Study on Properties of Fibre Reinforced Light Weight Aggregate Concrete

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Abstract— Lightweight concrete is commonly used in civil engineering field, especially as a filler material (or) for the manufacture of heat and sound insulating units. In most industrialised countries, lightweight concrete production is performed by using a highly mechanised processes based on different automation techniques. Various artificial and natural porous aggregates are generally used in these types of concrete. All the porous aggregates have their own characteristic properties, which markedly affect the properties of lightweight concrete. Among the lightweight concrete, pumice concrete was generally considered as being unsuitable for load bearing uses. Increasing utilization of lightweight materials in structural applications is making pumice stone a very popular raw material. The experimentations are designed by replacing the coarse aggregates by pumice aggregates in different percentage, such as 10%, 20%, 30%, 40%, and 50% for M20 grade concrete. From this replacement, the optimum value is achieved at 30% and 0.5%, 1%, 1.5% of polyester (Recron 3s) fiber is added. The compressive strength, splitting tensile strength of concrete samples made with different fibers amounts varies from 0%, 0.5%, 1%, 1.5% were studied. The compressive strength, Split tensile strength and flexural strength of pumice concrete is seen to increase with the fiber content and reaches an optimum value. The samples with added Polyester fibers of 1% showed better results in comparison with the others.

Key words: Pumice Stone, Recron 3s Fibre, Compressive Strength, Split-Tensile Strength, Flexural Strength

I. INTRODUCTION

A. General:
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 nailability 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 in strength.

Therefore, this fundamental research report is prepared to show activities and progress of the lightweight concrete. Focused were on the performance of lightweight concrete such as compressive strength tests, water absorption and density and supplementary tests and comparisons made with other types of lightweight concrete.

II. MATERIAL INVESTIGATION

A. Materials Used:
1) Cement:
The cement used should confirm to IS specifications. There are several types of cements are available commercially in the market of which Portland cement is the most well-known & available everywhere. OPC 53 grade was used for this study. The physical properties of the cement tested according to standard procedure conform to the requirement of IS 12269: 1989.

2) Aggregates:
   – Fine Aggregate
   Locally available river sand passing through 4.75mm sieve conforming to the recommendation of IS383-1970 is used.
   Specific gravity of fine aggregate is 2.66.
   – Coarse Aggregate
   Coarse aggregates to be used for production of concrete must be strong, impermeable, durable & capable of producing a sufficient workable mix with minimum water cement ratio to achieve proper strength. Locally available coarse aggregate retaining on 4.75mm sieves is used. Specific gravity of coarse aggregate is 2.9.

3) Pumice Aggregate:
The name “Pumice” is a generic term for a range of porous vesicular materials produced during explosive volcanic eruptions. Pumice is essentially composed of solidified frothy lava which is generally rhyoliti in composition, but can also be produced in a less acid form.

Fig. 1: Pumice Stone

a) Chemical Properties:
Pumice is a pozzolanic material because of its reaction with lime (calcium hydroxide) liberated during the hydration of cement (Jackson, 1983). Amorphous silica present in the
pozzolanic materials combines with lime and forms cementitious materials.

b) Porosity and Water Absorption

The porosity and water absorption characteristics greatly affect the properties of the fresh mix, as well as the hydration properties. According to ASTM C566 (1997).

c) Aggregate Strength

BS 812 (Part III), 1990 describes a method for the determination of ten percent fines value (TFV) of aggregates, which give a relative measurement of resistance of an aggregate to crushing under a gradually applied compressive load.

- Properties Of Pumice Aggregate:
  - Size: 12.5mm
  - Fineness modulus: 7.3mm²/kg
  - Specific gravity: 2.35
  - Water absorption: 25%

4) Polyester Fibers (PP):

The fibres used were fine polyester monofilaments. The fibers were supplied by Reliance Industry by name RECRON 3s. It is available in 3 different sizes i.e 6mm, 12mm and 24mm. In the present investigation 12mm fiber length is used.

Fig. 2: Recron 3S Fiber

- Properties Of Polyester Fiber:

<table>
<thead>
<tr>
<th>Properties</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength</td>
<td>600 MPa</td>
</tr>
<tr>
<td>Density</td>
<td>1.36 kg/cm³</td>
</tr>
<tr>
<td>Fiber length</td>
<td>12mm</td>
</tr>
<tr>
<td>Fiber Diameter</td>
<td>0.37mm</td>
</tr>
<tr>
<td>Aspect ratio</td>
<td>32.43</td>
</tr>
</tbody>
</table>

Table 1:

5) Water:

The quality of mixing water for concrete has a visual effect on the resulting hardened concrete. Impurities in water may interfere with setting of cement & will adversely affect the strength and durability of concrete with fibers.

B. Concrete Mix Proportions:

The Control mix was designed as per IS: 10262-2009 for M20 grade concrete. Five concrete mixes (F-10, F-20, F-30, F-40, F-50) were made by replacement of coarse aggregate by pumice stone in 10%, 20%, 30%, 40% and 50% respectively. The recron fiber of three different percentages 0.5%, 1% and 1.5% by volume of concrete was added to the optimum pumice stone replacement. The water-cement ratio used in the experimental work was 0.5.

Mix Proportion Ratio: 1:1.54: 3.33

C. Hardened Concrete Properties:

Specimens of 150mm x 150mm x 150mm concrete cubes were casted for compressive strength, 150mm x 300mm cylinders for splitting tensile strength and 500mm x 100mm prisms for flexural strength. After casting, the specimens were and left in casting room for 24hours at a room temperature. Then, they were demolded and cured.

Various tests performed were compressive strength test of cubes (IS: 516-1959), split-tensile strength of cylinders (IS: 5816-1959.) and flexural strength of prisms (IS: 516-1959) at 14 and 28 days.

III. RESULTS AND DISCUSSION

![Fig. 2: Compressive Strength Test Results for Pumice Stone at 14&28 Days](image)

With the optimum 20% pumice stone, carbon fibres were added at three different percentages 0.5%, 0.1% and 1.5%. Test results showed that, the maximum strength achieved at 1% recron fibre addition and beyond that strength reduces due to balling effect of fibres in concrete. Figure shows the compressive test results for pumice stone (20%) and recron fibres (0.5%, 1% and 1.5%) at different proportions.

A. Hardened Concrete Test Results:

For M20 grade conventional concrete and fiber reinforced concrete the compressive strength, tensile strength and load deflection test results are conducted. LWC values are lower than conventional concrete higher concentration (in terms of molar).

1) Compressive Strength:

Natural aggregate is replaced at 10%, 20%, 30%, 40% and 50% with pumice stone. Increasing the amount of pumice stone up to 30% caused an increase in compressive strength at 14 and 28 days. At 14 days, the percentage increase in compressive strength was obtained at 20% replacement at 14 and 28 days. Figure 2 shows the compressive strength test results for pumice stone at different proportions. Beyond 20% replacement, the lack of compressive strength of the concrete mixtures could probably due to increase in surface area of fine particle led to the reduction in water cement gel in matrix; hence binding does not take place properly.

With the optimum 20% pumice stone, carbon fibres were added at three different percentages 0.5%, 0.1% and 1.5%. Test results showed that, the maximum strength achieved at 1% recron fibre addition and beyond that strength reduces due to balling effect of fibres in concrete.
Figure shows the compressive test results for pumice stone (20%) and recron fibres (0.5%, 1% and 1.5%) at different proportions.

B. Split Tensile Strength:

Maximum Splitting Tensile strength obtained at 20% replacement of pumice stone and 1% fibre addition. Figure 3 shows the split tensile strength of pumice stone and recron fibre.

![Split Tensile Strength Test Results for Pumice Stone at 14 & 28 Days](image)

Table 2: Test Results of Hardened Concrete (With the Addition of Polyester Fiber)

<table>
<thead>
<tr>
<th>Mix ratio</th>
<th>Compressive strength N/mm²</th>
<th>Split tensile strength N/mm²</th>
<th>Flexural strength N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14day s</td>
<td>28day s</td>
<td>14day s</td>
</tr>
<tr>
<td>0%</td>
<td>22.95</td>
<td>26.95</td>
<td>1.88</td>
</tr>
<tr>
<td>0.5%</td>
<td>25.10</td>
<td>29.15</td>
<td>2.38</td>
</tr>
<tr>
<td>1%</td>
<td>26.95</td>
<td>30.20</td>
<td>2.75</td>
</tr>
<tr>
<td>1.5%</td>
<td>25.98</td>
<td>28.85</td>
<td>2.54</td>
</tr>
</tbody>
</table>

C. Flexural Strength:

Higher value of flexural strength is observed at 20% pumice stone at 28 days. Further replacement of pumice stone beyond 20% decreases the strength. The optimum strength attained at 1% recron fibre addition. Figure 4 shows the flexural strength test results for pumice stone and recron fibre at 28 days.

While increasing the percentage replacement of pumice Stone at the beginning increases the strength of Concrete because of its filler effect; i.e., filling the voids in concrete and densifies the concrete. The decrease strength beyond 20% replacement reduces the binding strength of concrete. Coarse aggregate higher replacement of pumice stone in concrete also leads to the formation of voids and increases water demand in concrete. An optimum increase in compressive, split tensile and flexural strength is obtained for a recron Fibre content of 1% of cement weight in the concrete. The substitution of fine aggregate by pumice stone increases the strength of samples for any percentage of recron fibre as a consequence of the reduction of porosity.

![Flexural Strength Test Results for Pumice Stone at 14 & 28 Days](image)

IV. Conclusion

- The compressive strength of concrete is found to decrease with the increase in pumice content. But when polyester fiber is added in the concrete the strength will increase from 22.95N/mm² to 26.95N/mm² in 1% of fiber and strength decrease after 1.5% for 14 days and for 28 days strength will increase from 26.95N/mm² to 30.02N/mm².
- The split tensile strength of concrete is found to decrease with the increase in pumice Content. But when polyester fiber is added in the concrete the...
The flexural strength of concrete is found to decrease with the increase in pumice content. But when polyester fiber is added in the concrete the strength will increases from 1.88 N/mm² to 4.58 N/mm² in 1% of fiber and strength decrease after 1.5% for 14 days and for 28 days strength will increase from 2.35 N/mm² to 5.75 N/mm².

REFERENCE