Experimental Study on Strength Properties of Light Weight High Strength Fibre Reinforced Concrete With Partial Replacement of Coarse Aggregate With Pumice Stone

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Abstract- *Concrete is the most common building material which is accepted in and around the world. The problems of the concrete are, it is very week in tension and it is having very high self-weight. In order to compensate this problem the concept of reinforcement came into use as reinforced concrete. Also the constituents of concrete like coarse aggregate and fine aggregate are also being wiped up with very high usage. So in order to safeguard the natural raw materials like coarse aggregate and to increase the tensile strength of concrete, it is proposed to conduct an experimental study on the strength properties of concrete with partial replacement of coarse aggregate with pumice stone with addition of hooked steel fibres to increase the tensile strength of the concrete.*

In the present study, percentage of hooked steel fibres is varied as 0.5%, 1.0%, 1.5%, 2.0%, 2.5% and 3.0% along with a percentage variation of light weight aggregate pumice stone as 10%,20%,30%,40% and 50 % by volume are considered. Workability of wet mix is found to be reduced with increased fibre content. Super plasticizer is used to increase workability. The optimum percentage of steel fibres is calculated at 7 and 28 days strength and then the pumice stone is mixed . The strength and durability properties of M50 grade high performance concrete were studied in the present work.

Keywords- hooked end steel fibers, compressive strength, split tensile strength, flexural strength, light weight aggregate (pumice), super plasticizer (Glaninum), Durability (H_2SO_4).

I. INTRODUCTION

Most of the normal weight aggregate of normal concretes is natural stone such as lime stone and granite. With the increasing amount of concrete used, natural environment and resources are excessively exploited. Synthetic light weight aggregate produced from environmental waste like fly ash, is a viable new source of structural aggregate material. The use of light weight concrete permits greater design flexibility and substantial cost savings, reduced dead load, improved cyclic loading, structural response, longer spans, better fire ratings, thinner sections, smaller size structural members, less reinforcing steel and lower foundations costs. Weight of light weight concrete is typically 25% and 35% lighter but its strengths are comparable to normal weight concrete.

The conventional cement concrete is a heavy material having a density of 2600 Kg/m^3 and high thermal conductivity. The dead weight of the structure made up of this concrete is large compared to the imposed load to be carried, and a relatively small reduction in dead weight, particularly for members in flexure ex. in high rise buildings, can save money and manpower in construction.

Light Weight Aggregate is a relatively new material. For the same crushing strength, the density of concrete made with such an aggregate can be as much as 35 percent lower than the normal weight concrete. In addition to the reduced dead weight, the lower modulus of elasticity and adequate ductility of light weight concrete may be advantageous in the seismic design of structures. Other inherent advantages of the material are its greater fire resistance, low thermal conductivity, low coefficient of thermal expansion and lower erection and transport costs for prefabricated members.

At present more awareness has been made to the development of light weight aggregate concrete which is the most probable way in reducing the weight of structure and acts as a relatively new material where weight saving is an important factor. Light weight concrete is a type of concrete material that is lighter than the conventional concrete because of its varying material composition. It maintains good

durability in satisfying the required demands by making the concrete as a high performance material. Density of this concrete is considerably low (300 kg/m^3 to 1850 kg/m^3) when compared to normal concrete (2200kg/m^3 to 2600kg/m^3).
Light weight concrete includes an expanding agent which increases the volume of the mixture by reducing its dead weight that is lighter than the conventional concrete. The main importance in lightweight concrete is its low density and thermal conductivity. Its allowance is that there is a reduction of dead load and faster building construction. This even improves lower haulage and handling costs by maintaining its large voids which does not form laitance layers or cement films when placed on the wall. By using sufficient water cement ratio, it cans adequate cohesion between cement and water. Insufficient water can cause lack of cohesion between particles where there is loss in strength of concrete. In the same way, by using more water can cause cement to run off from laitance aggregate layers which subsequently weakens in strength.

In design factor, the building self-weight on the foundation plays a prominent role which is important in case of low bearing capacity soils and high rise buildings. The structural components in multi-storied buildings such as beams and columns have to carry load on floors and walls. The structure is designed in an economical way by using light weight concrete for floors and walls which lowers power consumption due to extreme climatic conditions.

The lightweight concrete is produced from the natural aggregates that are available in nature and are found at many places over the globe are pumice stone, volcanic cinders, scoria, saw dust etc., which comprises of low density. The artificially aggregates are produced with combinations of cinders, clinker & breeze, foamed slag and bloated clay which helps in improving bond strength between materials of concrete.

Light weight aggregate concrete

Light weight concrete is defined as concrete having an oven dried density of not less than 800 kg/m3 and not even more than 2000 kg/m3 when compared to normal weight concrete (NWC). The major benefit in adopting the light weight concrete (LWC) mixes is of reducing the self-weight of the structure up to 15% or more. Light weight concrete will include an expanding agent by increasing the volume of the mixture.

Light weight aggregate may be grouped in the following categories

(i) Naturally occurring materials which require further processing such as expanded clay, shale and slate, vermiculite etc.,
(ii) Industrial by-products such as sintered pulverized fuel ash, foamed or blast furnace slag, hematite etc.,
(iii) Naturally occurring materials such as pumice, foamed lava, volcanic tuff and porous lime stone.

Table1: Classification of light weight aggregates

Natural light weight aggregate	Artificial light weight aggregate
a)Pumice stone	a) artificial cinders
b)Scoria	b)coke breeze
c)Volcanic cinders	c)foamed slag
d)Sawdust	d)bloated clay
e)Rice husk	e)expanded shales and slate
	f)sintered fly ash
	g) exfoliated vermiculite
	h) expanded Prelites
	i) thermo Cole beads

Natural light weight aggregates are less preferred over artificial aggregates. Important natural aggregates are Pumice stone & Scoria. Type of aggregate will decides the density of concrete. For a structural light weight concrete, it has an in- place density (unit weight) on the order of 90 to 115 lb/ft^3 (1440 to 1840 kg/m^3) compared to normal weight concrete with a density in the range of 140 to 150 lb/m^3 (2240 to 2500 kg/m^3). For structural applications the concrete strength should be greater than 2500 psi (17.0 Mpa).

Among the natural aggregates pumice stone which is of natural origin and mostly volcanic tuff is preferred as a best material for the partial replacement to coarse aggregate. It gives good strength when compared to the other natural aggregates like scoria, saw dust and rice husk. More research work is being carried out because of its low density, porous nature and high volume occupancy.

When a light weight aggregate is made for the same crushing strength the density of concrete obtained will be 35% lower than compared to the normal weight concrete.

Figure1: Pumice stone when placed on tray

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We all know that concrete is weak in tension and strong in compression in order to compensate the tension in the concrete we use either reinforcement or fibers in concrete it is hard to reinforce very thin members so we use fibers to reinforce thin members. Fiber is a small piece of reinforcing material possessing some characteristic property. Fiber is often described with a parameter called "aspect ratio". Generally aspect ratio of fiber ranges from 30 to 150. Steel fibers are most commonly usedfiber which is generally round in shape. The diameter varies from 0.25 to 0.100mm. Use of fibers enhances properties like flexural strength, impact, and fatigue strength of concrete. Steel fibers have wide range of application in road construction, airfield, and bridge decks.

II. SCOPE OF THE WORK

The aim of this study is to assess the strength properties of M50 grade for strength proper ties of high strength fiber reinforced light weight aggregate concrete.

III. EXPERIMENTAL PROGRAM

The work deals with an experimental investigation of study on strength properties of high strength fiber rein forced light weight aggregate concrete. The purpose of this research is based on this investigation of hooked steel fibers in structural concrete. In Design of concrete structures, light weight concrete plays a prominent role in reducing the density and to increase the thermal insulation. The work deals with an experimental investigation on strength durability properties of high strength fiber rein forced light weight aggregate concrete. The effects of fibers onworkability,densityandonvariousstrengthpropertiesofhighstrengthconcrete (M_{50}) grade concrete have been studied. The fiber content varies from 0.5%, 1%, 1.5% 2% 2.5%and 3% by volume of cement is used inconcrete.

For this purpose along with a Control Mix, 15 sets were prepared to study the compressive strength, tensile strength, and flexural strength and durability properties. Each set comprises of 9 cubes, 3cylinders and 3 prisms. All specimens are water cued and tested at the age of 7and 28-days. Workability of wet mix is found to be reduced with increase fiber content. Super plasticizer is to be used to increase workability. 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%,50% by volume, the strength and durability properties of M50 concrete were studied.

IV. RESULT AND DISCUSSION

Optimized Mix proportion ratio-1.1.13:2.193(addition of hooked steel fibers)

M-1-Cement (100%) + HSF (0.5%)+ sand (100%) + CA (100%)

M-2-Cement (100%) + HSF (1.0%) + sand (100%) + CA (100%)

M-3-Cement (100%) +H SF (1.5%) + sand (100%) + CA (100%)

M-4-Cement (100%) + HSF (2.0%) + sand (100%) + CA (100%)

M-5-Cement (100%) + HSF (2.5%) + sand (100%) + CA (100%)

M-6-Cement (100%) + HSF (3.0%) + sand (100%) + CA (100%)

Table 2: Test result for Compressive strength by using steel fibers

	7 days (N/mm^2)	28 days (N/mm^2)	Cube weight	Density of cube
Conventional	43.21	61.52	8.88	2631
0.5%	47.52	63.42	8.84	2619
1.0%	52.14	72.15	8.86	2625
1.5%	50.32	70.63	8.79	2604
2.0%	49.74	68.56	8.75	2592
2.5%	49.89	66.45	8.72	2583
3.0%	49.97	67.22	8.83	2616

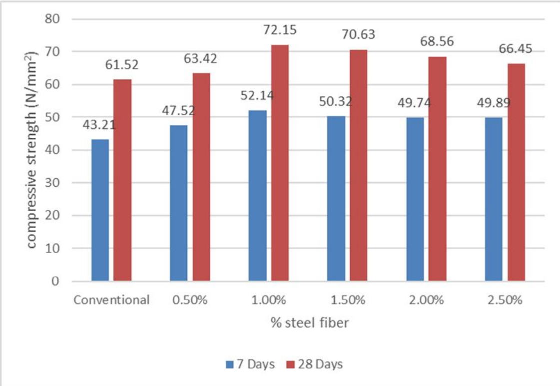

Fig.1: Comparison of compressive strength by using different percentage of steel fibers

Table3: Test result for split tensile strength by using steel fibers

Addition of steel fibers	Split tensile strength 28 days (N/mm²)
Conventional	4.79
0.5%	5.36
1.0%	6.24
1.5%	5.32
2.0%	5.62
2.5%	5.79
3.0%	5.98

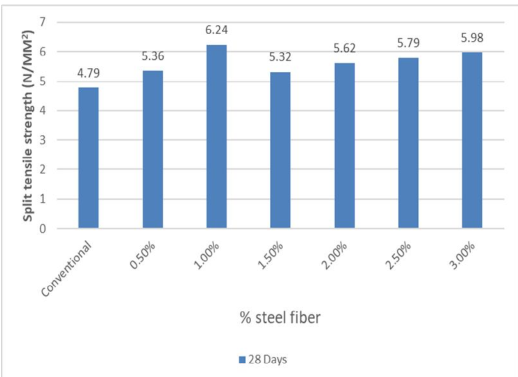

Fig 2: Comparison of split tensile strength by using different percentage of steel fibers

Table 4: Test result for flexural strength by using steel fibers

Addition of steel fibers	Flexural strength 28 days (N/mm²)
Conventional 0%	5.58
0.5%	6.13
1.0%	6.96
1.5%	6.31
2.0%	6.24
2.5%	6.30
3.0%	6.43

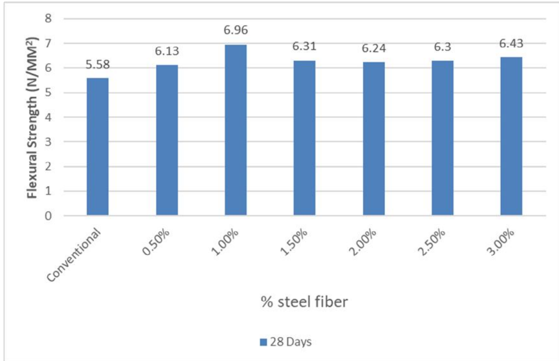

Fig. 3: Comparison of flexural strength using different percentage of steel fibers

OPTIMUM MIX RESULT

Mix proportion ratio-1:1.13:2.193 (steel fiber + pumice stone)

M-1-Cement (100%) +H SF (1.0%) + sand (100%) + CA (100%) + pumice (0%)

M-2-Cement (100%) + HSF (1.0%) + sand (100%) + CA (90%) + pumice (10%)

M-3-Cement (100%) +H SF (1.0%) + sand (100%) + CA (80%) + pumice (20%)

M-4-Cement (100%) +HSF (1.0%) + sand (100%) + CA (70%) + pumice (30%)

M-5-Cement (100%) + HSF (1.0%) + sand (100%) + CA (60%) + pumice (40%)

M-6-Cement (100%) + HSF (1.0%) + sand (100%) + CA (50%) + pumice (50%)

Table 5: Compressive strength test results for various proportions of light weight coarse aggregate (Pumice) and with steel fibre

	Percentage replacement of pumice stone	Compressive strength (N/mm²)		cube weights	Density of cube (kg/m³)
		7 days	28 days		
1% of steel fibers	conventional	48.96	71.47	8.88	2631.03
	10%pumice	43.56	62.69	8.65	2562.26
	20%pumice	39.41	54.65	8.02	2376.29
	30%pumice	34.65	47.51	7.80	2314.07
	40%pumice	31.25	39.61	7.41	2195.55
	50%pumice	28.87	37.51	7.26	2151.11

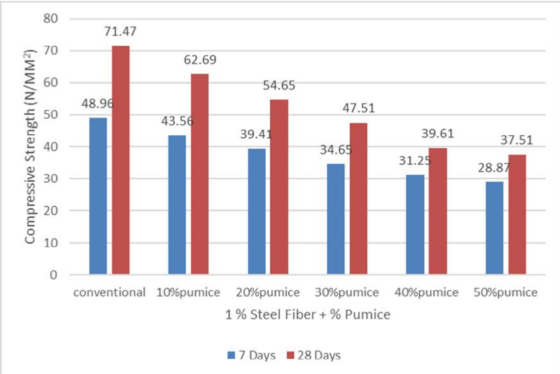

Fig.4: Compressive strengths for various proportions of pumice stone with steel fibers

Table 6: Split tensile strength test results for various proportions light weight coarse aggregate (Pumice) and with steel fiber

	Partial replacement of pumice	Split tensile strength
		28 days(N/mm²)
1% of optimum steel fiber	conventional	6.154
	10% pumice	4.956
	20% pumice	4.235
	30% pumice	3.864
	40% pumice	2.745
	50% pumice	2.412

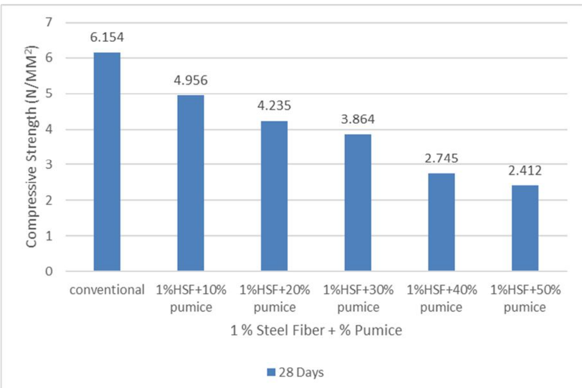

Fig.5 : Splittensilestrengths for various proportions of pumice stone with steelfiber

Table 7: Flexural strength test results for various proportions light weight coarse aggregate (Pumice) and with steel fiber

	Partial replacement of pumice	Flexural Strength test
		28 days(N/mm²)
1% of optimum steel fiber	conventional	7.11
	10% pumice	6.63
	20% pumice	5.86
	30% pumice	5.32
	40% pumice	4.65
	50% pumice	4.21

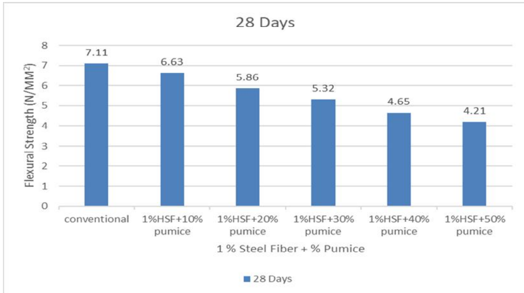

Fig. 6: Flexural strengths for various proportions of pumice stone with steel fibers

DURABILITY TEST RESULTS

Table 8: percentage of compressive strength loss and weight loss at 28 days.

	Percentage replacement of pumicestone	Percentage loss of weight in cubes	Percentage loss in strength
1% of steel fiber	Conventional	1.58	14
	1%HSF+10% pumice	1.12	13
	1%HSF+20% pumice	1.36	21
	1%HSF+30% pumice	2.31	28
	1%HSF+40% pumice	2.48	32
	1%HSF+50% pumice	2.75	35

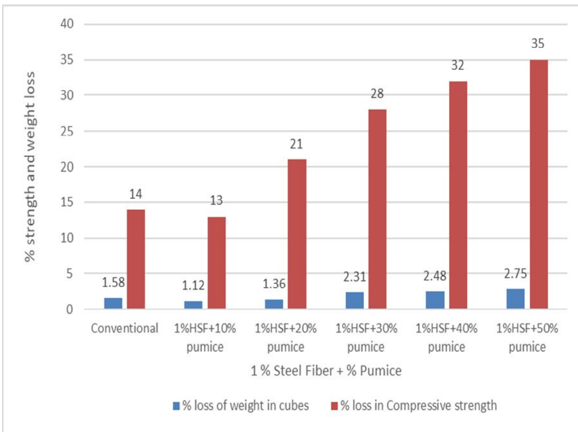

Fig. 7: percentage loss in strength and loss of weight in cubes

V. CONCLUSION

Following conclusions may be drawn based on the observations based on experimental investigation.

- With addition of 1% of steel fibres to M50 conventional concrete, there is an increase in compressive strength to 14.96%, tensile strength to 32.96%, flexural strength to 26.07% and further addition of steel fibres results in reduction of the strength.
- With the increase in pumice content in the concrete, the density of the concrete is decreased which reduce the weight of the concrete.
- With 20% of partial replacement of pumice to natural coarse aggregates, the strength of the concrete is within the limits of target mean strength and is acceptable, whereas further increase of pumice content resulted in the decrease of strength.
- Durability tests shows reduction in compressive strength by 22%, when tested against 5% H_2SO_4
- Though it is not a light weight concrete the density of concrete is reduced by 9.68% for promising strength results.
- Light Weight Aggregate is no way inferior to natural coarse aggregate and it can be used for construction purpose

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