Flexural Behavior of Pumice Light Weight Aggregate RCC Slabs

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Abstract - Use of light weight concrete in construction sector, has increased due to its improved mechanical properties compared to ordinary concrete. The suitability of Light Weight aggregate Concrete as a structural material can be accepted only when its behavior along with less dead and less weight proves to be satisfactory. Therefore the present work is taken up to study the Flexural behavior of Lightweight aggregate RCC slabs.For the present work, M50 grade of concrete was adopted. 5% by volume of cement was replaced by Alccofine and light weight aggregate of 0%, 25% and 50% were added in various volume fractions of concrete. The test program was designed for a comparative study of concrete with and without pumice aggregates. Water cementations material ratio was kept a constant value of 0.55. The comparative study of the varying percentage of light weight aggregates on workability, compression strength, flexural strength and split tensile strength are made. To study the flexural behavior, six concrete slabs were considered from three mixes containing alccofine (5%) and differing proportions of light weight aggregates (0%, 25% and 50%) with normal coarse aggregates. The slabs of dimension, 1000mmX1000mmX55mm were designed using limit state concept. The experiment was conducted on loading frame of 25T capacity. They were tested as simply supported slabs subjected to uniformly distributed load. Test results are presented in terms of Load deflection behaviour and crack patterns. The results achieved from experiments are studied and compared with theoretical values obtained from ACI 318, IS 456:2000 and BS: 8110.

Keywords - Pumice, Light Weight, RCC.

I. INTRODUCTION

The construction industry has been one of the top most sectors growing day by day with time. The demand for building materials has been continuously rising. The high and increasing cost of these materials has greatly hindered the development of shelter and other infrastructural facilities in developing countries. There arises the need for the use of alternative, cheaper and locally available materials to meet desired need, enhance self-efficiency, and lead to an overall reduction in construction cost for sustainable development. Any industrial by-product should be carefully studied before using it as raw material in the manufacture of processed building material. Concrete can act as an effective repository for large quantities of waste

Materials, if their combination with Ordinary Portland cement (OPC) based products has no adverse effect.

Pumice is a common rock of volcanic origin, which occurs in many parts of the world, strong enough to be used as lightweight aggregate. There are ecological advantages to use this in construction. The low density is due to their cells with cavities being formed by gases expanding with release of pressure. Pumice is the oldest known natural lightweight aggregate dating back to 100 BC. It was first introduced by the Romans in the second century where ‘The Pantheon’ has been constructed using pumice. It is still standing eminently in Rome even after 18 centuries [2]. Light

weight concrete (LWC) is lighter than the conventional concrete with a dry density of 300 kg/m^3 up to 1950kg/m^3. The advantages of LWC are reduction of dead load, faster building rates in construction and lower haulage and handling costs. The reason for choosing lightweight concrete as a construction material is becoming increasingly important as more attention is being paid to energy conservation and to the use of waste materials to replace exhaustible natural sources The light weight will make LWC preferable for structures in seismic zones, because of the reduced dynamic actions, and for pre-cast structures, as it makes it easier to move the elements to be connected. LWC can be used in structural frames, but it is more suitable for wall system structures.

II. OBJECTIVES

The objectives of the present study are as follows

1) To compare the compressive strength of conventional aggregate concrete and light weight aggregate concrete.
2) To generate a mix design for high strength concrete (M-50) by using the properties of light weight aggregates.
3) To study the behaviour of light weight concrete based on the crushing strength, impact strength and water absorption of light weight coarse aggregate (pumice aggregate).
4) Comparison of experimental results obtained from light weight aggregate concrete and normal aggregate concrete based on impact value, crushing value and dry density of cube.
5) Comparison of experimental results obtained from light weight aggregate concrete slab and normal aggregate concrete slab based on load v/s deflection.

Lightweight aggregate concrete are widely incorporated in construction and development. This study, presents an experimental investigation on the properties of volcanic pumice lightweight aggregate concrete. This experiment has been done in order to achieve a high strength light weight concrete having dry density near to 2000kg/m^3. In order achieve this we have replaced more than 50% of pumice aggregate by coarse aggregates.

III. TESTS CONDUCTED

Though basic studies are concerned with determination of flexural behavior, the study would be incomplete if compressive strength variations are not considered. The compressive strength tests are conducted for a curing ages of 7 to 28 days.

Tests conducted are classified as follows:

a) Compression test on cubes to determine the compressive strength

b) Flexural tests on reinforced light weight aggregate Concrete and reinforced normal aggregate concrete slabs after 28 days of curing.

Summary of reinforcement details

M 50 grades

1. 50% REPLACEMENT LWA S1

Simply supported 9#8mm diameter @85mm spacing on x-direction & 9#8 mm dia@85 mm spacing on y-direction.

2. 50%REPLACEMENT LWA S2

Simplysupported 9#8mm diameter @85 mmspacing on x-direction &9#8 mm dia@85 mmspacing on y-direction.

3.75% REPLACEMENT LWA S3

Simplysupported9#8mm diameter @85 mmspacing on x-direction & 9#8 mm dia@85 mmspacing on y-direction.

4. 75% REPLACEMENT LWA S4

Simplysupported 9#8mm diameter @85 mmspacing on x-direction &9#8 mm dia@85 mmspacing on y-direction.

5.100% NCA S5

Simplysupported9#8mm diameter @85 mmspacing on x-direction & 9#8mm dia@85 mmspacingon y-direction.

6. 100% NCA S6

Simplysupported9#8mm diameter @85 mmspacing on x-direction &9#8 mm dia@85 mmspacingon y-direction.

The constituent materials used in the present investigation were

- Cement
- Fine Aggregate
- Coarse Aggregate
- Water
- Steel Reinforcement bars
- Super plasticizers
- Alccofine
- Pumice Aggregate

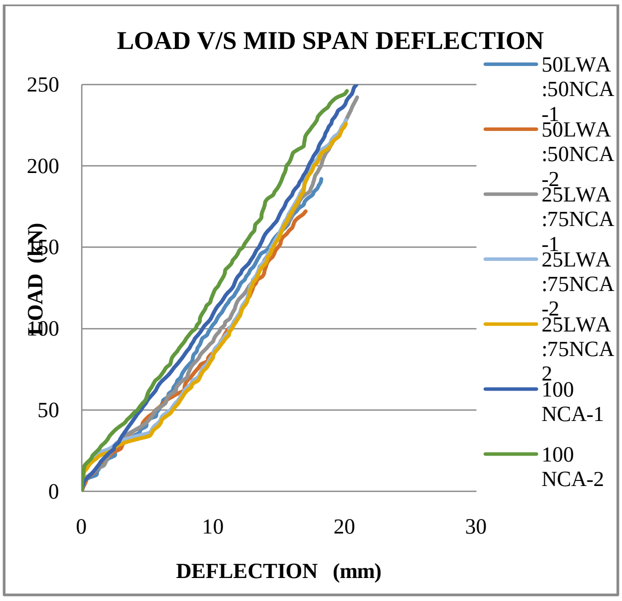
Mix proportion of M50 Normal Concrete

100% COARSE AGGEGATES			
CEMENT	3.15	447	0.141905
ALCCOFINE	2.8	39	0.013929
SAND	2.6	622	0.239231
WATER	1	136	0.136
PUMICE	0	0	
COARSE AGGREGATE S	2.7	1255	0.464815
ADMIXTURE	1	5.83	0.00583
WATER CEMENT RATIO		0.279835	
DENSITY OF MIX		2504.83	1.001709

The experimental results of the studies that were described in the previous chapter are presented in the following sections.

Slump of different percentage replacement of LWCA

Sl No	Designation of specimen	Slump in (mm)
1	0%LWCA	120
2	25%LWCA+75%NCA	105
3	50%LWCA+50%NCA	100



Load V/s mid span deflection curve of all the specimen slabs

These results include data on the Lightweight aggregates reinforced concrete mix proportion, compressive strength, split tensile strength, flexural behavior and the crack patterns of the slab. A comparison is made between light weight aggregates reinforced concrete and normal aggregates mix concrete. Workability, compressive strength and split tensile strength results are presented for concrete mixtures containing various percentages of pumice aggregates. Results on the flexural behavior of light weight aggregates reinforced concrete slab are presented and compared to the theoretical values. Also the photographic views of crack patterns of slabs are presented.

Measurement of Workability

Comparative study on compressive strength of concrete for different replacement level of LWCA to NCA by volume.

Sl. No	Concrete mix	Dry density kg/m^3	Compressive strength on 7 days N/mm^2	Avg. 7 days compressive strength in N/mm^2	Compressive strength on 28 days N/mm^2	Avg. 28days compressive strength in N/mm^2
1	100%NCA	2426.67	43.21	43.4	62.11	61.83
			43.49		61.17	
			43.50		62.22	
2	75%NCA+ 25%LWCA	2227.16	43.55	43.25	62.22	59.89
			42.66		57.34	
			43.55		60.11	
3	50%NCA+ 50%LWCA	1997.03	33.77	33.47	46.22	45.46
			33.78		44.5	
			32.88		45.65	
4	25%NCA+ 75%LWCA	1802.59	25.77	24.18	26.22	28.70
			22.66		32.00	
			24.88		27.88	
5	100%LWCA	1615.80	19.55	17.62	23.11	22.53
			16.44		22.20	
			16.88		22.44	

Crack width and Crack pattern:

Crack width is an important factor from the durability point of view. On the other hand, cracks have a major influence on structural performance including bending stiffness, energy absorption capacity, and ductility and corrosion resistance of reinforcement. For a member exposed to aggressive environment IS: 456-2000 specifies the width of surface cracks as explained earlier.

Crack pattern can appear during testing of slab can be seen by using microscope

Bottom of slab

Tension crack pattern of Slab containing concrete mix of 100% replacement of light weight aggregates the propagation of cracks was observed and marked during each increment of load up to failure. The cracks were well distributed and symmetrical about the centre. The crack patterns of all the slabs were similar. No bond cracks are observed in any of the slab. After each increment of load a clear observation was made to understand the crack propagation.

The cracks started from the centre of tension face and gradually moved to the edges of the slab as the load increased for both with and without light weight aggregates. The crack pattern observed clearly showed that, as the load increased, additional cracks were formed and already developed cracks propagated in the form of branches and widened. It was observed in normal aggregates mix concrete slabs that 3-4 cracks appeared simultaneously at the first crack load. As the load increased, a number of cracks formed and reached the edges of the slab.

Tension crack pattern of Slab containing concrete mix of 50% replacement of light weight aggregates.

Bottom of slab

Tension crack pattern of Slabs containing concrete mix of 75% replacement of light weight Aggregates

Bottom of slab

In light weight aggregates reinforced concrete slabs, it was observed that only one crack appeared at the first crack load and more number of cracks appear as the slab reached the ultimate load.

Maximum crack widths were less in normal aggregates mix concrete slabs than Light weight aggregates reinforced concrete slabs. The depth of cracks was found to be less in case of normal aggregates mix concrete slabs as compared to light weight reinforced concrete slabs. All the slabs exhibited ductile failure with no crushing.

IV. MODE OF FAILURE

As expected, all the slabs of different mixes failed in flexure zone only as it can be seen from crack pattern of all the slabs reported in figures 5.16 to 5.18.

All the Normal reinforced concrete slabs and light weight reinforced concrete slabs developed initial flexural cracks at the bottom of the slab. As the load increased, additional cracks were formed and already developed cracks extended in the form of branches and widened. These slabs failed in bending after large deflections, indicating yielding of steel (which is characteristic of ductile failure).

Crack widths for all mix (light weight aggregates and normal aggregates mix) were compared. Obviously cracks at mid span were wider than cracks observed at supports. Maximum crack widths were less in normal aggregates mix concrete slabs than light weight aggregates reinforced concrete slabs. The light weight aggregates reinforced concrete slabs fails in more ductile failure compared to normal aggregates mix concrete.

V. CONCLUSIONS

The results obtained from this investigation offer valuable information on properties of various materials, fresh and harden properties of concrete produced from lightweight aggregate up to 50% replacement to normal coarse aggregate by volume. By partial replacement of LWCA to NCA the density of concrete can be reduced in a substantial margin. Six RCC slabs with varying percentage of LWA (0%, 25%, and 50%) to NCA by volume were casted and tested individually for flexure under uniformly distributed load and experimental values obtained are compared with theoretical values calculated using different codes.

This study leads to the following broad conclusions. The present chapter begins with a conclusion on the experimental results

1) Lightweight aggregate (pumice) has less crushing value and impact value when compared to normal coarse aggregate hence to compensate the LWA is replaced by volume to NCA and achieved comparatively good crushing and impact value for 25% and 50% of LWA to NCA.
2) Structural lightweight aggregate concrete with pumice has an advantage of reducing dry density hence density has been reduced by 5 to 8% for the MIX-2(25%LWA+75%NCA) and 10 to 15% for the MIX -1(50% LWA+50% NCA) when compared to MIX-3(100% NCA).
3) The strength of LWA is the primary factor controlling the strength of lightweight concrete with LWA. As the LWA increased in the concrete, simultaneously the compressive strength decreases.MIX-2(25%LWA+75%NCA) achieved compressive

strength more than target mean strength whereas MIX-1(50% LWA+50% NCA) achieved 8 to 10% lower value of calculated characteristic strength at 28 days. Hence it is possible to produce structural high strength lightweight aggregate concrete having dry density less than 2000 kg/m3 with pumice aggregate of 50% replacement to normal coarse aggregate by volume.

4) The compressive strength, flexural strength and split tensile strength values are almost same for MIX-2(25%LWA+75%NCA) compared with MIX-3 but slight decrease in case of MIX-1(50% LWA+50% NCA).
5) From the 100% normal coarse aggregate concludes that use Alccofine in optimum percentage increases the strength of concrete.
6) The mineral admixture such as Alccofine becomes very much reactive after the curing period of 7 days.
7) All the slabs were failed in flexural mode, the cracks are initiated in the tension face of the slab and cracks are propagate towards compression face as the load increases, followed by the crushing of concrete in compression face.
8) The experimental value of the ultimate load is relatively higher than the calculated load for each of the RCC lightweight aggregates concrete slabs.
9) The experimental deflection obtained is much higher compared to calculated values of various codes at cracking, service and ultimate loads.
10) The maximum crack width of RC slab at ultimate load is not supposed to exceed 0.3mm according to the code, whereas in the experiment it is observed that the Width of crack is slightly more than the limiting crack width.
11) From this study we can conclude that by partially replacing pumice aggregate to natural coarse aggregate helps in achieving structural high strength lightweight concrete.
12) We can conclude that as the density of concrete increases the compressive strength also increases with irrespective of age of concrete for 50%LWA, 25%LWAand 100%NCA. In case of 25%LWCA compressive strength remains almost same as the 50% LWCA the reason behind this is the pumice coarse aggregate crushing value is approximately same.

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