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RESEARCH ARTICLE

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AN EXPERIMENTAL INVESTIGATION ON THE BEHAVIOUR OF SELF CURING CONCRETE UNDER ACIDIC ATTACK

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ABSTRACT

Concrete is a mixture of cement, aggregates and water with or without suitable admixtures. To attain desirable strength and other properties, curing is necessary. Curing is the process of maintaining the proper moisture content to promote optimum cement hydration immediately after placement. The main objective of this experimental investigation is to find out behaviour of self-curing concrete under acidic attack. The experimentations are designed by replacing the natural aggregates by pumice aggregates in different percentage, such as 0%, 10%, 20%, 30%, 40%, 50%. The specimens are casted by soaking the pumice stone in water and without water curing of specimen for 28 days. Another set of specimens were casted without soaking the pumice stone in water and curing the specimen in water for 28 days. After 28 days immerse the specimens in H_2SO_4 media of PH 3 for 90 days, later different strength characteristics such as compressive strength, tensile strength, flexural strength, impact strength and shear strength are studied.

Key words: Pumice, Water soaked pumice, Dry pumice, compressive strength, tensile strength, flexural strength, impact strength, shear strength and Sulfuric acid of PH 3.

INTRODUCTION

Concrete is a mixture of cement, aggregates and water with or without suitable admixtures. To attain desirable strength and other properties, curing is necessary. Curing is the process of maintaining the proper moisture content to promote optimum cement hydration immediately after placement. Proper moisture conditions are critical because water is necessary for the hydration of cementitious materials. Concrete is a non-homogeneous material consisting of aggregate in a cement paste matrix. While the cement paste is initially a fluid suspension, it reacts over time causing it to solidify, thus binding the aggregates together. If water is lost from the paste due to evaporation at early ages, there are two main consequences. First, the hydration reaction will slow and ultimately stop which limits strength development and produces a more permeable material when compared with a sample that did not lose water. Second, the loss of water causes concrete to shrink and, if restrained, the concrete develops stresses that may lead to cracking.The concept of self-curing (internal curing) is to reduce the water evaporation from concrete and hence increase the water retention capacity of the concrete compared to conventional concrete. The self-curing concrete means that no external curing required for concrete. The concept of self-curing is to reduce the water evaporation. Self-curing can be defined as "supplying water throughout a freshly placed cementations mixture using reservoirs, via pre-wetted lightweight aggregates, that readily release water as needed for hydration or to replace moisture lost through evaporation or self-desiccation". Concrete is susceptible to attack by sulfuric acid produced from either sewage or sulfur dioxide present in the atmosphere of industrial cities. This attack is due to the high alkalinity of Portland cement concrete, which can be attacked by other acids as well. Sulfuric acid is particularly corrosive due to the sulfate ion participating in sulfate attack, in addition to the dissolution caused by the hydrogen ion.' Since sulfur compounds are formed as a result of the sulfuric acid-cement paste reaction, the increase in sulfur content of concrete specimens could be used as a measure of the chemical manifestation of deterioration.

MATERIALS AND METHODOLOGY

Cement: In this experimental work, ordinary Portland cement (OPC) 43 grade conforming to IS: 8112 – 1989 was used. Specific gravity 3.15, Fineness 4%, Normal consistency 34%, Initial setting time 30 minutes, Final setting time 5 hrs 45 minutes.

Fine aggregates: Locally available river sand belonging to zone II of IS: 383–1970 was used for the project work. Specific gravity 2.58, Bulk density 1752 kg/m^3, Water absorption 1.0%.

Coarse aggregates: Locally available crushed aggregates confirming to IS: 383–1970 is used in this dissertation. Specific gravity 2.56, Bulk density 1670 kg/m^3, Water absorption 0.6 %.

Sulfuric acid: Sulfuric acid is a highly corrosive strong mineral acid with the molecular formula H_2SO_4. It is a colorless to slightly yellow viscous liquid which is soluble in water at all concentrations. Density: 1.84 g/cm^3, Molar mass: 98.079 g/mol.

Water: Water fit for drinking is generally considered fit for making concrete. Water should be free from acids, oils, alkalis, vegetables or other organic Impurities. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form a cement paste in which the inert aggregates are held in suspension until the cement paste has hardened. Secondly, it serves as a vehicle or lubricant in the mixture of fine aggregatesand cement.

Pumice aggregates: The pumice aggregates were having a maximum size of 20mm and minimum size of 12mm. Pumice is commonly pale in colour.Specific gravity0.84, Dry density336 kg/m^3, Density at saturated state566 kg/m^3.

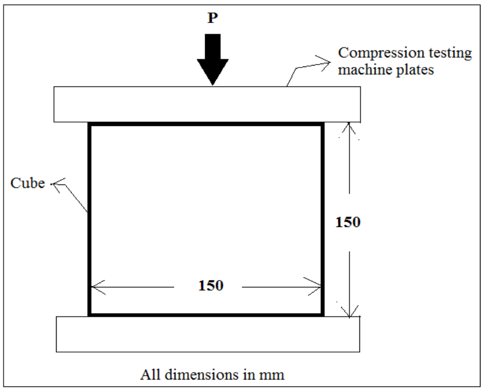
Dry Pumice

Water soaked Pumice

METHODOLOGY

Strength tests

Compressive strength test : The following procedure is adopted to conduct the compressive strength test.



Compression test on cubes

Size of the test specimen is determined by averaging perpendicular dimensions at least at two places. The size of the cube specimen is 150x 150 x 150 mm.

Place the specimen centrally on the compression testing machine and load is applied continuously and uniformly on the surface perpendicular to the direction of tamping.

The load is increased until the specimen fails and record the maximum load carried by each specimen during the test as shown in Fig. 4.16 Compressive stress was calculated as follows

Compressive strength = (P / A) × 1000

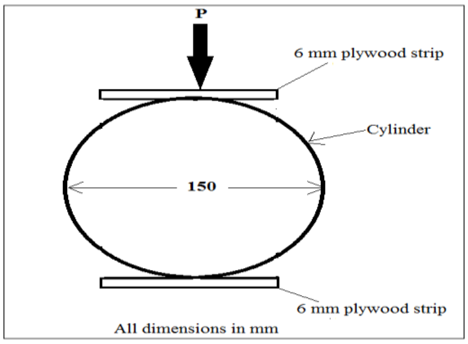
Where,

P = Load in kN

A = Area of cube surface = 150 x 150 mm^2

Tensile strength test

The following procedure is adopted to conduct the tensile strength test.



Split tensile test on cylinders

Draw diametrical lines on two ends of the specimen so that they are in the same axial plane.

Determine the diameter of specimen to the nearest 0.2 mm by averaging the diameters of the specimen lying in the plane of premarked lines measured near the ends and the middle of the specimen. The length of specimen also shall be taken be nearest 0.2 mm by averaging the two lengths measured in the plane containing pre marked lines. The size of the cylinder specimen is of 150 mm diameter and 300 mm length.

Centre one of the plywood strips along the centre of the lower platen. Place the specimen on the plywood strip and align it so that the lines marked on the end of the specimen are vertical and centered over the plywood strip. The second plywood strip is placed length wise on the cylinder centered on the lines marked on the ends of the cylinder.

Apply the load without shock and increase it continuously at the rate to produce a split tensile stress of approximately 1.4 to 2.1 N/mm^2/min, until no greater load can be sustained. Record the maximum load applied to specimen as shown in Fig. 4.11

Computation of the split tensile strength was as follows.

Split tensile strength = (2P/πdL)

Where,

P = Load in kN

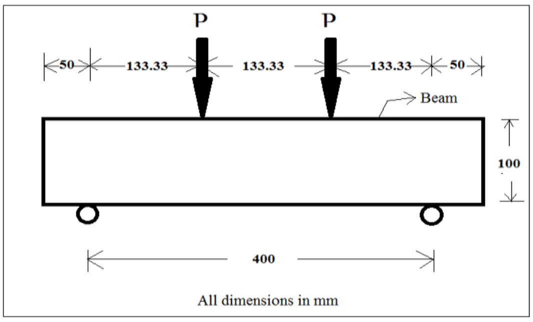
π = 3.142

d = Diameter of cylinder = 150 mm

L = Length of cylinder = 300 mm

Flexural strength test

The following procedure is adopted to conduct theflexural strength test.



Flexural test on beams

Brush the beam clean. Turn the beam on its side, with respect to its position as moulded and place it in the breaking machine. The size of the beam specimen is 100 x 100 x 500 mm.

Set the bearing plates square with the beam and adjust for distance by means of the guide plates furnished with the machine.

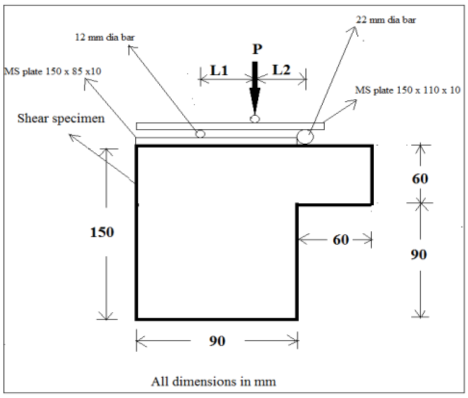
Place a strip of leather or similar material under the upper bearing plate to assist in distributing the load.

Bring the plunger of the jack into contact with the ball on the bearing bar by turning the screw in the end of the plunger.
After contact is made and when only firm finger pressure has been applied, adjust the needle on the dial gauge to “0”.
Here we are applying two points loading on the beam specimen, apply load till it breaks and note that as failure load as shown in Fig. 4.12.
Computation of the flexural strength was as follows.

Flexural strength = [(PL / bd^2) X 1000]Where,
P = Load in kN
L = Effective length of beam = 400 mm
b = Width of the beam = 100 mm
d = Depth of the beam = 100 mm

Shear strength test

The following procedure is adopted to conduct theshear strength test.
Place the specimen centrally on the compression testing machine and load is applied continuously and uniformly. The specimen is of L shape having dimensions as shown in Fig. 4.13.
The load is increased until the specimen fails and record the maximum load carried by each specimen during the test.
Note the type of failure and appearance of crack.



Shear test on L shape shear specimen

Computation of the shear strength was as follows.
Failure load = [PL_1 / ($L_1 + L_2$)]
Shear strength = (Failure load / A) X 1000
Where, P = Load in kN
A = Area of shear surface = 60 x 150 mm^2
L1 = 25 mm
L2 = 25 mm

4.4.1.5 Impact strength test

For impact test strength, cylindrical specimens of 150mm diameter & 60mm height were prepared. Drop weight test was adopted for testing impact specimen. The specimens were kept in the Schrader’s impact testing machine and a hammer weighing 4.54 kg was dropped from a height of 457mm. Number of blows required to cause first crack and final crack were noted down. The final failure is defined as the opening of cracks in the specimen sufficiently so that pieces of concrete are touching at least three out of the four positioned lugs on the base plate. These numbers of blows were converted into impact energy by the following formulae:

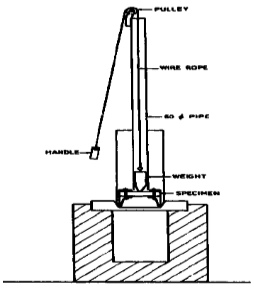
Impact energy = w×h×n.

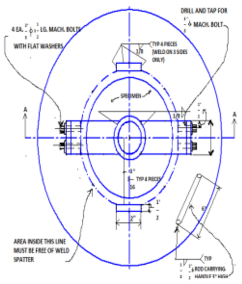
Where,

w = weight of the hammer = 4.54 kg = 45.4 N.

H = height of the fall = 45.7 cm = 0.457 m.

N = number of blows required to cause first crack and final crack as the case may be.





Plan view of impact test **Impact test machine**

EXPERIMENTAL RESULTS

The overall results of compressive strength in fig 1, Tensile strength in fig 2, Flexural strength in fig 3, Shear strength in fig 4, Impact strength in fig 5 of self-curing concrete and water cured concrete, when coarse aggregates are replaced by pumice aggregates in different percentages and then subjecting them to acidic attack for 90 days. The variation of the compressive strength is depicted in the form of graph as shown below

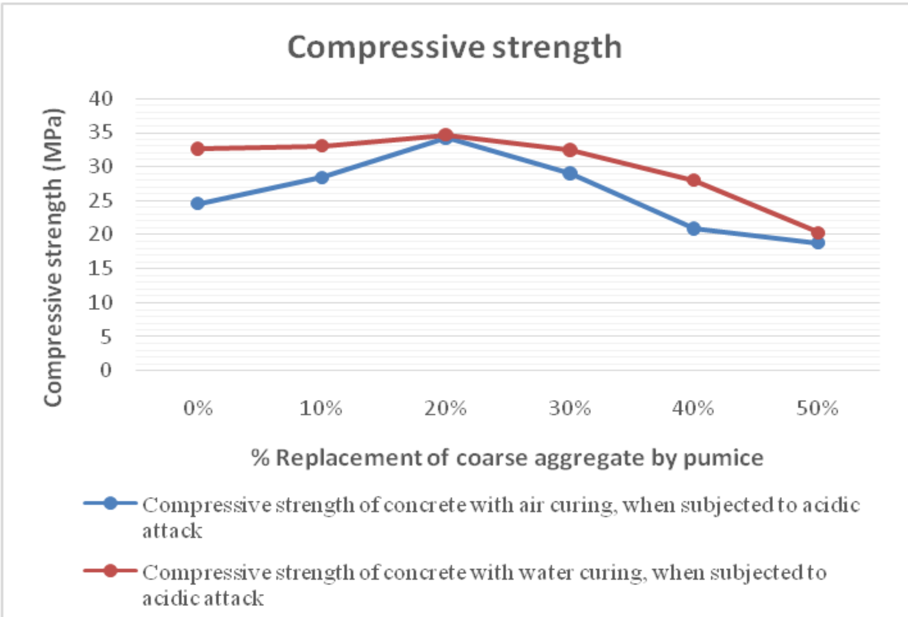


Fig 1: Variation of compressive strength when subjected to acidic attack

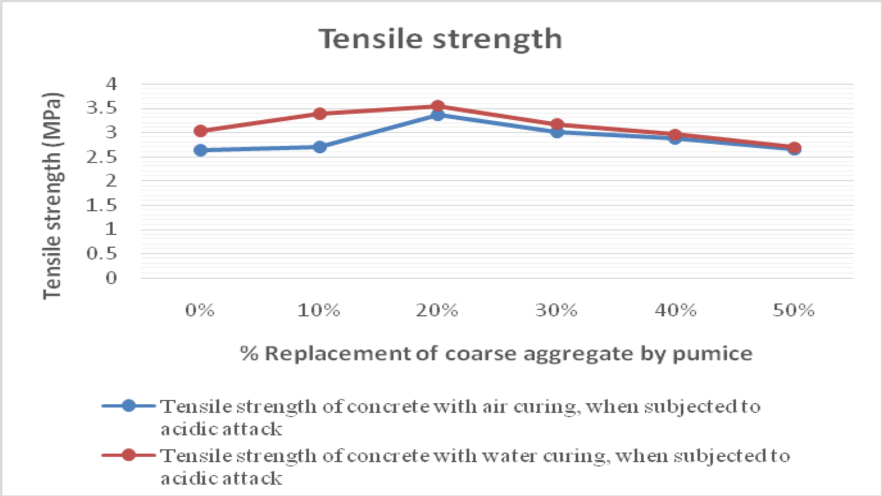


Fig 2: Variation of tensile strength when subjected to acidic attack

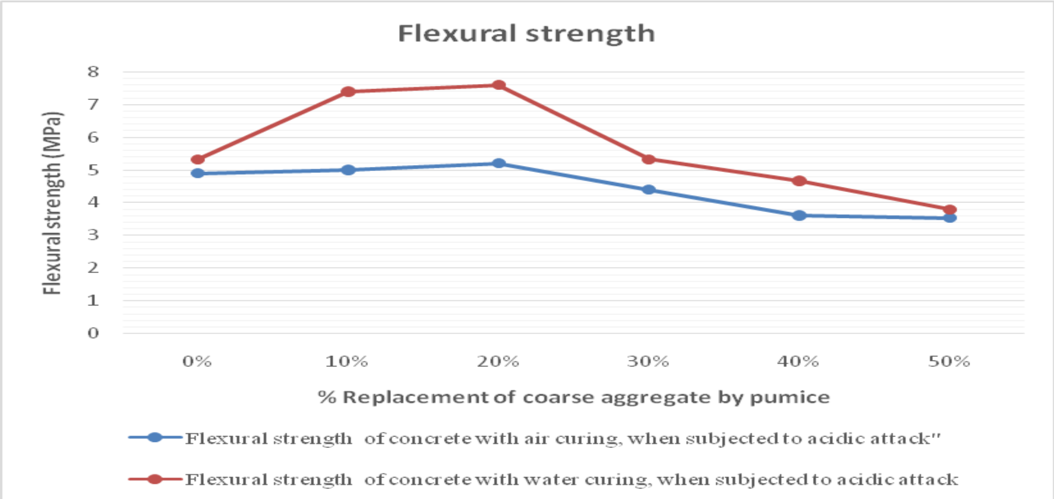


Fig 3: Variation of flexural strength when subjected to acidic attack

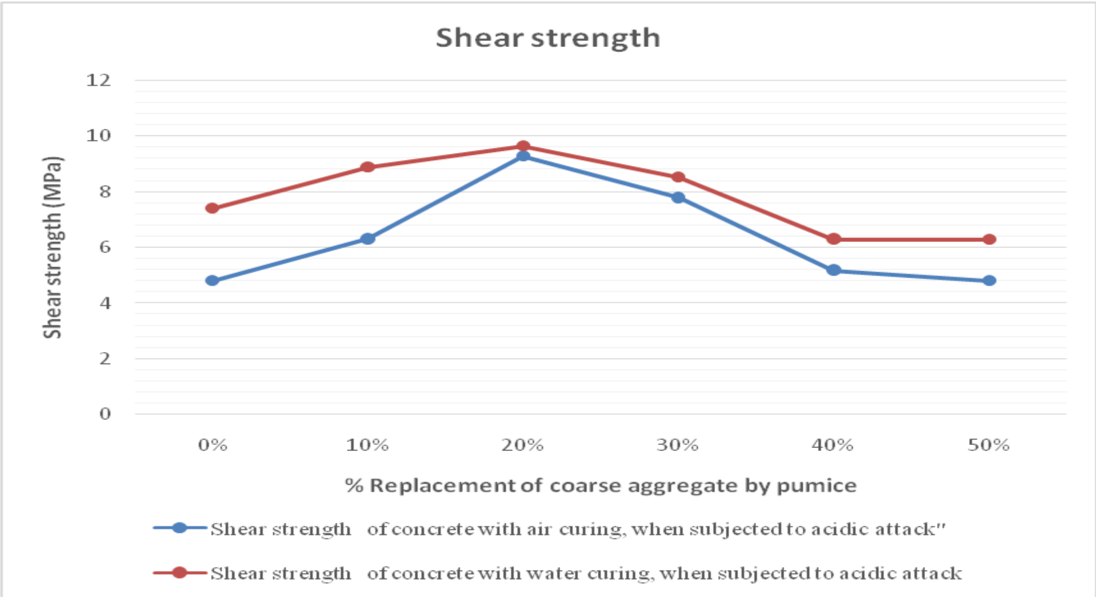


Fig4: Variation of Shear strength when subjected to acidic attack

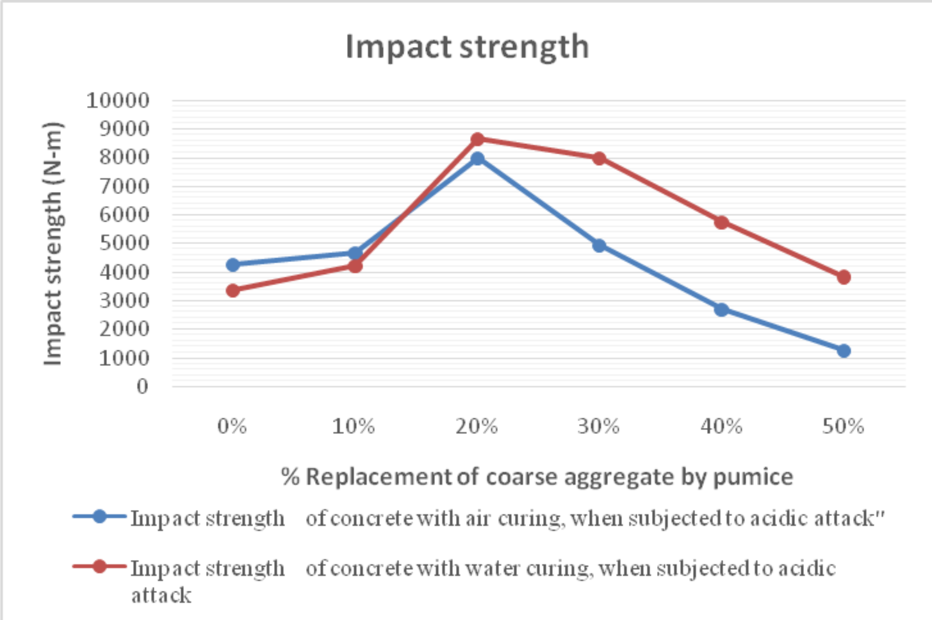


Fig 5: Variation of impact strength when subjected to acidic attack

RESULTS AND DISCUSSIONS

1. It is observed that the compressive strength of self-cured and water cured concrete when subjected to 90 days acidic attack goes on increasing up to 20% replacement level of coarse aggregate by pumice aggregate. Beyond this replacement level the compressive strength of self-curing and water curing concrete goes on decreasing. Thus the higher compressive strength of self-curing and water curing concrete when subjected to acidic attack may be obtained by replacing 20% coarse aggregate by pumice aggregate. At 20% replacement level the percentage increase of compressive strength is found to be 39.12 % and 6.35 % respectively.
2. It is observed that the tensile strength of self-cured and water cured concrete when subjected to 90 days acidic attack goes on increasing up to 20% replacement level of coarse aggregate by pumice aggregate. Beyond this replacement level the tensile strength of self-curing and water curing concrete goes on decreasing. Thus the higher tensile strength of self-curing and water curing concrete when subjected to acidic attack may be obtained by replacing 20% coarse aggregate by pumice aggregate. At 20% replacement level the percentage increase of tensile strength is found to be 27.76 % and 16.78% respectively.
3. It is observed that the flexural strength of self-cured and water cured concrete when subjected to 90 days acidic attack goes on increasing up to 20% replacement level of coarse aggregate by pumice aggregate. Beyond this replacement level the flexural strength of self-curing and water curing concrete goes on decreasing. Thus the higher flexural strength of self-curing and water curing concrete when subjected to acidic attack may be obtained by replacing 20% coarse aggregate by pumice aggregate. At 20% replacement level the percentage increase of flexural strength is found to be 6.12 % and 42.59 % respectively.
4. It is observed that the shear strength of self-cured and water cured concrete when subjected to 90 days acidic attack goes on increasing up to 20% replacement level of coarse aggregate by pumice aggregate. Beyond this replacement level the shear strength of self-curing and water curing concrete goes on decreasing. Thus the higher shear strength of self-curing and water curing concrete when subjected to acidic attack may be obtained by replacing 20% coarse aggregate by pumice aggregate.

At 20% replacement level the percentage increase of shear strength is found to be 92.51 % and 29.96 % respectively.

5. It is observed that the impact strength for final failure of self-cured and water cured concrete when subjected to 90 days acidic attack goes on increasing up to 20% replacement level of coarse aggregate by pumice aggregate. Beyond this replacement level the impact strength of self-curing water curing concrete goes on decreasing. Thus the higher impact strength of self-curing water curing concrete when subjected to acidic attack may be obtained by replacing 20% coarse aggregate by pumice aggregate. At 20% replacement level the percentage increase of impact strength is found to be 87.31 % and 157.57% respectively.

CONCLUSION

1. Higher compressive strength for self-curing and water curing concrete when subjected to 90 days acidic attack may be obtained by replacing 20% of coarse aggregate by pumice aggregate, water cured concrete shows little higher compressive strength as compared to self-curing concrete.
2. Higher tensile strength for self-curing and water curing concrete when subjected to 90 days acidic attack may be obtained by replacing 20% of coarse aggregate by pumice aggregate, water cured concrete shows little higher tensile strength as compared to self-curing concrete.
3. Higher flexural strength for self-curing and water curing concrete when subjected to 90 days acidic attack may be obtained by replacing 20% of coarse aggregate by pumice aggregate, water cured concrete shows little higher flexural strength as compared to self-curing concrete.
4. Higher Shear strength for self-curing and water curing concrete when subjected to 90 days acidic attack may be obtained by replacing 20% of coarse aggregate by pumice aggregate, water cured concrete shows little higher shear strength as compared to self-curing concrete.
5. Higher impact strength for self-curing and water curing concrete when subjected to 90 days acidic attack may be obtained by replacing 20% of coarse aggregate by pumice aggregate, water cured concrete shows little higher impact strength as compared to self-curing concrete.

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