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Research Article

Compressive strength test on Porous concrete manufactured using Pumice Stone.

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ABSTRACT

In this study, Pumice stone is used as a replacement for coarse aggregate. The replacement is done with a percentage of 15, 20, 25 and 30. Before replacement various tests are conducted on various constituents of concrete such as cement, coarse aggregate, fine aggregates and also on pumice stone. The results obtained are satisfactory. After finding the initial test results on materials, we designed the mix for a grade of 35. The various constituents with and without replacement of coarse aggregates are discussed. After mix are prepared they are tested for compressive strength test for 3 days, 7days and 21 days. The optimum results by replacing coarse aggregate with pumice stone are obtained at a mix of 20% replacement. The results obtained are 13.02, 22.79 and 31.91 N/mm^2 for 3, 7 and 21 days respectively.

Keywords: Pumice stone, Porous Concrete, Compressive strength test, Cement.

Introduction:

In general concrete, the ingredients are cement, water, coarse aggregates and fine aggregates. These ingredients make concrete have properties such as high compressive strength, tensile strength, flexural strength, non-porous, zero permeability and less hydraulic properties. To alter the hydraulic properties of normal concrete, sometimes along with admixture we do alteration in these main ingredients also such as by replacing them with other similar properties materials. In cement we add some pozzolonic materials to enhance its density and strength while reducing its porosity and permeability. For water replacement we can use various types of plasticizers and super plasticizers to enhance its rheological and workability properties. For coarse and fine aggregates various type of materials are used now a days.

Pumice Stone:

Pumice stone which is obtained from volcanic eruptions have found to a greater use in replacing the coarse aggregate as well as fine aggregates. The properties of pumice stone are as follow:

- Their density is low
- Weight is less
- Floats on water
- Low specific gravity
- High water absorption percentage.

Due to these above specified these pumice are used in various places such as in construction of light weight concrete, filler materials, acoustic barrier, and porous roads and also to reduce damage in earthquake prone areas.
In this study, we are going to use pumices stone as a replacement of coarse aggregates in concrete of grade M35 and discuss the results obtained.

Material and its properties:

The following materials are used in this study:

- Cement
- Coarse aggregate
- Fine aggregate
- Pumice Stone
- Water
- Plasticizer

Cement:

The grade of cement which we are using in this study is of 53 grade. The approximate chemical composition and physical requirement of OPC of 43 Grade as per IS code 8112:2013 are given in table no 1 and 2 respectively.

Table no 1: Chemical requirement of Cement of 43 Grade.[IS 8112:2013].

Sl No.	Characteristic	Requirement
1	Ratio of percentage of lime to percentages of silica, alumina and iron oxide, when calculated by the formula: $(CaO\ 0.7\ SO_3)/(2.8\ SiO_2 + 1.2\ Al_2O_3 + 0.65\ Fe_2O_3)$	0.66-1.02
2	Ratio of percentage of alumina to that of iron oxide, Min	0.66
3	Insoluble residue, percent by mass, Max	4.4
4	Magnesia, percent by mass, Max	6
5	Total sulphur content calculated as sulphuric anhydride (SO_3), percent by mass, Max	3.5
6	Loss on ignition, percent by mass, Max	5
7	Chloride content, percent by mass, Max	0.1
8	Alkali content	0.05 (for prestressed structures)

Table no 2: Physical requirement of Cement of 43 Grade.[IS 8112:2013].

Sl No.	Characteristic	Requirement
1	Fineness, m^2 /kg, Min	225 370
2	Soundness:	
	a) By Le Chatelier method, mm, Max	10
	b) By autoclave test method, percent, Max	0.8
3	Setting time: IS 4031 (Part 5)	
	a) Initial, min, Min	30
	b) Final, min, Max	600
4	Compressive strength, MPa	
	a) 72 ± 1 h, Min	23
	b) 168 ± 2 h, Min	33 37.5 for 43-S grade
	c) 672 ± 4 h, Min	43
	Max	58

Coarse Aggregates:

The size of coarse aggregates utilized in this test ranges from 10-20 mm. The Aggregates passing from 20mm sieve and retained on 10 mm sieve are selected for this experiment. These aggregates are of mix broken boulder aggregates bought from Local market in Greater Noida.

Fine aggregates:

Fine aggregates used in this study are od river sand having size smaller than 4.75 mm or passing through 4.75 mm sieve. The sand is also should be free from silt, clay and organic matter to obtain precise results.

Water:

Water utilized is tested for various impurities such ad organic and inorganic matter to ensure that any ill effects over the strength, void ratio or porosity are avoided. The water which we have taken is from regular filtered water directly from taps or we can say that it is a portable water. The water is used in two different places one for mixing the components and another for curing the specimens.

Pumice stone:
The pumice stone utilized in this study are bought from gardening equipment store from Delhi. They are crushed and then sieved. The Pumice stone aggregates passing from 20mm sieve and retained on 10 mm sieve are selected for this experiment. The general chemical composition of pumice stone is shown in table no 3.

Table no 3: General chemical characteristics of pumice stone. (observed by N. Bhavana and CH. Rambabu.[5])

Chemical Composition	Values (%)
	Pumice Stone
Silicon Dioxide	71.91
Aluminum Oxide	12.66
Ferric Oxide	1.13
Calcium Oxide	1.46
Magnesium Oxide	0.32
Sodium Oxide	3.45
Potassium Oxide	4.3
Sulphur Trioxide	0.03
Calcification	4.53
Indefinable Content	0.21

Plasticizer:
For reducing water cement ratio or we can say water requirement for mixing the components of concrete plasticizer is used. The plasticizer used is of Asian Paint Smart-care brand. This plasticizer is only used for concrete.

Methodology:

The test are performed on concrete as well as its materials which we are using in this study.

Test on Cement:
• **Water consistency test (As per IS 4031–Part 4:1988):**The water requirement for a paste of cement to bring to a particular viscosity when used to fill vicat's apparatus giving a reading of 33-35mm from top or 5-7 mm from bottom is termed as its normal standard consistency expressed in percentage by weight.

• **Initial and final setting time of cement (As per IS 4031–Part 5:1988):**When water is added, the cement start reacting resulting in setting as the time elapses. When we use a needle of 1mm2 section causes a penetration of 35 mm in vicat's apparatus, at this duration, initial setting time is obtained. Similarly, when we use a needle of 1mm2 section causes no penetration in vicat,s apparatus, at this duration, final setting time is obtained. Both of these value are expressed in minutes.

• **Fineness test of cement (As per IS 4031–Part 1:1996):**The reaction amongst cement particles and water directly depends on surface area which is increased by fine grinding. The finer particle higher the heat of hydration and rate of development of strength is higher.

Test on Coarse Aggregates:
• **Crushing value of Coarse aggregate (As per IS 2386–Part 4:1963):**When a compressive load is given progressively to coarse aggregates, the Aggregate Crushing Value Test provides a relative indicator of the aggregate's resistance. The proportion of crushed material by weight that results from subjecting test aggregates to a given load under uniform circumstances is known as the coarse aggregate crushing value.

• **Impact value of Coarse aggregate (As per IS 2386–Part 4:1963)**Toughness is a material's ability to withstand impact. The road's movement causes the aggregates to be impact-prone, which causes them to fragment into smaller pieces. It is imperative that the aggregates possess adequate toughness to withstand disintegration caused by impact. The impact value test measures this attribute. The ability to withstand a rapid shock or impact is measured by the aggregate impact value.

Test on Pumice Stone used as Coarse Aggregates:
• **Crushing value of Pumice Stone used as Coarse aggregate:**As we are using pumice stone in replacement of coarse aggregate, therefore we will perform the same standard test of crushing value as per IS 2386-Part 4:1963.

• **Impact value of Pumice Stone used as Coarse aggregate:**As we are using pumice stone in replacement of coarse aggregate, therefore we will perform the same standard test of impact value as per IS 2386-Part 4:1963.

Test on hardened Concrete:

• **Compressive strength test (IS Code 516:1959):**A specimen of 150mm x 150mm x 150mm is utilized for sample preparation. The cube is oiled and then prepared concrete is poured and compacted. After 24 hrs., the specimen is taken out and put into curing pond for curing and strength test are performed.

The ability of a material or structure to support loads on its surface without cracking or deflecting is known as its compressive strength. Under compression, a material's size tends to decrease, but under tension, it elongates. Any material's compressive strength can be calculated by applying a load on the face's cross-section area at the point of failure.

Compressive Strength = Load / Cross-sectional Area

Result analysis:

Cement:

The test as stated earlier, performed as per IS code mentioned along with them. The results obtained for 43 Grade Cement is shown in table no 4.

Table no 4: Properties of Cement,

Sr. No.	Properties of Cement	Values	Is Code
1	Water consistency test	31%	IS 4031–Part 4:1988
2	Initial setting time of cement	34 Mins	IS 4031–Part 5:1988
3	Final setting time of cement	624 Mins	IS 4031–Part 5:1988
4	Fineness test of cement	2.90%	IS 4031–Part 1:1996

From above obtained results, it is observed and concluded that values are as per required standard results. Slight fluctuation can be seen which could be result of change in atmospheric conditions like temperature, moisture content etc. as responsible. .

Coarse Aggregates:

The test as stated earlier, performed as per IS code mentioned along with them. The results obtained are shown in table no 5.

Table no 5: Result for tests conducted on Coarse aggregates.

Sr. No.	Properties of Cement	Values	Is Code
1	Crushing value	21.10%	IS 2386–Part 4:1963
2	Impact value	14.57 %	IS 2386–Part 4:1963

From above obtained results, it is observed and concluded that values are as per required standard results. Slight fluctuation can be seen which could be result of change in atmospheric conditions like temperature, moisture content etc. as responsible.

Pumice stone as Coarse Aggregates:

The test as stated earlier, performed as per IS code mentioned along with them. The results obtained are shown in table no 6.

Table no 6: Result for tests conducted on Pumice Stone.

Sr. No.	Properties of Cement	Values
1	Crushing value	29%
2	Impact value	26.60%

Mix Design Proportion:

The grade of concrete used for the study is M35 grade. As per calculation the various mix proportion calculated as shown in table no 7.

Table no 07: Mix Design.

Designation	Cement (Kg/M³)	Water/Cement Ratio	Plasticizer	Water (l)	Coarse Aggregate (Kg/M³)	Pumice Stone (Kg/M³)
N.C	3	0.35	3.00%	157.5	450	1340
M1 (15%)	3	0.35	3.00%	157.5	450	1139
M2 (20%)	3	0.35	3.00%	157.5	450	1072
M3 (25%)	3	0.35	3.00%	157.5	450	1005
M4 (30%)	3	0.35	3.00%	157.5	450	938

Compressive strength test:

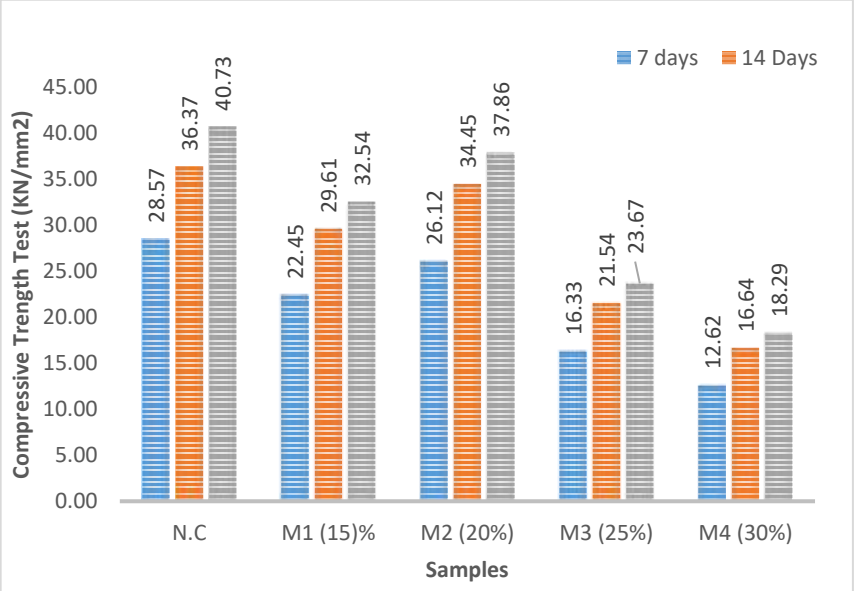
The result of compressive strength test is discussed in table no 8 and shown in graph no 1.

Table no 8: Compressive strength test result of various Mix design.

Mix Design	Compressive Strength N/mm²		
	3 days	7days	28 days
N.C	28.57	36.37	40.73
M1 (15)%	22.45	29.61	32.54
M2 (20%)	26.12	34.45	37.86
M3 (25%)	16.33	21.54	23.67
M4 (30%)	12.62	16.64	18.29

The Compressive Strength test of the different sample which are prepared using the design mix indicated above are tested for porosity test. The result obtained are shown in the table no 4.8 to 4.11 below and for better and easy understanding a graph is plotted and shown in Graph No 4.3 to 4.6.

From the results we obtained by performing compressive strength test on the specimen prepared using the mix design for 7 days strength the maximum value obtained are 28.57 KN/mm² for 7 days, 36.37 KN/mm² for 14 days and 40.73 KN/mm² for 28 days which is observed in the case of normal concrete. As we increased the pumice stone percentage for the replacement of coarse aggregate, the value of compressive strength test starts to reduce drastically. The minimum value obtained are 12.62 KN/mm² for 7 days, 16.64 KN/mm² for 14 days and 18.29 KN/mm² for 28 days. But for a cement concrete road, the required value for compressive strength of a mix should lie between 20 to 40 KN/mm2. Based on this we can easily conclude that the mix design with 25% pumice stone can be used effectively for the construction. The value obtained are 16.33 KN/mm² for 7 days, 21.54 KN/mm² for 14 days and 23.67 KN/mm² for 28 days.



Graph no 1: Compressive strength test result of various Mix design.

Conclusion:

The conclusion drawn from the above experiment are as follow:

1) For Cement:

- The normal water consistency is observed to be 31% by weight.
- The initial setting time and final setting time are 34 minutes and 624 minutes respectively.
- The fineness result is 2.90% by weight.

2) For Coarse Aggregate:

- The crushing value observed for coarse aggregate is 21.10%.
- The impact value observed is 14.57%.

3) For Pumice Stone:

- The crushing value observed for coarse aggregate is 29%.
- The impact value observed is 26.60%.

4) For Compressive strength result:

- For 3 days results maximum value observed for pumice stone is 13.02 N/mm^2.
- For 7 days results maximum value observed for pumice stone is 22.79 N/mm^2.
- For 21 days results maximum value observed for pumice stone is 31.91 N/mm^2.
- The optimum results above concluded are observed for 20% replacement of coarse aggregate with pumice stone aggregates.

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