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An Experimental Study on Compressive Strength of Steel Fibre Reinforced High Strength Light Weight Aggregate (Pumice Stone) Concrete

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Abstract:- Steel fiber reinforced concrete (S F R C) is a composite material developed to reduce the brittleness of concrete and dramatically increases its ductility. Steel fiber reinforced concrete (S F R C) is used extensively to line the tunnels and other underground structures, to increase the thickness of pavements, and to repair and strengthen various structures. Increasing utilization of lightweight materials in structural applications is making pumice stone a very popular raw material. More than the target means strength of M 50 concrete is achieved with 10 percent and 20 percent replacement of natural coarse aggregate by pumice aggregate, silica fume and with 1% & 1.5 percent of fiber. The compressive strength of pumice concrete is seen to increase with the fiber content and reaches an optimum value at 1.5% of fiber content and afterwards it gets decreased for various contents of pumice.

Keywords:- Cube Compressive Strength, Light Weight Aggregate Concrete, Natural Pumice Stone, Steel Fibre

I. INTRODUCTION

PUMICE is a natural sponge-like material of volcanic origin composed of molten lava rapidly cooling and trapping millions of tiny air bubbles. In recent years, the existing limited research that has been conducted in this area of structural concrete with compressive strength up to 50 M Pa can be produced with adequate economic benefits using pumice. Pumice is the only rock that floats on water, although it eventually becomes waterlogged and sinks. Worldwide, over 50 countries produce pumice products. The largest producer is Italy, which dominates pozzolonic production. Other major pumice producers are Greece, Chile, Spain, Turkey, and the United States. Pumice and pumicites are used to make lightweight construction materials. About three-quarters of pumice and pumicite are consumed annually for this purpose.

II. LITERATURE REVIEW

Banthia, N. and Trottier,J.,[1] conducted research on concrete reinforced with deformed steel fibers and suggested that in lightweight fiber reinforced concrete the addition of fibers produces an increase in compressive strength.

Compione, G., et all [2-4] suggested that brittle nature of lightweight aggregate can be overcome by increasing the ordinary confinement of transverse reinforcement and/or by adding reinforcing fibers to the concrete matrix. Also they have suggested that the presence of fibbers reduces material decay in the field of the strains exceeding that corresponding to the peak value of strength.

Balaguru, P.; and Ramakrishnan, V. [5] conducted research on Properties of fiber reinforced concrete and suggested that Properties of lightweight fiber-reinforced concrete resemble that of normal- weight concrete except for air entrainment. Controlling air content is the primary problem in lightweight fiber concrete. By incorporating high-range water-reducing admixtures, one can formulate lightweight fibber concrete that is of higher workability.

Campione G., Mindess S., and Zingone G. [6] suggested that in the case of normal weight or light weight high strength concrete fibers in combination with traditional steel reinforcements reduce the brittleness characterizing these advanced materials. Fibers improve ductility of concrete and avoid congestion of secondary reinforcements required in critical regions of structures designed in seismic zones. Lightweight concrete, which was largely utilized for its non-structural properties (as lagging or soundproofing material), has also been employed more recently to make structural elements, in particular in the field of precast concrete structures.

P.Muthupriya, K.Subramanian, B.G.Vishnuram [7] studied the behaviour of short columns produced from High Performance Concrete (HPC). In this investigation HPC grade M60 was manufactured with usual ingredients such as cement, fine aggregate, coarse aggregate, water and mineral admixtures such as silica fume and fly ash at various replacement levels and the super plasticizer(1.5% by weight of cement). The water binder ratio adopted was 0.3. specimens such as cubes, cylinders and prisms were casted and tested for various mixes viz., seven mixes M1 to M7 are casted with 0%,5%, 7.5% and 10% replacement of silica fume to cement and another replacement of fly ash to study the mechanical properties such as compressive strength, split tensile strength and flexural strength at different ages of concrete 3,7,28,56 and 90 days. The result showed that the optimum replacement of silica fume is at 7.5%.

III. EXPERIMENTAL INVESTIGATION

Mix design has been conducted for M 50 concrete making use of ACI-211:4R code with normal constituents of concrete like locally available UltraTech OPC 53 grade cement. river sand and mechanically crushed 20 mm conventional granite. Pumice light weight aggregate and steel fibre were procured from Nagpur.The experimental investigation is divided into two phases. In the first phase of investigation, natural granite aggregate is replaced with pumice stone in percentages of 10%,20% and 30% using silica fume as mineral admixture.Silica Fume was used in this study as a partial replacement to cement at a percentage of 7.5%. After getting the compressive strengths of the above said proportions, a strategy has been developed to improve the compressive strength by incorporating the steel fibers of type : Hooked end of length 35 mm and diameter 0.45 mm. For this study, 8 sets of cubes were casted with varying proportions of pumice stone and fibers, in which each set comprises of 3 cubes to determine the compressive strength of concrete.

IV. RESULTS AND DISCUSSIONS

4.1 Comparison of Compressive Strengths with partial replacement of Pumice Stone

The following tabular form presents the compressive strengths of various proportions of M30 grade concrete mix with and without the partial replacement of Light Weight Aggregate (Pumice Stone).

Table 1: Cube Compressive Strength with Pumice Stone and Silica Fume

S.No	Mix Designation	Compressive Strength (28 days) N/mm^2
1.	M50 Control Mix	59.00
2.	M50 (7.5% SF+10% PS)	57.77
3.	M50 (20% PS)	55.55
4.	M50 (30% PS)	53.33
5.	M50 (40% PS)	44.44

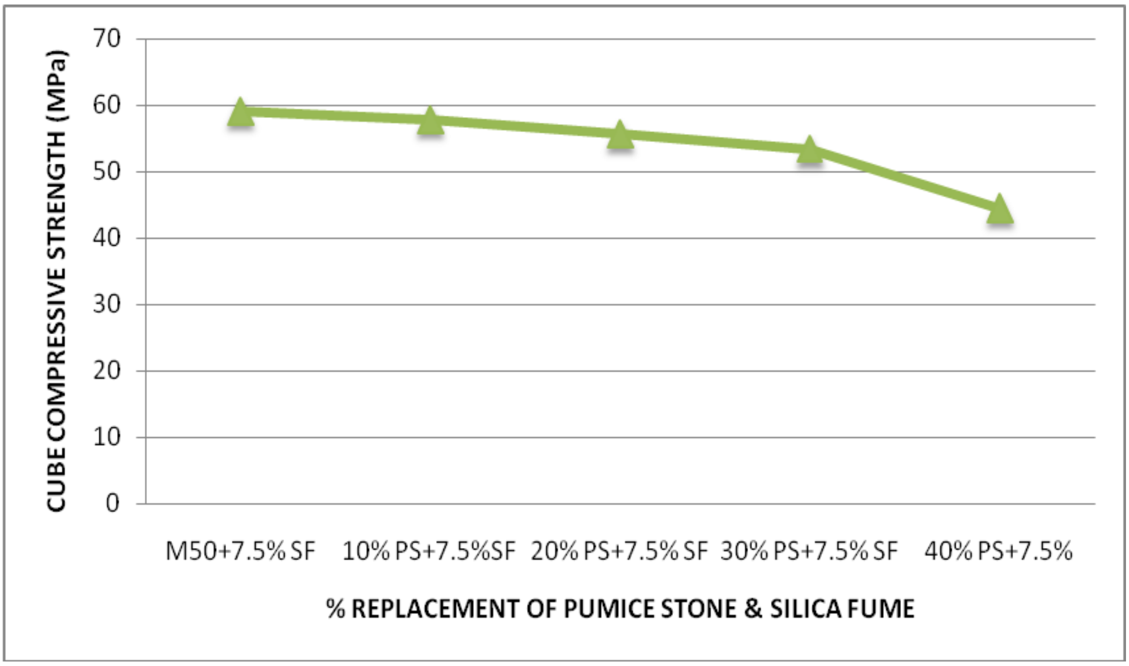

Fig: 1 Cube Compressive Strength (Mpa) with the replacement of Pumice Stone

From table:1 & fig.1, it is seen that with the replacement of 10%,20% and 30% Pumice Stone with natural coarse granite aggregate, the compressive strengths are consistently decreasing. Hence a strategy is made to improve the compressive strength of 30% replacement of pumice stone by adding steel fibers.

4.2 Comparison of Compressive Strengths with partial replacement of Pumice Stone & addition of steel fibers

Table 2: Cube Compressive Strength with Pumice Stone and Steel Fibers

S. No	Mix Designation	Compressive Strength (28 days) N/mm^2
1.	M50 (30% PS) 0.5% SF	60.00
2.	M50 (30% PS) 1% SF	61.77
3.	M50 (30% PS) 1.5% SF	63.11
4.	M50 (30% PS) 2% SF	60.88

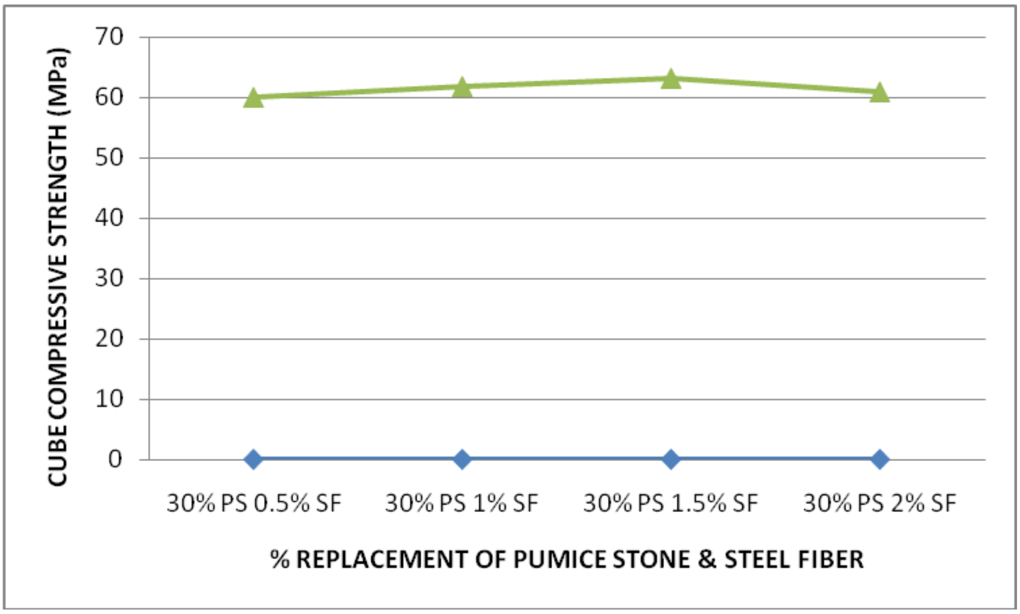

Fig: 2 Cube Compressive Strength (Mpa) with the replacement of Pumice Stone & addition of Steel Fiber

From table:2 & fig.2, it is seen that with the addition of steel fibers the compressive strength is increasing relatively when compared with the cube compressive strength of replacement by pumice stone.

Hence, it is concluded that by the 30% replacement of natural aggregate by 30% pumice and with 1.5% fiber is supposed to be optimum percentage with respect to compressive strength within the scope of present investigation. Also pumice content of 20% without fiber is supposed to be the recommendable range to achieve the design strength of concrete and the value is around 55.55 N/mm^2.

4.3 Weight reduction of Cube Specimens

The Weight of the cube specimens with varying proportions of light weight coarse aggregate (Pumice Stone) are as follows

Table 3: Weight of Cube Specimens with Pumice Stone

S. No	Mix Designation	Average Weight of Cube Specimen in Kgs.
1.	M50 Control Mix	9.81
2.	M50 (10% PS)	8.53
3.	M50 (20% PS)	8.46
4.	M50 (30% PS)	8.37
5.	M50 (40% PS)	8.22

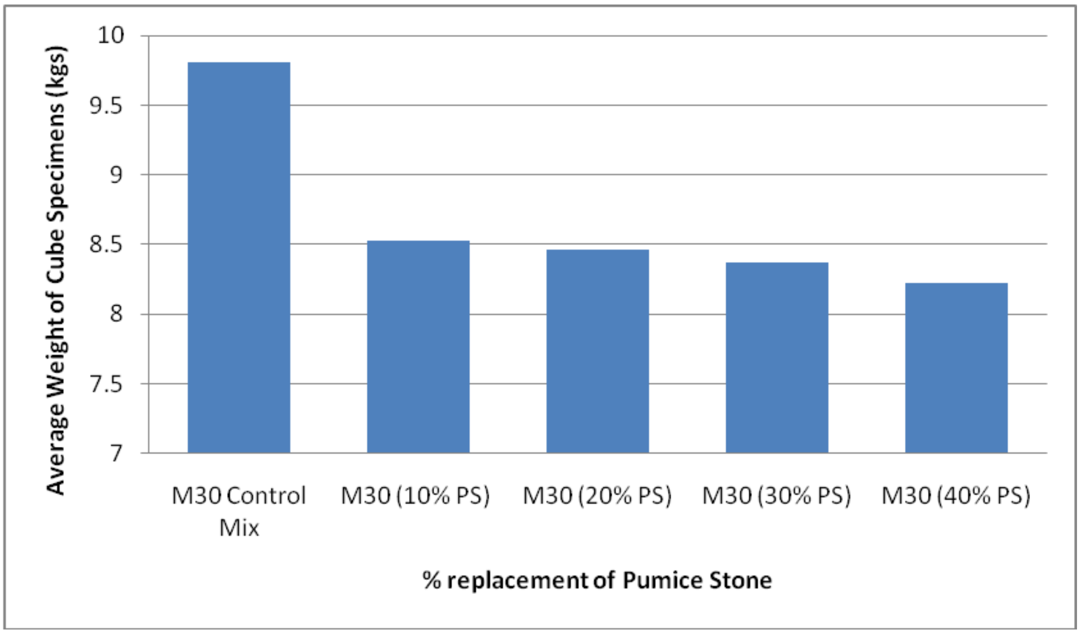

Fig.3 Average Weight of Cube Specimens (kgs)

From Fig.3 , it is observed that by the replacement of pumice stone with natural granite aggregate, there is a weight reduction considerably. Even though the weight loss is reduced considerably in 40% replacement of pumice stone, the cube compressive strength is not upto the mark of the design grade strength i.e., 50N/mm$^{2.}$

Fig: 4 Hooked End Steel Fibers used in study

V. CONCLUSIONS

1. The density of concrete is found to decrease with the increase in percentage replacement of natural aggregate by pumice aggregate.
2. The compressive strength of concrete is found to decrease with the increase in pumice content. It is found to decrease from 59.00 to 53.33 with the increase in pumice stone replacement from 10 to 30%.

3. The compressive strength of pumice concrete is seen to increase with the fiber content and reaches an optimum value at 1.5% of fiber content and afterwards it gets decreased for various contents of pumice.
4. Pumice content of 20% without fiber is supposed to be the recommendable range to achieve the design strength of concrete and the value is around 55.55 N/mm^2.
5. With the addition of Steel Fiber, the compressive strength of the trail mixes has improved effectively while comparing with the other trail mixes.
6. Finally, the weight reduction of the specimens with Pumice Stone is more compared with the weights of specimen with normal aggregate which, in turn results in the reduction of self weight of structure.

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