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ijirset@gmail.com

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Experimentation of Strength and Durability of Light Weight Concrete by Adding Steel Fibers and Mineral Admixtures

K. Rajyalakshmi¹, V. Rajendra Kumar²

II. M.Tech, Dept. of CE, Kallam Harinadhreddy Institute of Technology, Andhra Pradesh, India¹

Asst. Professor, Dept. of CE, Kallam Harinadhreddy Institute of Technology, Andhra Pradesh, India².

ABSTRACT: Light weight aggregate concrete means expanding the volume of concrete mixture by adding an expanding agent with the additional quality that is less dead weight. It is lighter in weight compared to ordinary concrete. This light aggregate concrete is very special about its less density and its thermal conductivity. It is used in the construction of larger precast units. In this experiment we are going to study the mechanical properties of light weight aggregate concrete M60 using the natural light weight aggregate pumice stone as a replacing material to coarse aggregate (10%, 20%, 30%, 40% and 50%) sets are prepared to study the compressive strength, tensile strength and flexural strength. Each set comprises of 9 cubes, 9 cylinders and 9 beams. 7, 14 and 28-days compressive test, tensile strength and flexural strength tests are to be performed in the hardened state. The test results are shown on overall strength properties in various trials. Therefore, the strength properties of M60 grade of concrete was studied.

KEYWORDS: Silica fume, light weight aggregate, Metakaolin, pumice stone, mechanical properties, master glenium, steel fibers.

I. INTRODUCTION

Light weight concretes is used as a building material from olden days. Grecian and Italian pumice are used as a lightweight aggregates to create the earliest forms of light weight concrete. Developments in the manufacture light weight concrete started in the 20th century. The conventional cement concrete is a heavy material having a density of 2696kg/m³. The dead weight of the structure made up of this concrete is large compared to the imposed load to be carried, and a relatively less reduction in dead weight, particularly for members in flexure ex. in high rise buildings, can save money and manpower in construction.

II. RELATED WORK

Parhizkar*, M. Najimi and A.R. Pourkhorshidi, "(Application of pumice aggregate in structural lightweight concrete)", *asian journal of civil engineering (building and housing)* VOL. 13, NO. 1 (2012) PAGES 43-54. In this investigation light weight concrete have been used as a construction materials. The earliest types of light weight concrete were made by using Grecian and Italian pumice as a light weight aggregate is used to developments in light weight concrete production started in 20th century. Pumice is one of the oldest lightweight aggregates used in constructions. During volcanic activation, the outflow of gases from cooling magma produces small hollow voids resulting in the porous structure of pumice. Hitherto, widespread researches have been devoted to the properties of pumice lightweight aggregate concrete and mix proportion effects. These researches indicated that pumice lightweight aggregate concretes can satisfy the requirements of semi-lightweight structural concretes. Compressive strengths (28-day) up to 55 Mpa were achieved incorporating Turkish pumice aggregates.

III. METHODOLOGY

Experimental investigation consists of casting and testing of 18 sets along with control mix. Each set comprises of 9 cubes, 9 cylinders and 9 beams for determining compressive, tensile and flexural strengths respectively. Hooked steel fibers is used to study with The fiber content varies from (0.5%, 1% and 1.5%) by volume of cement is used in concrete. All specimens are water cured and tested at the age of 7 and 28-days. Workability of wet mix is found to be reduced with



increase fiber content. Super plasticizer is to be used to increase workability. Ductility and bond of concrete is to found to increase in steel fiber reinforced concrete. In this study optimum percentage steel fibers arrived at the keeping optimum percentage addition of steel fibers constant and replacing granite aggregate with pumice by (10%,20%,30%,40% and 50%) by volume of Pumice stone is used. The different admixtures like steel fiber. Cube section dimension is of15cmx15cmx15cm, cylinder section dimension is 15cmx30cm and prism dimension is 50cmx10cmx10cm. The moulds are applied with a lubricant before placing the concrete. After a day of casting, the moulds are removed. The cubes, cylinders and prisms are moved to the curing tank carefully.

MATERIALS:

The constituent materials used in these studies are given below:

1. Cement
2. Fine aggregate
3. Normal weight of coarse aggregate
4. Pumice stone(light weight coarse aggregate)
5. Glenium B233 (chemical admixture)
6. Hook-end steelfibers

CEMENT:

The cement used was Ordinary Portland cement (OPC) of 53-grade conforming to IS 12269 is used in experimental work.

Table 1: Cement Test Results

S.No	Property	Experimental Value	Requirements As Is Codes
1	Normal consistency	34%	IS 4301-1988(part-4)
2	Specific gravity	3.12	3.15
3	Initial setting time Final setting time	44 min 460 min	30 min 600 min (max)As per12269
4	Soundness test	7 mm expansion	

AGGREGATE: It should be passed through IS Sieve. As fine aggregate (F.A) natural sand from river is used conforming to IS383-1970.Which comes under zone II. As a course aggregate hard granite chips passing 20mm down where used conforming to IS383-1970. Various tests such as specific gravity water absorption and sieve analysis have been conducted on (F.A) and (C.A) to know the good quality and grading.

PUMICE STONE (LIGHTWEIGHT AGGREGATE):

Structural light weight concrete has an in-place density (unit weight) on the order 1440 to 1840 kg/m3 compared to normal weight concrete with a density in the range of 2240 to 2500 kg/m3. The pumice aggregate 20 mm size was used. Specific aggregate of pumice used is0.86.

GLENIUM B233 (Chemical Admixture):

GLENIUM B233 is an admixture of new generation based on modified polycarboxylic ether. The addition of this super plasticizer to dry aggregate or cement is not recommended and forced action for 60 seconds in mixers is recommended after addition of GLENIUM B233. This is based on a unique carboxylic ether polymer with long lateral chains. This greatly improves cement dispersion. At the start of mixing process the electrostatic dispersion occurs but the presence of lateral chains, linked to the polymer backbone, generate a seric hindrance which stabilizes the cement particle to separate and disperse. The physical properties of GLENIUM B233 obtained from BASF construction chemicals are shown below in the table.



Table 2: Properties of GLENIUM B233

Properties	Limits
Colour	Light brown liquid
Relative density	1.09±0.01
p ^H	>6
Chloride ion content	<0.2%

IV. EXPERIMENTAL RESULTS

➤ COMPRESSIVE STRENGTH RESULTS

Mix	Compressive strength(N/mm ²)		
	7 days	14 days	28 days
M0	43.26	66.86	69.33
M1	45.25	67.01	71.88
M2	47.01	67.37	73.31
M3	49.90	67.58	73.91
M4	50.70	68.37	75.57
M5	51.84	70.67	77.85
M6	45.89	67.34	72.64
M7	43.09	64.09	69.34

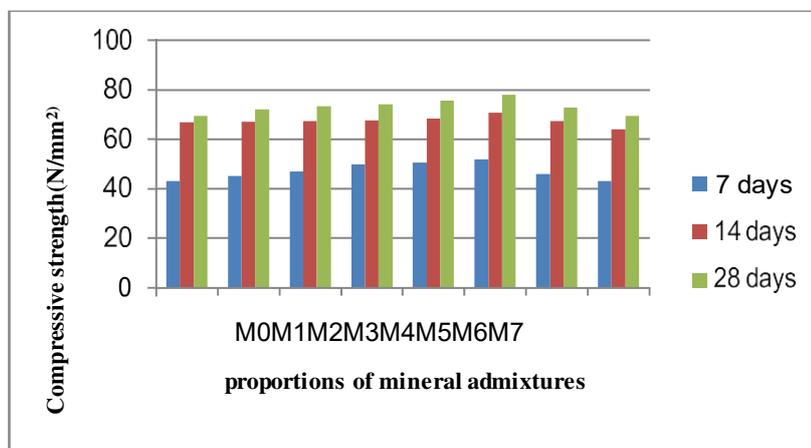


Fig. 1. Overall results of compressive strength

➤ SPLIT TENSILE TEST RESULTS

When silica fume percentage increases from 0% to 20%, the normal consistency is increases about 40%. Increase in split tensile strength beyond 10% silica fume replacement was almost unsatisfactory. I this study M60 grade concrete and it was found that maximum split tensile strength of 6.07 N/mm² was obtained for 1.5% replacement of silica fume and 1% of metakaolin with 1% of steel fibers.

Table 4: Split tensile strength results

Mix	Split tensile strength (Mpa)		
	7 days	14 days	28 days
M0	1.18	3.17	4.73



M1	1.51	3.47	4.96
M2	1.74	3.76	5.28
M3	1.89	3.97	5.41
M4	2.01	4.13	5.84
M5	2.48	5.10	6.07
M6	2.31	4.81	5.37
M7	2.46	3.72	4.96

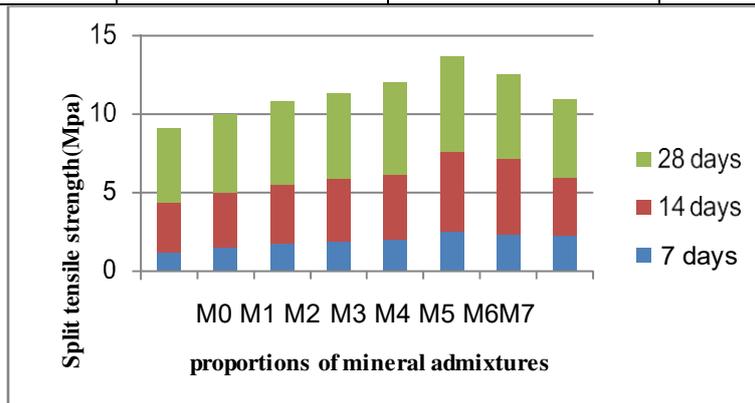


Fig.2. Split tensile testing of cylinder

Table 6: compressive strength results of replacing pumice stone

M5	% replacement of pumice	Compressive strength(N/mm ²)		
		7days	14 days	28 days
S.F-1.5 % MK-1.0% & steel fibers 1%	0%	48.84	70.67	77.85
	10%	49.27	71.95	78.08
	20%	50.34	72.30	78.19
	30%	36.91	49.78	69.45
	40%	32.12	42.70	53.35
	50%	30.17	35.40	49.40

➤ COPRESSIVE STRENGTH TEST RESULTS WITH PUMICE AND STEEL FIBERS

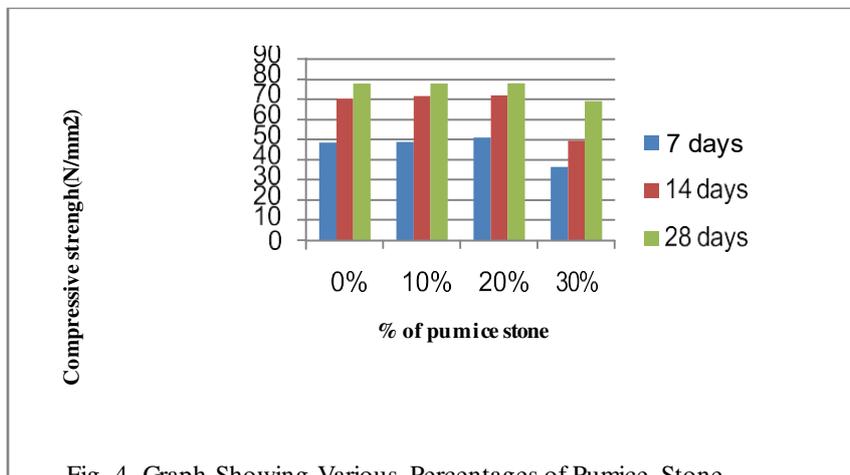


Fig. 4. Graph Showing Various Percentages of Pumice Stone



Table 7: split tensile strength of pumice stone

M5	% replace of pumice	Tensile strength(Mpa)		
		7 days	14 days	28 days
S.F-1.5% MK-1 % Steel fibers- 1%	0	2.76	5.88	6.84
	10	2.34	4.66	6.95
	20	2.51	4.32	7.25
	30	1.68	3.68	5.89
	40	1.30	3.24	4.10
	50	1.18	2.48	3.78

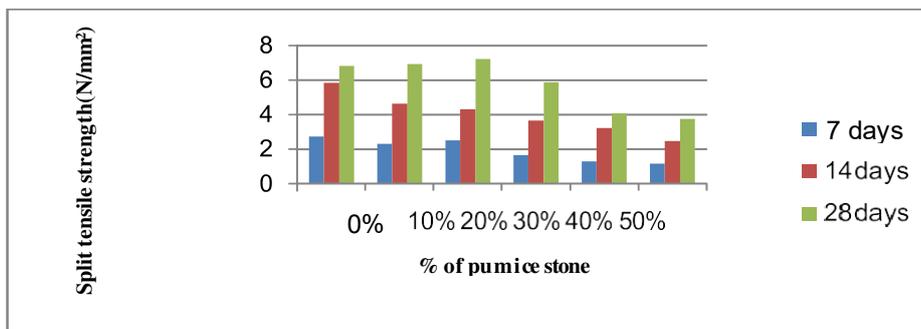


FIG. 5. GRAPH SHOWING TENSILE STRENGTH FOR VARIOUS

Table 8: flexural strength of pumice stone

M5	% replacement of pumice	Flexural strength(Mpa)		
		7 days	14 days	28 days
S.F-1.5% MK-1% And steel fibers-1%	0	2.33	5.83	7.88
	10	2.56	5.98	7.91
	20	2.81	6.18	8.21
	30	1.86	3.61	5.36
	40	1.42	2.96	4.28
	50	1.16	2.42	3.25

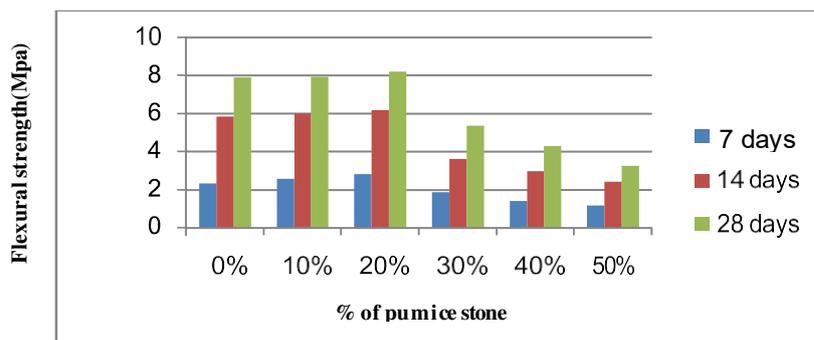


Fig. 6. Graph showing flexural strength of pumice & fibers



➤ **Density of pumice concrete M60 mix**

Table 9: Density values of concrete

M5	% replace of pumice stone	Density of concrete(Kg/m ³)
S.F-1.5% M.K-1% Steel fibers-1%	0	2696.30
	10	2577.78
	20	2459.25
	30	2307.40
	40	2216.30
	50	2097.77

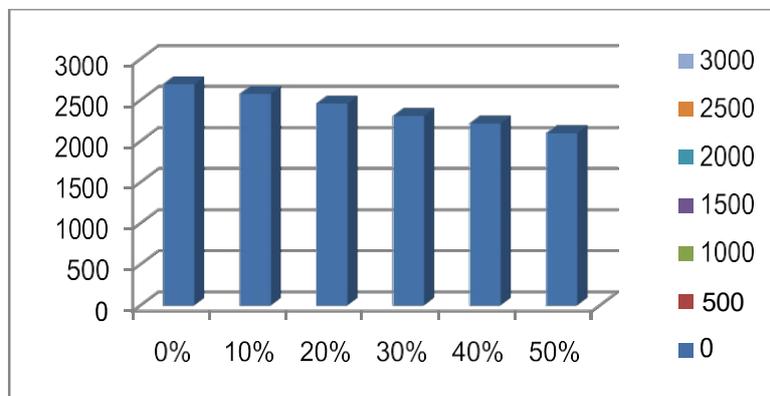


Fig. 7. Density of Light Weight Aggregate Concrete at Different Replacement Levels

➤ **Durability studies of lightweight aggregate concrete:**

The concentrations of acids in water are 2% HCL and 2% H₂SO₄. Durability studies of compressive strength of lightweight aggregate concrete is effected with chemicals as follows

Table 10. Compressive strength of lightweight aggregate concrete is effected with chemicals

s.no	% of pumice stone	% of weight loss	Compressive strength(N/mm ²)	
			28 days	90 days(2%H ₂ so ₄)
1	0	4.85	78.85	74.39
2	10	3.51	74.35	71.25
3	20	4.52	71.28	68.25
4	30	5.7	64.35	51.53
5	40	6.61	54.45	47.97
6	50	7.74	51.35	43.76

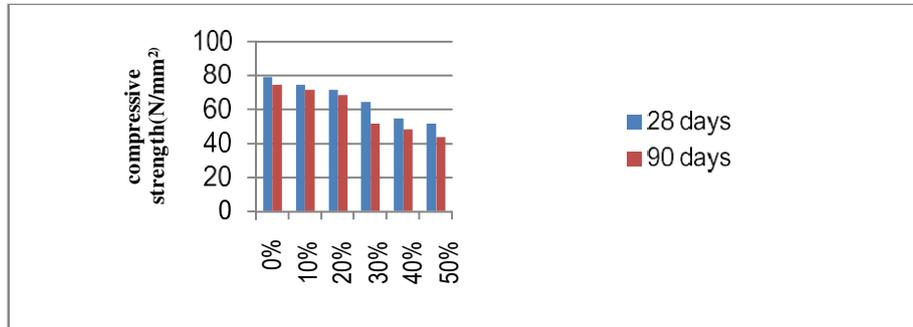


Fig. 8. Compressive strength of lightweight aggregate concrete with steel fibers

➤ **Durability test in presence of HCL solution**

Table 11. Compressive strength of Light Weight aggregate concrete with HCL Solution

S.no	% of pumice stone	% of weight loss	Compressive strength(N/mm ²)	
			28 days strength	90 days(2% HCL)
10		2.65	78.85	71.39
210		3.92	74.35	67.25
320		4.70	71.28	61.25
430		5.24	64.35	49.53
540		6.61	54.45	43.97

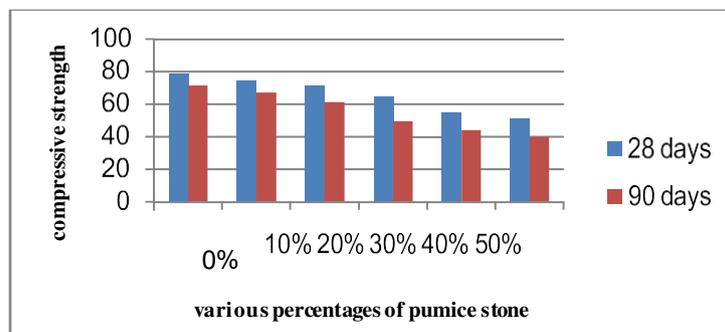


Fig. 9. Durability test in presence of HCL

V. CONCLUSION

Based on the analysis of experimental results and discussion there upon the following conclusions can be drawn:

- Addition of 2.0% Silica Fume and 1.5% Metakaolin and steel fibers 1% to M60 Conventional concrete mix, there is an increase in compressive strength up to 21.3% over conventional concrete.
- Up to 20% replacement of coarse aggregate with light weight aggregate, the optimized conventional concrete has good compressive strength and strength results are promising upto 30% replacement.
- Split Tensile Strength increases by 16.5% with addition of 2.0% Silica Fume and 1.5% Metakaolin and steel fibers 1% to M60 Conventional concrete.
- Up to 20% replacement of coarse aggregate with light weight aggregate, the optimized conventional concrete has good Split Tensile Strength and strength results are promising upto 30% replacement.
- Flexural strength increases by 25% with addition of 2.0% Silica Fume and 1.5% Metakaolin and 1% steel fibers to M60 Conventional concrete.



- Up to 20% replacement of coarse aggregate with light weight aggregate, the optimized conventional concrete has good Flexural Strength and strength results are promising up to 30% replacement.
- Though it is not a light weight concrete the density of concrete is reduced by 18.69% for promising strength results.

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