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Study on Various Properties of Light Weight Aggregate Concrete by Mineral Admixtures and Steel Fibers

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ABSTRACT:
In this experimental investigation stands for improving the properties of light weight aggregate concrete of various properties with respect to strength and durability aspects. Especially in this aggressive investigation review states on addition of Cement with mineral admixtures and steel fibers. High performance concrete appears to be better choice for strong and durable structures. Proper introduction of silica fume and metakaolin in concrete improves both the strength and durability characteristics of the concrete. The effects of fibers on workability, density and on various strength properties of high strength concrete M_{70} of grade concrete have been studied. The Steel fibers content varies from (1% and 1.5%) by volume of cement is used in concrete. For this purpose along with a Control Mix, 24 sets were prepared to study the compressive strength, tensile strength and flexural strength. Each set comprises of 12 cubes, 12 cylinders and 12 beams. All specimens are water cured and tested at the age of 7, 14, 24 and 56 days. Super plasticizer (Master Glenium SKY 233) is to be used to increase workability with the adequate proportions (0.5%, 0.6% 0.7% and 0.8%). Ductility and bond of concrete is to found to increase in steel fibers in the concrete as observed from the Compressive test, Tensile Strength and Flexural Strength tests were performed in the hardened state. In this study optimum percentage steel fibers arrived at the keeping optimum percentage addition of steel fibers constant and replacing granite aggregate with pumice stone by (0% 10%, 20%, 30%, 40% and 50%) by volume, the strength and durability properties of M_{70} grade of concrete was studied.

***KEYWORDS*:** Silica fume, Metakaolin, Compressive Strength, Split tensile Strength, lightweight aggregate; lightweight concrete.

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I. INTRODUCTION:

Lightweight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as nailbility and lessened the dead weight. It is lighter than the conventional concrete. The use of lightweight concrete has been widely spread across countries such as USA, United Kingdom and Sweden. The main specialties of lightweight concrete are its low density and thermal conductivity. Its advantages are that there is a reduction of dead load, faster building rates in construction and lower haulage and handling costs. Lightweight concrete maintains its large voids and not forming laitance layers or cement films when placed on the wall. This research was based on the performance of aerated lightweight concrete. However, sufficient water cement ratio is vital to produce adequate cohesion between cement and water. Insufficient water can cause lack of cohesion between particles, thus loss in strength of concrete. Likewise too much water can cause cement to run off aggregate to form laitance layers, subsequently weakens. Therefore, this fundamental research report is prepared to show activities and progress of the lightweight aggregate concrete. Focused were on the performance of lightweight concrete such as compressive strength tests, split tensile strengths, flexural strength tests, water absorption, density and supplementary tests and durability comparisons made withLWC.

II. LITERATURE REVIEW

T. 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.

Srivastava V, Kumar R, Agarwal VC, Mehta PK.. Effects of silica fume and metakaolin combination on concrete. IJCSE 2012.

In this investigation the use of supplementary cementitous materials is fundamental in developing low cost construction materials for use in developing countries. By addition of some pozzolanic materials, the various properties of concrete viz, workability, durability, strength, resistance to cracks and permeability can be improved. Silica fume is a by product resulting from the reduction of high purity quartz with coal or coke and wood chips in an electric arc furnace during the production of silicon metal or silicon alloys. Silica fume is known to improve both the mechanical characteristics and durability of concrete. The principle physical effect of silica fume in concrete is that of filler, which because of its fineness can fit into space between cement grains in the same way that sand fills the space between particles of coarse aggregates and cement grains fill the space between sand grains. The 28 day compressive strength of concrete generally increases with the Metakaolin content upto its optimum content, at all the Silica fume contents, and thereafter declines. The 7 day compressive strength of concrete generally decreases with the increasing Metakaolin content at all the Silica fume contents. The optimum dose of Silica fume and Metakaolin in combination is found to be 6% and 15% (by weight) respectively at both 7 and 28 day compressive strength. The slump is found to decreases with increase in Metakaolin content at all the Silica fume contents considerably.

Koneru VS Sukhesh Raja*1, K Venkateswara Rao STRENGTH PROPERTIES OF LIGHTWEIGHT AGGREGATE CONCRETE WITH SILICA FUME AND METAKAOLIN

In this experiment we are going to study the Mechanical Properties of a light weight aggregate concrete M50 using the natural light weight aggregate pumice stone as a replacement to coarse aggregate (10%, 20%, 30%, 40%and 50%) and addition of mineral admixture materials Metakaolin and Silica Fume. For this purpose along with a Control Mix, 18 sets are prepared to study the compressive strength, tensile strength and flexural strength. Each set comprises of 6cubes, 3cylinders and 3 prisms. 7and 28-days Compressive test, Tensile Strength and Flexural Strength tests are to be performed in the hardened state. The test results will be showed on overall strength properties in various trails. Therefore, the strength properties of M50 concrete was studied

VENKATESAN et al., "Strength Characteristics and Durability Characteristics of Silica fume and Metakaolin based Concrete", IJIET, ISSN 2319-1058,[Vol. 5 Issue 1, February 2015]:

This project deals with the properties of concrete, with varying percentage replacement of Silica fume and Metakaolin as a partial replacement for cement. The mix was obtained by replacing (35%, 15%); (40%, 10%) and (45%, 5%) mass of cement by Silica fume and Metakaolin respectively. Finally required specimens were casted to study the behaviors such as compressive strength, tensile strength and durability. Compressive strength and split tensile test were carried out for testing the strength properties is conducted to check the durability properties of concrete. The test results indicated that the two admixtures Silica fume and Metakaolin when used at an optimum combination tend to increase the strength and durability of concrete when compared with conventional concrete.

Sruthi V(1), Elba Helen George(2) A REVIEW ON SILICA FUME – AN ADDITIVE IN CONCRETE

Silica fume is also known as micro silica and it is a very fine pozzolanic material and composed of amorphous silica produced by electric arc furnaces as a by- product of the production of elemental silicon or ferrosilicon alloys and also consists of spherical particles. The main field of application of silica fume is as pozzolanic material for high performance concrete. Silica fume can also be used in a variety of products such as grouts, and mortars. The range of properties of silica fume generally

III. EXPERIMENTAL INVESTIGATION:

Experimental investigation consists of casting and testing of 24 sets along with control mix. Each set comprises of 12 cubes, 12 cylinders and 12 beams for determining compressive, tensile and flexural strengths respectively. Hooked end steel fibers are used to study with the fiber content varies from (1.5%, 2%, 2.5% and 3%) by volume of cement is used in concrete. All specimens are water cured and tested at the age of 7, 14, 28 and 56 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 of steel fibers arrived at the keeping optimum percentage addition of steel fibers constant and replacing granite aggregate with pumice by (25%, 50%, 75% and 100%) by volume of Pumice stone is used. The different admixtures like steel fiber. Cube section dimension is of 15cm x 15cm x 15cm, cylinder section dimension is 15cm x 30cm and prism dimension is 50cm x10cm x 10cm. 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 OPC 53 Grade (Ultra-Tech gold)
2) Fine aggregate
3) Normal weight of coarse aggregate
4) Pumice stone(light weight coarse aggregate)
5) Master Glenium SKY B233 (chemical admixture)
6) Hook-end steel fibers

CEMENT:

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

s.no	*Property*	*Experimental value*	*Requirements As Is codes*
1	Normal consistency	35%	IS 4301-1988(part-4)
2	Specific gravity	3.13	3.15
3	Initial setting time Final setting time	46 min 473 min	As per12269 30 min 600 min (max)
4	Soundness test	8 mm expansion	IS 4031-3 (1988)

Table 1: cement test result

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): 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 2340 to 2500 kg/m3. The pumice aggregate 20 mm size was used. Specific aggregate of pumice used is 0.96.

GLENIUM B233 (Chemical Admixture):

GLENIUM SKY 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 SKY B233 obtained from BASF construction chemicals are shown below in the table

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

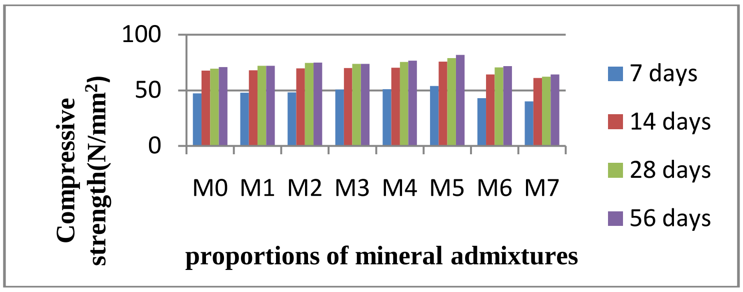
Table 2: Properties of GLENIUM B233

IV. RESULTS AND ANALYSIS

Results for various percentages of mineral admixtures

Mix	Compressive strength(N/mm^2)			
	7 days	**14 days**	**28 days**	**56 days**
M_0	47.26	67.86	69.33	70.83
M_1	47.94	68.01	71.96	72.08
M_2	48.01	69.63	74.51	74.91
M_3	50.70	70.00	73.91	73.91
M_4	50.90	70.37	75.57	76.57
M_5	**53.84**	**75.67**	**78.85**	**81.97**
M_6	42.89	64.34	70.64	71.64
M_7	40.09	61.09	62.34	64.34

Table 3: compressive strength results



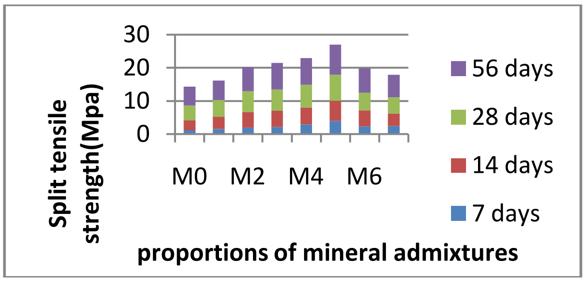
Overall results of compressive strength

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 M_{70} grade concrete and it was found that maximum split tensile strength of 9.07 N/mm^2 was obtained for 2.5% replacement of silica fume and 1.5% of metakaolin with 1% of steel fibers.

Mix	Split tensile strength(Mpa)			
	7 days	14 days	28 days	56 days
M_0	1.18	3.02	4.43	5.73
M_1	1.51	3.74	4.96	5.96
M_2	1.94	4.76	6.28	7.28
M_3	2.09	4.97	6.41	7.97
M_4	2.91	5.13	6.84	8.01
M_5	**3.97**	**6.10**	**7.87**	**9.07**
M_6	2.31	4.81	5.37	7.37
M_7	2.46	3.72	4.96	4.96

Table 4: Split tensile strength results



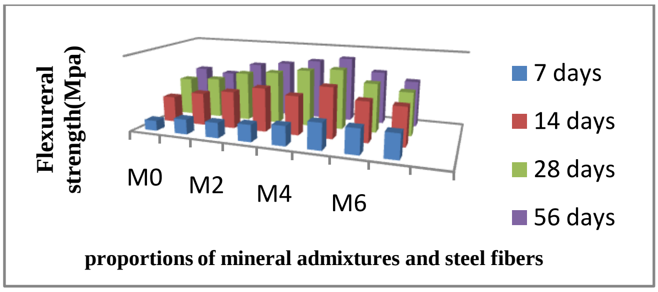
Split tensile strength of cylinder

Flexural Strength:

The steel mould of size 500cm x 100cm x100cm is well tighten and oiled thoroughly . They were allowed for curing in a tank After 28 days curing, prismatic specimens are placed on flexural testing machine having a maximum of 100 KN and a constant rate of loading of 40 kg/m^2 per minute is applied on the test specimen by placing the specimen in such a way that the two point loading should be placed at a distance of 13.3 cm from both the ends. Ultimate load at which the prismatic specimen fails is noted down from dial gauge reading.

Table 5: Flexural strength results

Mix	Flexural strength(Mpa)			
	7 days	14 days	28 days	56 days
M0	1.34	3.47	5.09	5.79
M1	1.98	4.34	5.41	5.41
M2	2.01	4.93	6.53	6.97
M3	2.24	5.80	6.96	7.46
M4	2.58	5.16	7.57	8.07
M5	**3.46**	**6.69**	**7.98**	**8.68**
M6	3.27	5.30	6.48	7.08
M7	3.19	5.07	5.73	6.13



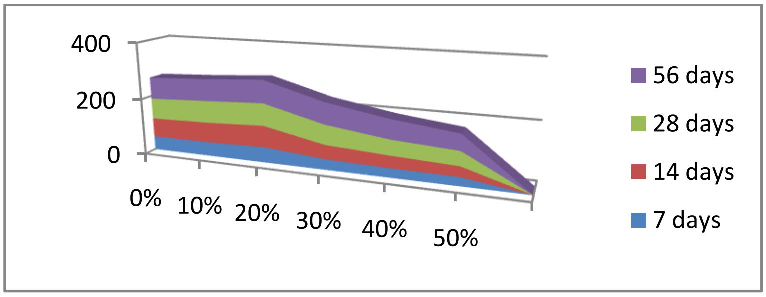
Flexural strength results variation

Lightweight aggregate replacement to optimized conventional M_{70} mix

M_5	% replacement of pumice	Compressive strength(N/mm^2)			
S.F-2.5% M.K-1.5% & steel fibers 1%		7 days	14 days	28 days	56 days
	0%	48.84	67.67	73.85	77.01
	10%	49.27	71.95	78.08	78.04
	20%	**54.34**	**76.30**	**79.19**	**81.24**
	30%	36.91	49.78	69.45	76.21
	40%	32.12	42.70	53.35	67.45
	50%	30.17	35.40	49.40	55.55

Table 6: compressive strength results of replacing pumice stone

COPRESSIVE STRENGTH TEST RESULTS WITH PUMICE AND STEEL FIBERS

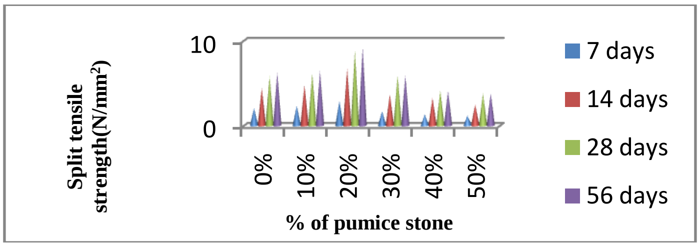


Graph showing various percentages of pumice stone

The behaviour of cylinders casted with pumice stone and steel fibers

M5	% replce of pumice	Tensile strength(Mpa)			
S.F-2.5%, M.K-1.5 % Steel fibers-1%		7 days	14 days	28 days	56 days
	0	2.06	4.38	5.84	6.24
	10	2.34	4.76	6.15	6.45
	20	**2.91**	**6.72**	**8.85**	**9.25**
	30	1.68	3.68	5.89	5.89
	40	1.30	3.24	4.10	4.10
	50	1.18	2.48	3.78	3.78

Table 7: split tensile strength of pumice stone

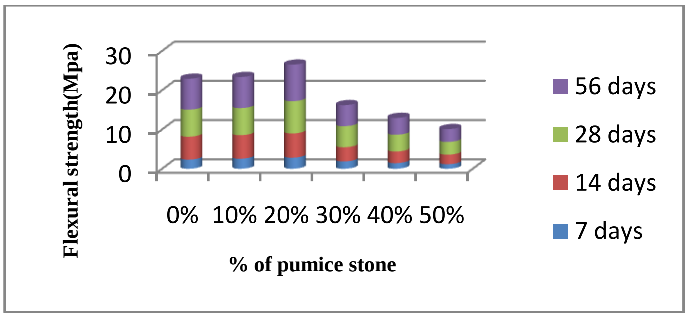


Graph showing tensile strength for various percentages

The behaviour of prisms casted with different % of pumice stone and steel fibers

M5	**% replacement of pumice**	**Flexural strength(Mpa)**			
S.F-2.5% M.K-1.5% And steel fibers-1%		**7 days**	**14 days**	**28 days**	**56 days**
	0	**2.33**	**5.83**	**6.88**	**7.88**
	10	**2.56**	**5.98**	**6.91**	**7.91**
	20	**2.81**	**6.18**	**8.21**	**9.31**
	30	**1.86**	**3.61**	**5.36**	**5.36**
	40	**1.42**	**2.96**	**4.28**	**4.28**
	50	**1.16**	**2.42**	**3.25**	**3.25**

Table 8: flexural strength 0f pumice stone

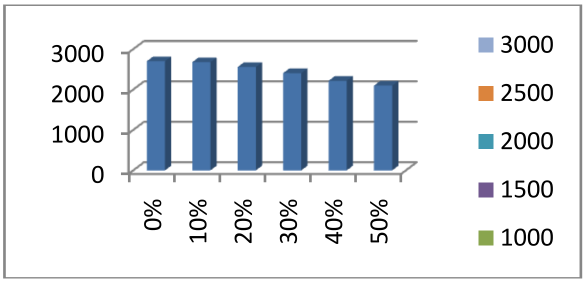


Graph showing flexural strength of pumice & fibers

Density of pumice concrete M_{60} mix

M_5	**% replace of pumice stone**	**Density of concrete(Kg/m^3)**
S.F-2.5% M.K-1.5% Steel fibers-1%	0	2701.30
	10	2677.78
	20	2559.25
	30	2407.40
	40	2216.30
	50	2097.77

Table 9: Density values of concrete

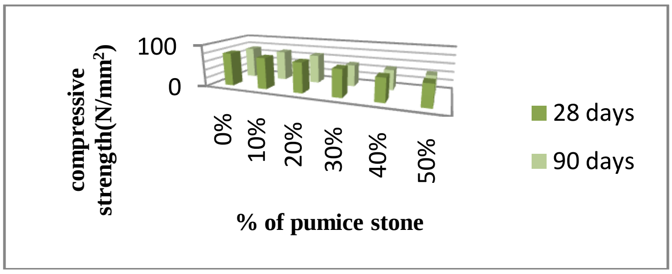


Graph showing density variations of pumice stone

Durability studies of lightweight aggregate concrete:
The concentrations of acids in water are 2% HCL and 2% H_2SO_4. Durability studies of compressive strength of lightweight aggregate concrete is effected with chemicals as follows

Table 10: Durability strength of pumice aggregate (H_2SO_4)

S.no	% of pumice stone	% of weight loss	Compressive strength(N/mm^2)	
			28 days	90 days(2%H_2S0_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

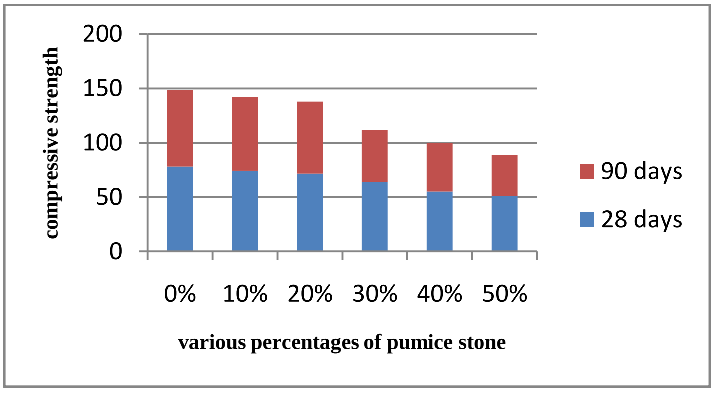


Compressive strength of lightweight aggregate concrete with steel fibers

Durability test in presence of HCL solution

S.no	% of pumice stone	% of weight loss	Compressive strength(N/mm^2)	
			28 days strength	90 days(2% HCL)
1	0	2.54	78.01	70.39
2	10	3.72	74.15	68.25
3	20	4.85	71.52	66.25
4	30	5.34	64.04	47.53
5	40	6.91	54.99	44.97
6	50	7.92	51.01	37.76

Table 11: Durability strength of pumice aggregate(HCL)



Graph showing the compressive stength variations with presence of HCL

V. CONCLUSIONS:-

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

- Addition of 2.5% Silica Fume and 1.5% Metakaolin and steel fibers 1% to M_{70} Conventional concrete mix, there is an increase in compressive strength up to 27.3% 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 up to 30% replacement. Split Tensile Strength increases by 18.5% with addition of 2.5% Silica Fume and 1.5% Metakaolin and steel fibers 1% to M_{70} 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 up to 30% replacement.
- Flexural strength increases by 27.25% with addition of 2.5% Silica Fume and 1.5% Metakaolin and 1% steel fibers to M_{70} 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 upto30% replacement.
- The Durability characteristics also conducted to the light weight aggregate concrete with the presence of HCL and Conc.H_2SO_4.
- The weight loss should be happen in cubes immersed with H_2SO_4 then comparing to the immersed HCL solution cubes.

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