrying capacity. In such cases light weight aggregate concrete plays important role.

Due to lower dead load light weight aggregate concrete can be used instead of normal concrete. Lower density light weight aggregate concrete having low compressive strength comparing to normal concrete. In order to increase the strength and ductile property of light weight aggregate concrete confinement is introduced in this concrete. This paper deals with rectilinear hoops of confinement. Rectilinear hoops are having effective confinement next to circular shape of confinement. For wall section using of rectilinear hoops confinement is more effective. During the earthquake, light weight concrete structures helps to reduce the degree of damage level. So light weight aggregate concrete structures are very much suitable for seismic region.

Research Significance: Till now, all researches and experiments for evaluating the effect of confining light weight concrete, ignore the effect of pumice light weight aggregate concrete with rectilinear hoops of wall section. In other words, study of pumice light weight aggregate concrete with confinement has never done.

In this research the confinement that produced by rectilinear hoops with pumice light weight aggregate concrete. And also effect of confinement checked by varying the volumetric ratio of hoops and varying diameter of hoops in wall sections.

2. EXPERIMENTAL WORK

Construction of Specimen: Fifteen reinforcement cages with different configuration were constructed. All the fifteen cages consisted of 10 no. of 12mm longitudinal bars and 8 no. of hoops with varying diameter in type A, type B & type C for 6mm, 8mm, 10mm respectively. Hoop spacing's for all the three sets of specimens are 40mm, 50mm, 60mm, 75mm, and 100mm. Confinement pattern or shape of the hoop is rectilinear. For all specimens maximum cover is 30mm for top and bottom of the specimen.

3. RESULTS & DISCUSSIONS

Effect of Volumetric Ratio on Axial Capacity: Volumetric ratio of hoops is the ratio of volume of hoops to the volume of confined core of the concrete. The formula used to calculate volumetric ratio of specimen is arrived from (Rasvi & Saaticioglu, 1999)

Volumetric ratio, $P_{sv} = \frac{Ast \times 2(p+l)}{p \times l \times s} \times 100$

Where, P_{sv} = Volumetric ratio of hoops; A_{st} = Area of hoops; s = Center to center hoop spacing (mm); p = Length of confined core; l = Width of confined core.

When load is applied continuously to the specimen firstly small shear cracks are forming in the edge i.e. cover of the specimen. After increasing the load the cracks slowly get developed to the core area. But confinement is resisting the crack so failure is delayed by the confinement of the core section. This proved that while increasing the volumetric ratio and increasing the diameter of hoops of the specimen it will have more load carrying capacity.

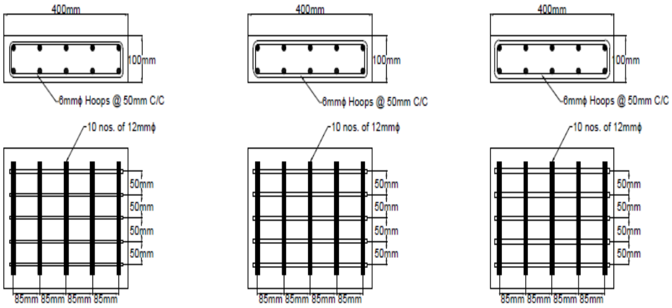

Figure.1.Typical view of reinforcement details for A4 & B4 & C4 specimens

Effect of Volumetric Ratio on Ductility: Rasvi and saatcioglu (1989) suggested the ductility of column subjected to axial load can be based on strain ductility which is the ratio between the strain at the 85% peak stress and strain at the peak stress. The same method also used by sundarsana et.al. (2004) and Tavio et.al (2008) and KetutSudarsana et.al (2013).

The table 1 shows that strain ductility is directly proportional to volumetric ratio and compressive strength of the specimen. When volumetric ratio and compressive strength of the specimen get increased eventually strain ductility also get increased.

Table.1.Volumetric Ratio and Strain Ductility of specimens

Specimen	Volumetric Ratio	Max Stress (mpa)	85% of Max Stress (mpa)	Max Strain (mm /mm)	Strain @ 85% Stress (mm/mm)	Axial Compressive Load Capacity	Strain Ductility
A1	0.02	11.77	10.004	0.004	0.005	463	1.25
A2	0.05	12.47	10.599	0.013	0.016	487	1.23
A3	0.08	15.67	13.319	0.010	0.014	624	1.40
A4	0.12	19.27	16.379	0.006	0.009	762	1.50
A5	0.25	21.70	18.445	0.012	0.021	857	1.75
B1	0.04	12.22	10.387	0.014	0.018	489	1.28
B2	0.09	13.10	11.135	0.019	0.025	524	1.31
B3	0.18	16.12	13.702	0.010	0.014	645	1.40
B4	0.29	19.67	16.719	0.006	0.010	787	1.67
B5	0.45	22.10	18.785	0.004	0.008	884	2.00
C1	0.07	12.67	10.769	0.018	0.023	507	1.28
C2	0.14	13.62	11.577	0.012	0.016	545	1.33
C3	0.23	16.57	14.084	0.008	0.018	663	2.25
C4	0.35	20.21	17.178	0.004	0.006	771	1.50
C5	1.00	22.62	19.269	0.002	0.006	868	3.00

Stress Strain Response: Comparing to all five specimens in type A specimens, A5 specimen shows good result due to its high volumetric ratio and increasing the diameter of hoops. This contrary is same for type B and type C specimens. The stress strain curve shows that type c specimen having more compressive strength due to more volumetric ratio comparing to all other specimens and increasing diameter of hoops.

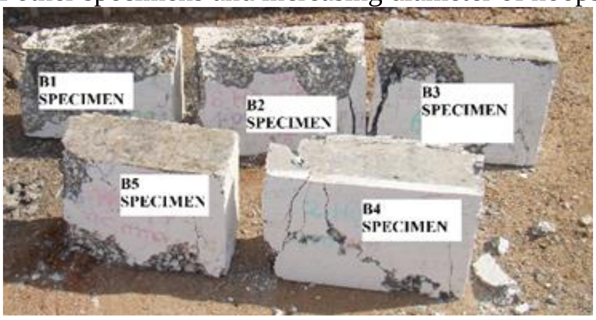

Figure.2.Failure patterns of type B specimen

Numerical modelling:

Modelling of light weight concrete column: This paper presents a confined view of numerical simulation of compressive behavior of light weight aggregate concrete using ANSYS® finite element software. The numerical simulation gives an effective result which can be compared with experimentally observed values. SOLID_CONCRETE 65 and BEAM 188 are the two main elements applicable for this numerical simulation.

The reinforcement and the hoops in the numerical simulation were modelled using BEAM 188 element and the lightweight concrete were modelled using SOLID_CONC_65 element. Beam element supports the bending load and buckling load and the concrete element is to simulate the crack initiation and propagation. The mesh type is quad mesh with mapped condition. The element edge length should be defined in order to create mesh of particular sized element. The bottom area where the specimen surface will be mounted is at rest. As a result, all degree of freedom should be arrested which is the necessary boundary condition to be applied. The load is classified as a pressure load over the surface area and it is applied on the top surface.

Compressive Behavior: The numerical simulation shows a good compression behavior characteristics which are shown in fig 3.The numerical simulation present in this paper mainly focuses on the three different configuration of hoops embedded in the light weight concrete. The various configuration modelled in this finite element model were 6mm, 8mm, 10mm diameter of hoops. In all the three configuration the number of hoops is 8 and the diameter of main reinforcement is 12 mm.

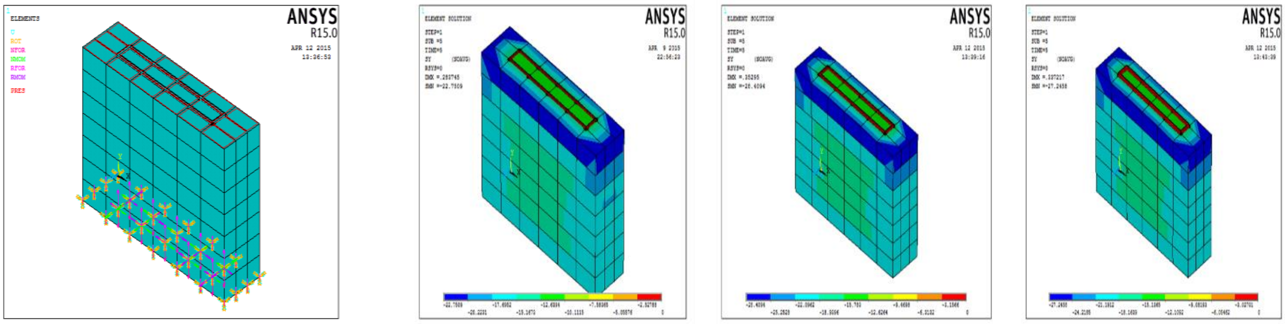

Figure.3.Numerical model & Prediction of Compressive stress for 3 different specimen

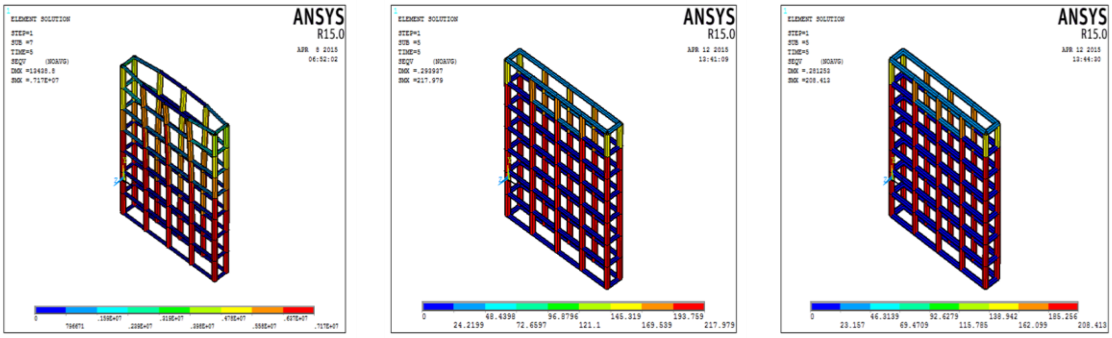

Figure.4.Stress behavior in the reinforcement of specimens

The simulation of the compressive behavior of the reinforcement and hoops which is embedded in the light weight concrete is shown in the fig. As steel is the main reinforcement and also materials for hoops. In this numerical simulation Von-misses stress is applied to study the compressive behavior of the reinforcement and hoops. The compressive behavior of hoops due to change in dimension of the hoops were numerically predicted by the stress developed during the load applied.

Consolidation of Results: The fig.5 shows the stress strain curve generated by both the experimental and by numerically simulated values. The generated value shows the peak vale for specimen A5- 22.75, for B5-27.4548 and C5- 28.4094. The experimental value obtained are for A5-21.70, B5-22.10 and for C5-22.62. The experimentally observed shows a good correlation with that of numerically simulated value. The compressive behavior of the light weight concrete was studied by both experimental and by numerical simulation. There is a deviation between numerically simulated value and the experimentally observed value due to fabrication process and presence of voids in the fabricated specimen.

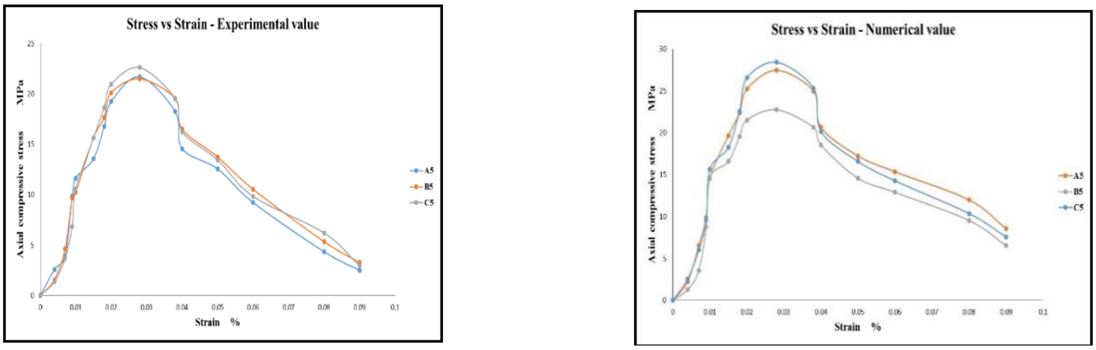

Figure.5.Experimental & Numerical value on stress strain relationship of specimen A5&B5&C5

4. CONCLUSION

The result showed that the volumetric ratio of light weight concrete is directly proportional to strength of light weight concrete. Therefore increasing the volumetric ratio and diameter of hoops also increases the strength and ductility of the concrete. Confining of the lowest concrete strength with rectilinear hoops lead to significant enhancement in strength and ductility. In addition, it is clearly concluded that the pumice light weight concrete is very much suitable for earthquake region due to its lower dead load.

ANSYS software is capable of predicting the actual stress- strain relationships of light weight concrete column specimens subjected to compressive loading. The accuracy of the proposed procedure has been well confirmed by the close value of maximum compressive load, compressive stress and compressive strain obtained from the FEM analysis which is raging from 1% to 10% compared with the experimental results. From the observed results, the following concluding remarks have been obtained. The specimen C5 exhibit more stress than other two specimens. The compressive behavior for the specimen C5 was found to have better properties to withstand more stress. Both in numerical and experimental results the value of peak stress was fount out to be 28.4094MPa in numerical simulation and was 22.62MPa in experimentally observed value.

5. ACKNOWLEDGEMENT

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