# Fibre Reinforced Light Weight Aggregate (Natural Pumice Stone) Concrete

N. Sivalinga Rao, Y.Radha Ratna Kumari, V. Bhaskar Desai, B.L.P. Swami

**Abstract**— Steel fibre reinforced concrete (S F R C) is a composite material developed to reduce the brittleness of concrete and dramatically increases its ductility. Steel fibre 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 $M_{20}$ concrete is achieved with 20 percent replacement of natural coarse aggregate by pumice aggregate and with 1.5 percent of fibber. Also with 40% pumice and with 0.5% of fibbers average target mean strength of $M_{20}$ concrete is achieved. 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.

**Index Terms**— Cube Compressive Strength, Cylinder Split Tensile Strength, Impact Resistance of slabs, Light Weight Aggregate Concrete, Natural Pumice Stone, Steel fibre, Strain energy Stored in Beams.

## 1 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 25 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.

## 2 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 fibbers 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.

Campione G., Cucchiara C., La Mendola L., Papia M.[8] suggested that although lightweight concrete is characterized by brittle behaviour it is possible to achieve the ductility required for seismic purposes by using adequate percentages of short fibbers. Also observed that, using fibers only moderate effects in terms of maximum and residual strength were increased.

## 3 EXPERIMENTAL INVESTIGATION

Mix design has been conducted for $M_{20}$ concrete making use of IS 10262:2009 code with normal constituents of concrete like locally available UltraTech OPC 43 grade cement, Pandameru


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river sand and mechanically crushed 20 mm conventional granite. Pumice light weight aggregate and steel fibre of size 0.6 mm dia and 25 mm length were procured from Turkey and Nagpur. In the course of investigation, normal granite aggregate has been replaced by 0%, 20%, 40%, 60%, 80% and 100% of light weight aggregate namely pumice by volume. In the present investigation the crimpled steel fibbers are added in equal proportions in five percentages i.e. 0, 0.5, 1.0, 1.5, 2.0. For the study of various properties, different specimens have been casted and tested. Here a constant water cement ratio of 0.50 has been adopted along with the usage of super plasticizer (SP-430) to maintain more or less same workability throughout the investigation.

### 3.1 Reinforcement Details

**Beams:** For casting of beams steel cages are prepared with Fe-415 grade Steel bars. Steel cage consists of 12 mm bars two at bottom and two at top with 8 mm diameter stirrups at 120 mm C/C.

**Slabs:** The slabs are also cast with reinforcement cage of Fe-415 grade Steel bars. The reinforcement for a square slab provided as a square mesh with 8 mm dia. bars in both ways at 100 mm C/C. The reinforcement for a slab is shown in Plate 1.3.

## 4 Results and Discussions

The 20% replacement of natural aggregate by 20% pumice and with 1.5% fiber is supposed to be optimum percentage with respect to compressive strength within the scope of present investigation. However with 40% pumice content and 0.5% of fibers more or less the target mean strength of M20 concrete 25.13 N/mm2 is achieved. For this combination more than target mean strength of M20 concrete (30.25 N/mm2) of the concrete is achieved. 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 23 N/mm2.

The replacement of natural aggregate by 20% pumice and 1.5% percentage of fiber is supposed to be optimum percentage, since for this combination maximum split tensile strength of the concrete is achieved. Also pumice content of 20% with out fibers is supposed to be the recommendable percentage as with 20% pumice maximum split tensile strength of concrete is achieved.

It is seen that at 1.5% of fiber and with 40% replacement of natural aggregate 40% pumice yields maximum strain energy.

It is also seen that at 0.5% of fiber and 100% replacement of natural aggregate by 100% pumice yields maximum strain energy.

From the investigation it is observed that 20% replacement of natural aggregate by 20% pumice and with 1.5% fiber is supposed to be optimum percentage, since for this combination higher number of blows is achieved. Also pumice content of 20% without fiber is supposed to be the recommendable range to achieve optimum impact value.

TABLE 1
CUBE COMPRESSIVE STRENGTH

| S No | CGA:PSA | Identification Mark | Compressive Strength (28Days) in N/mm$^2$ |
|---|---|---|---|
| 1 | 100:0 | N | 32.75 |
| 2 | 80:20 | $P_2$ | 22.93 |
| 3 | 60:40 | $P_4$ | 15.8 |
| 4 | 40:60 | $P_6$ | 14.35 |
| 5 | 20:80 | $P_8$ | 10.56 |
| 6 | 0:100 | $P_{10}$ | 7.95 |

TABLE 2
CYLINDER SPLIT TENSILE STRENGTH

| S No | CGA:PSA | Identification Mark | Split Tensile Strength in N/mm$^2$ (28Days) |
|---|---|---|---|
| 1 | 100:0 | N | 3.50 |
| 2 | 80:20 | $P_2$ | 2.72 |
| 3 | 60:40 | $P_4$ | 2.15 |
| 4 | 40:60 | $P_6$ | 1.54 |
| 5 | 20:80 | $P_8$ | 1.46 |
| 6 | 0:100 | $P_{10}$ | 1.22 |

TABLE 3
STRAIN ENERGY STORED IN BEAMS

| S No | CGA:PSA | Identification Mark | Strain Energy Stored in Beam (N/mm$^2$) |
|---|---|---|---|
| 1 | 100:0 | N | 17906.68 |
| 2 | 80:20 | $P_2$ | 17815.17 |
| 3 | 60:40 | $P_4$ | 15442.09 |
| 4 | 40:60 | $P_6$ | 15283.54 |
| 5 | 20:80 | $P_8$ | 12485.23 |
| 6 | 0:100 | $P_{10}$ | 11270.36 |

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TABLE 4
CYLINDER MOULD IMPACT RESISTANCE

| S No | CGA:PSA | Identification Mark | Strain Energy Stored in Beam ($N/mm^2$) |
|---|---|---|---|
| 1 | 100:0 | N | 17906.68 |
| 2 | 80:20 | $P_2$ | 17815.17 |
| 3 | 60:40 | $P_4$ | 15442.09 |
| 4 | 40:60 | $P_6$ | 15283.54 |
| 5 | 20:80 | $P_8$ | 12485.23 |
| 6 | 0:100 | $P_{10}$ | 11270.36 |

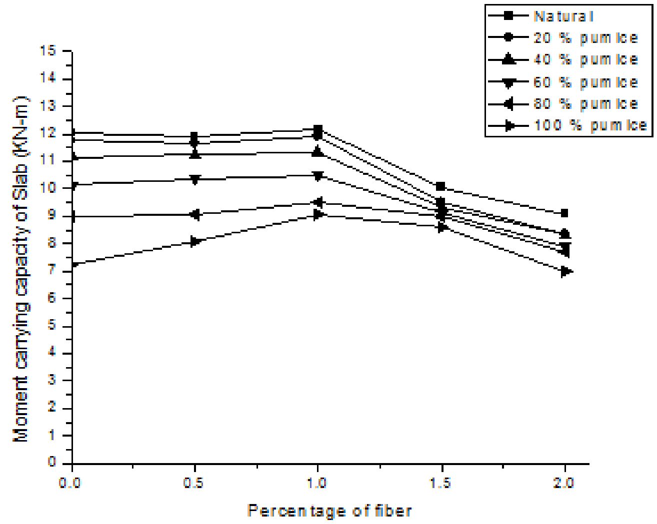


Fig. 3. Variation of Moment carrying capacity of slab vs. % of fibre

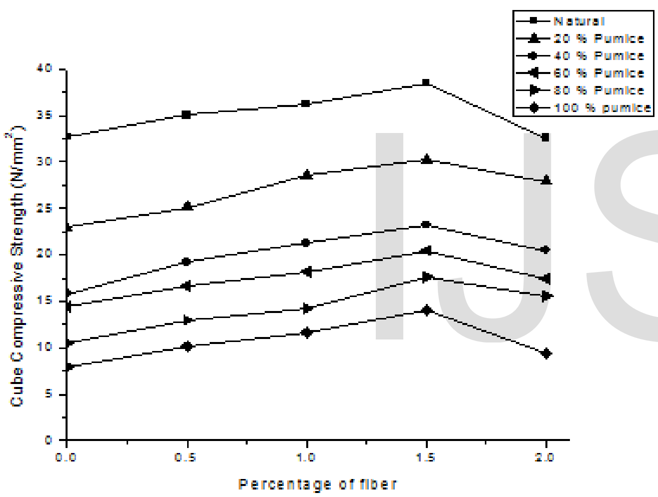


Fig. 1. Variation of cube compressive strength

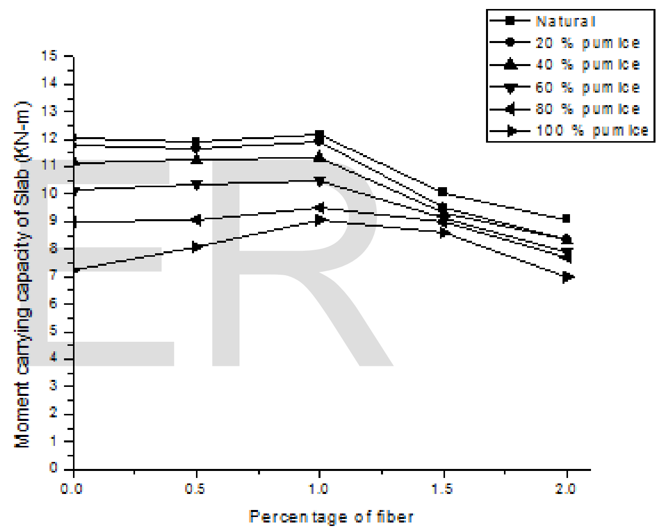


Fig. 4. Variation of No of Blows vs. % of fibre

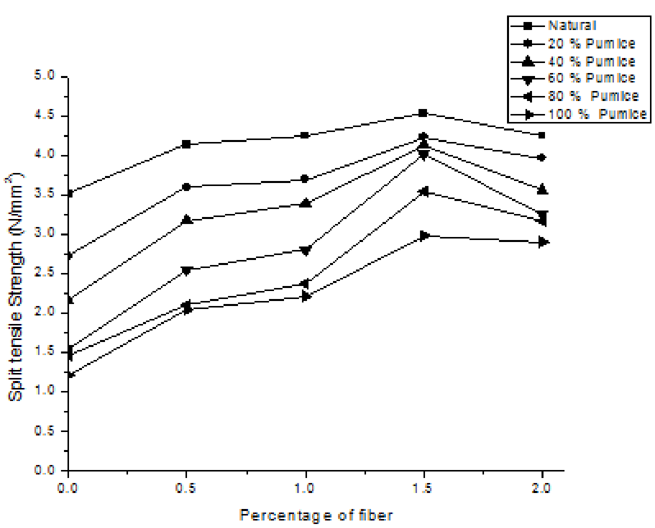


Fig. 2. Variation of split tensile strength

Plate. 1. Steel fibres

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Plate. 2. UDL Slab Pattern

Plate. 3. Two Point Load Arrangement

Plate. 4. Impact Mould

## 5. 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 32.75 to 7.95 M Pa as the pumice content is increased from 0 to 100 percent.
3. The compressive strength of pumice concrete is seen to increase with the fibber content and reaches an optimum value at 1.5% of fibber content and afterwards it gets decreased for various contents of pumice.
4. The split tensile strength of blended concrete is found to vary from 3.50 to 1.22 MPa with the replacement of natural aggregate by pumice from 0 to 100 percent.
5. The moment carrying capacity of slabs is found to vary from 12.05 K N-m to 7.23 K N-m with the replacement of natural aggregate by pumice from 0 to 100 percent. At 1.0 percentage of fibber the optimum values of moment carrying capacity are observed and afterwards it gets decreased for various contents of pumice.
6. The strain energy values stored in slabs varies are observed to vary 156671.68 to 52307.96 units with the replacement of natural aggregate by pumice from 0 to 100 percent. At 0.5% of fibber with 100% pumice optimum strain energy 46386.65 units is observed in case of slabs.
7. The impact values are optimum at 1.5% of fibber content for each percentage of pumice content considered in this investigation. The optimum value is achieved at the combination of 20% pumice content with 1.5% of fibber content.

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