AN EXPERIMENTAL INVESTIGATION ON BEHAVIOR OF SELF CURED STEEL FIBER REINFORCED CONCRETE

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ABSTRACT

Internal curing as "supplying water throughout a freshly placed cementitious 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" (American Concrete Institute, 2010). Self curing Concrete is known to be easily cracked under low level tensile stress, for its inherent weakness in resisting tensile forces. Incorporation of fibres into concrete is not only an effective way to enhance concrete tensile stress, but also fracture toughness, impact strength, durability, etc. Fibers are usually used in concrete to control cracking due to both plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibres produce greater impact, abrasion and shatter resistance in concrete steel fibre is one of the most popular and widely used fibres in both research and practice. Essentially, the fibres acts as crack arresters, restricting the development of crack and thus transforming an inherently brittle matrix into a strong composite with better crack resistance and ductility. The inclusion of fibres delays the dilation of concrete by acting as crack arresters and thus helps indirectly in confinement of concrete under compressive loads. The report is mainly focused on the utilization of pre-wetted lightweight aggregates as the internal reservoirs and the strength properties of self cured concrete by using flat steel fibres.

Key words: Steel fibers, pumice, Compressive, Flexural, Split Tensile and Impact Strength of Concrete.

1. INTRODUCTION

Concrete is most widely used construction material in the world due to its ability to get cast in any form and shape. It also replaces old construction materials such as brick and stone masonry. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cementitious material, aggregate and water and by adding some special self curing ingredients like pumice and steel fibres. Hence self curing concrete can use very well suitable for a wide range of applications. In this experimental work pumice is used as self curing agent or water reservoir in concrete, and steel fibres used to improve the strength properties of concrete. The use of Steel Fibers in Concrete in building structures, which may improve the toughness, flexural strength, tensile strength, impact strength as well as the failure mode of the concrete. Use of fibers into Self curing concrete mixes has been presented by many researchers. Depending on many parameters such as maximum aggregate size, fiber volume, fiber type, fiber geometry, and fiber aspect ratio, fiber inclusion to concrete reduces the workability of concrete. The basic concept of this technology is to provide water for concrete, so that it can continue the curing process on its own. This is done by embedding the water inside the materials used to make concrete. If the water just added as mixing water; this would lead to many other quality related problems, such as bleeding, segregation, and etc. The self curing technology has been intentionally incorporated into concrete mixtures at the proportioning stage, using a variety of materials including pre-wetted lightweight aggregates, pre-wetted crushed returned concrete fines, superabsorbent polymers, and pre-wetted wood fibres.

Objective of the study

The objective of the current research work to study the experimental investigation on the behavior of fiber reinforced self-cured M30 grade of concrete, containing 2% steel fibers and pumice aggregate replaced by the natural aggregates in different percentage, such as 0%, 10%, 20%, 30%, 40%, and 50%. The different strength characteristics that are studied are, compressive strength, tensile strength, flexural strength and shear strength.

2. MATERIALS AND METHODOLOGY

2.1. Material used

Cement: In this experimental work, ordinary Portland cement (OPC) 43 grade conforming to IS: 8112 – 1989 was used.

Sand: Locally available river sand zone II with specific gravity 2.58, water absorption 1% and conforming to I.S. – 383-1970.

Coarse aggregate: Crushed granite stones of 20 mm down size, having specific gravity of 2.61 conforming to IS 383-1970

Water: Potable water was used for the experimentation.

Pumice: Light weight aggregates having density 624 kg/m3 and specific gravity 0.84.

Steel Fibers: - In this experimentation Flat Steel fibers were used, having length 38mm and 2mm width. Aspect ratio of the steel fibre is 95.

2.2. Experimental methodology

The experimentations were designed for M30 grade of concrete and the concrete mix containing 2% steel fibers(volume fraction) and the pumice aggregates by replacing coarse aggregates in different percentages, such as 0%, 10%, 20%, 30%, 40%, and 50%. The different near surface characteristics such as water absorption and sorpitivity tests and strength characteristics that are studied are, compressive strength, tensile strength, flexural strength and shear strength.

The specimens are casted by soaking the pumice stone in water and then tested after 28 days, air curing. Another set of specimens were casted without soaking the pumice stone in water and curing the specimen for 28 days. The results will be compared to study the characteristic behavior of self-cured concrete by using pumice aggregates in different percentages.

2.2.1 Near surface characteristic tests

2.2.1.1 Water absorption test

To determine the water absorption of specimens, three specimens were dried at a room temperature for 24 hours and its weight is determined as initial weight (W1). The specimens were then immersed in water for 24 hours and its saturated surface dry weight was recorded as the final weight (W2). Water absorption of specimens is reported as follows.

Percentage water absorption

$$= [(W2-W1) / W1] \times 100$$

2.2.1.2 Sorptivity test

Sorptivity test determines the rate of capillary–rise absorption by a concrete prism which rests on small supports in a manner such that only the lowest 30 mm of the prism is submerged. The increase in the water level of the prism with time is recorded. It has been shown that there exists a relation of the form,

$$S = (i / t^{0.5})$$

Where,

S = Sorptivity in $mm/min^{0.5}$.

i = Depth of water level increased by capillary action, expressed in mm.

t = Time measured in minutes at which the depth determined.

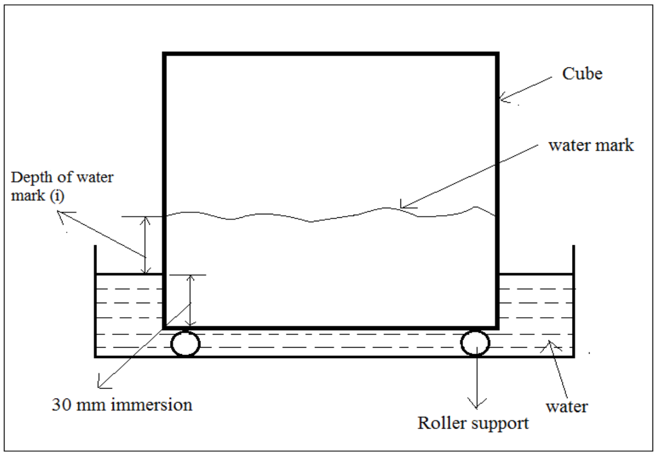


Fig.1: Sorptivity test

2.2.2 Strength tests

2.2.2.1 Compressive strength test:

For compressive strength test, cube specimens of dimensions 150 x 150 x 150 mm were cast. Vibration was given to the moulds using table vibrator. The top surface of the specimen was levelled and finished. After 24 hours the specimens were demoulded and were transferred to curing tank where in they were allowed to cure for 28 days. After 28 days curing, these cubes were tested on compression testing machine. The failure load was noted. In each category three cubes were tested and their average value is reported. The compressive strength was calculated as follows.

Compressive strength (MPa)

= Failure load / cross sectional area.

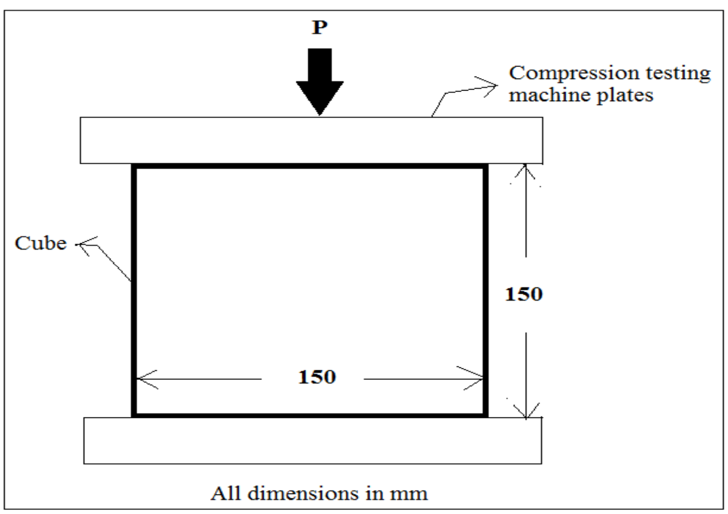


Fig.2: Testing of compressive strength test specimen

2.2.2.2 Flexural strength test:

For flexural strength test beam specimens of dimension 100x100x500 mm were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank where in they were allowed to cure for 28 days. These flexural strength specimens were tested under two point loading as per I.S. 516-1959, over an effective span of 400 mm on Flexural testing machine. Load and corresponding deflections were noted up to failure. In each category three beams were tested and their average value is reported. The flexural strength was calculated as follows.

$$\text{Flexural strength (MPa)} = (P \times L) / (b \times d^2),$$

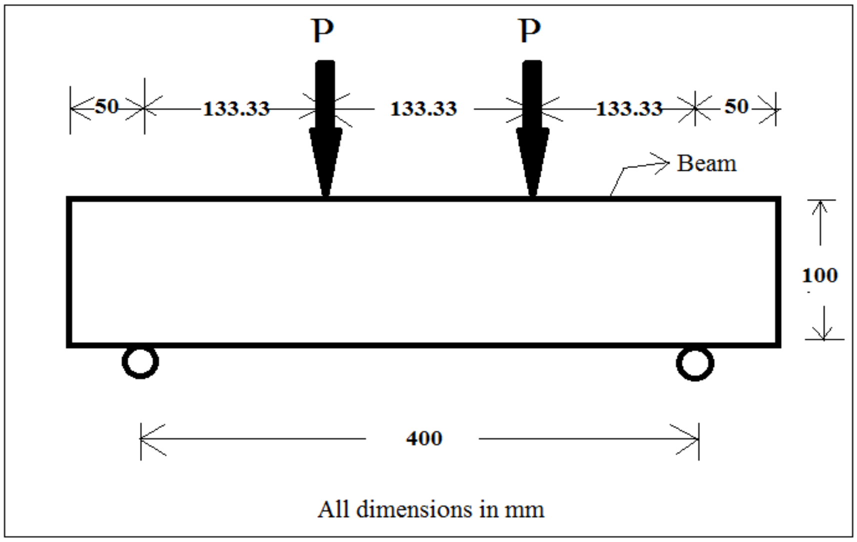
Where,

P = Failure load,

L = Centre to centre distance between the support = 400 mm,

b = width of specimen=100 mm,

d = depth of specimen= 100 mm.



2.2.2.3 Split Tensile strength test:

For Split tensile strength test, cylinder specimens of dimension 150 mm diameter and 300 mm length were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank where in they were allowed to cure for 28 days. These specimens were tested under compression testing machine. In each category three cylinders were tested and their average value is reported.

Split Tensile strength was calculated as follows as split tensile strength:

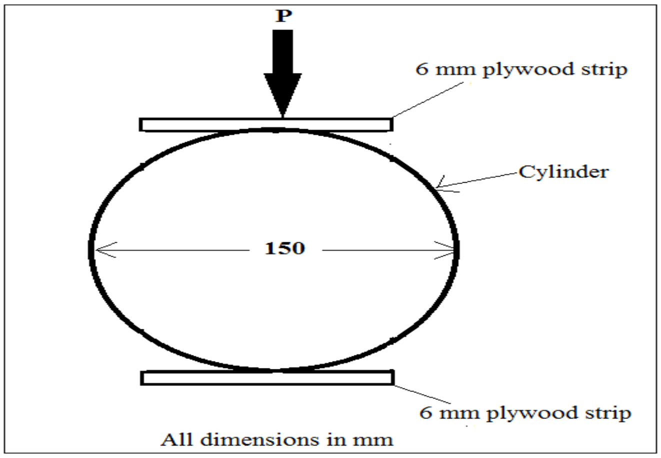
$$\text{Split Tensile strength (MPa)} = 2P / \pi DL,$$

Where,

P = failure load,

D = diameter of cylinder,

L = length of cylinder



2.2.2.4 Shear strength test:

The following procedure is adopted to conduct the shear 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.5. 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. Computation of the shear strength was as follows.

Failure load = [PL1 / (L1 + L2)]

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

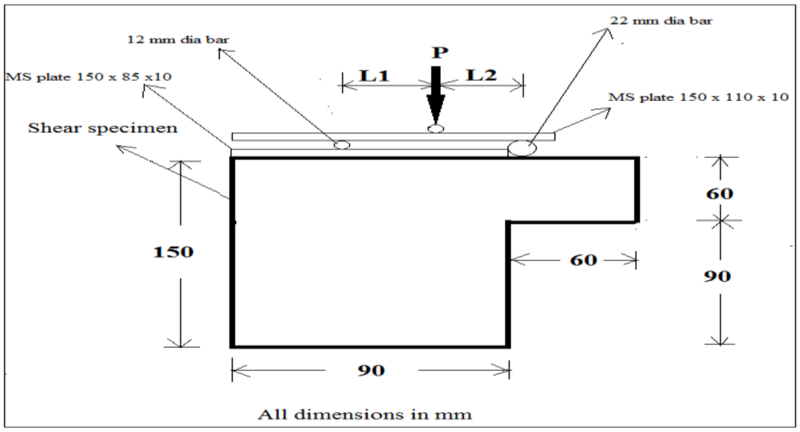


Fig.5: Shear test on L shape shear specimen

3. Experimental results

3.1 Near surface characteristic test results

3.1.1 Water absorption test results

Following fig 5.4 shows the variation of water absorption graphically. The water absorption test results of self cured fibre reinforced concrete for different percentage replacement of coarse aggregate by pumice.

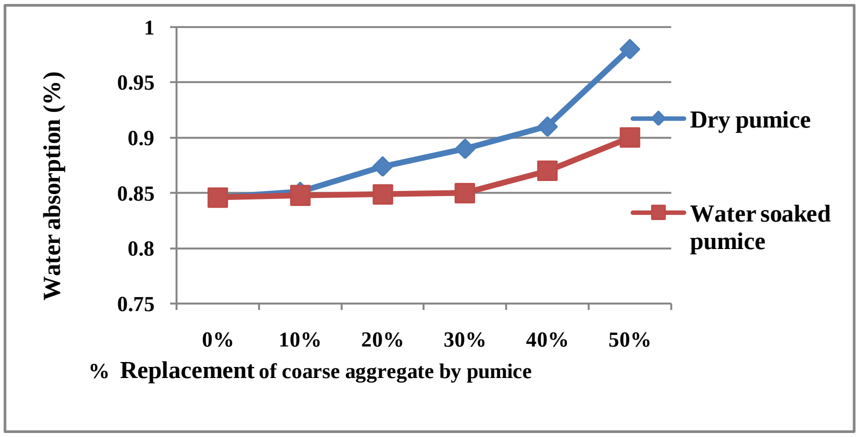


Fig. 6: Variation of water absorption

3.1.2 Sorptivity test results

Following Fig 5.5 shows the variation of water absorption graphically. The water absorption test results of self cured fibre reinforced concrete for different percentage replacement of coarse aggregate by pumice.

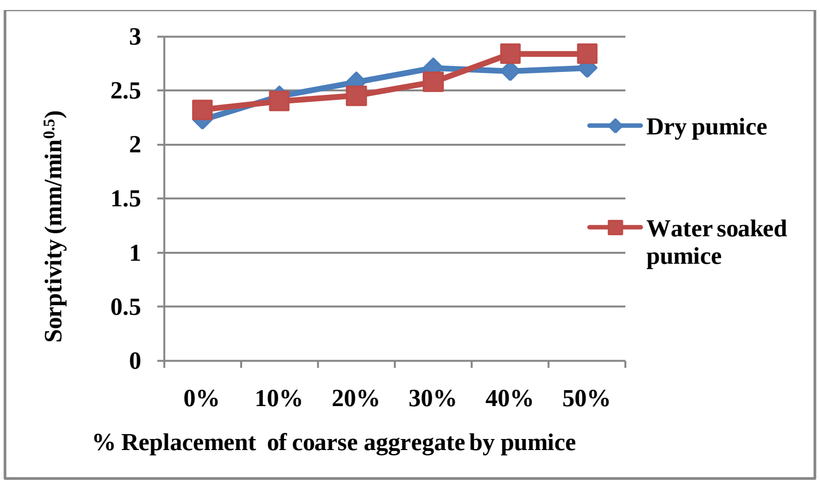


Fig. 7: Variation of sorptivity

3.2 Strength test results

3.2.1 Compressive strength test results.

The following fig shows the results of variation of the compressive strength is depicted in the form of graph as shown in fig 5.9. which gives the overall results of tensile strength of fibre reinforced concrete, when coarse aggregates are replaced by pumice aggregates in different percentages and then subjecting them to water curing and air curing.

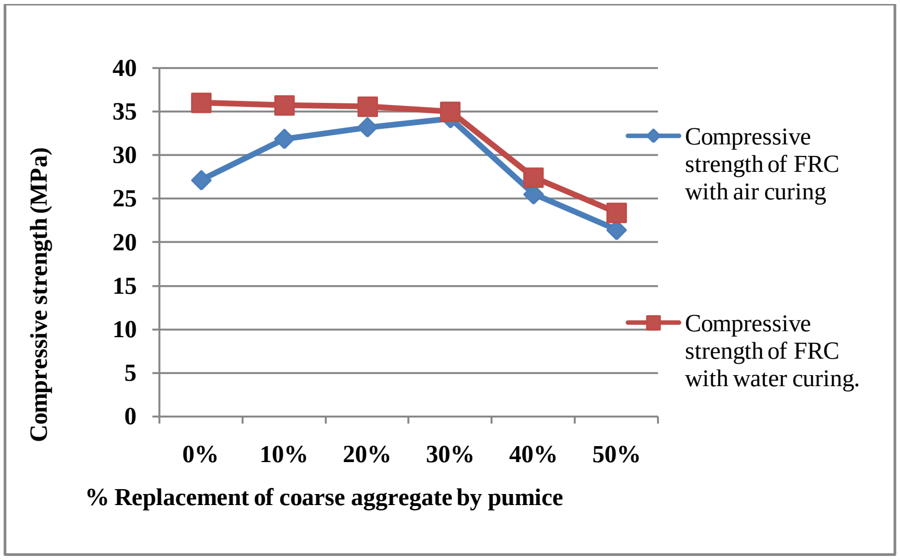


Fig. 8: Variation of compressive strength

3.2.2 Tensile strength test results

Following fig shows the variation of tensile strength of fibre reinforced concrete, when coarse aggregates are replaced by pumice aggregates in different percentages and then subjecting them to water curing and air curing.

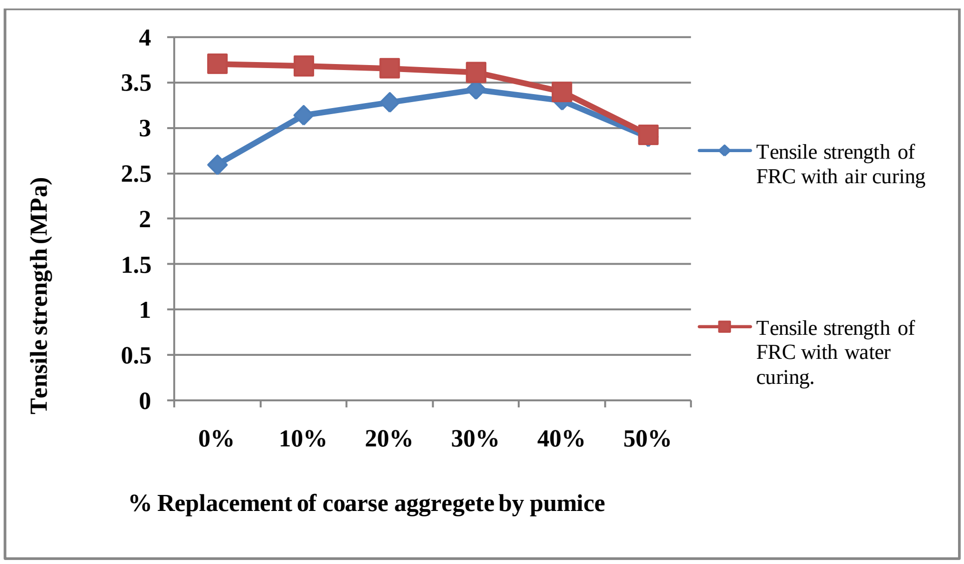


Fig. 9: Variation of tensile strength

3.2.3 Flexural strength test results

Following fig shows results of variation of the flexural strength of fibre reinforced concrete, when coarse aggregates are replaced by pumice aggregates in different percentages and then subjecting them to water curing and air curing.

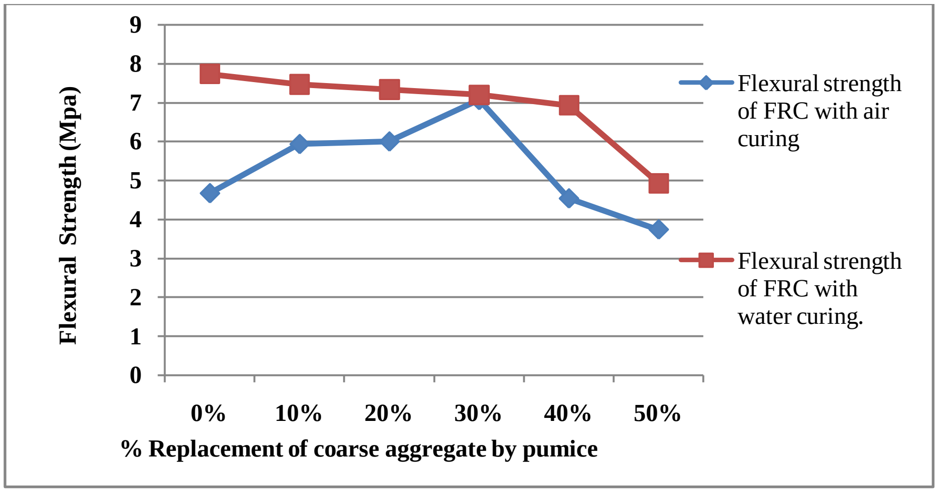


Fig. 10: Variation of flexural strength

3.2.4 Shear strength test results

Following fig shows the variation of results of the shear strength of fibre reinforced concrete, when coarse aggregates are replaced by pumice aggregates in different percentages and then subjecting them to water curing and air curing.

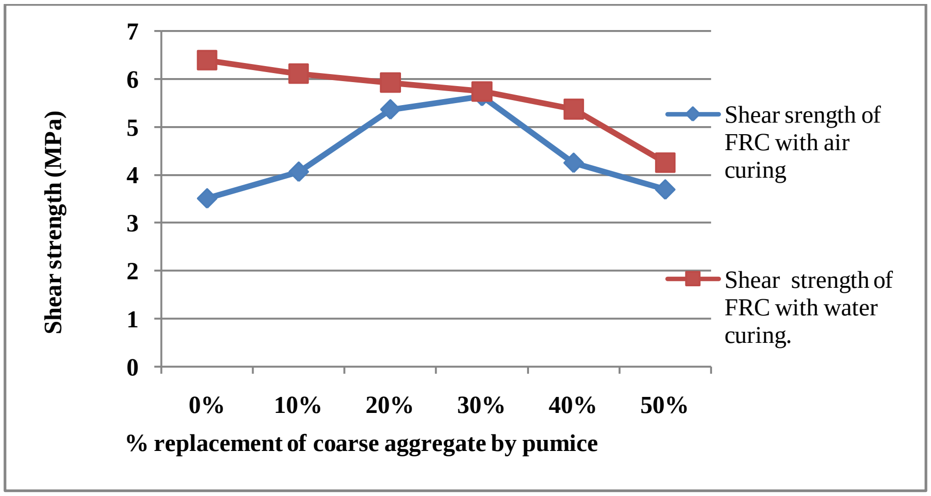


Fig. 11: Variation of shear strength

4. Observation and discussion

1. It is observed that the compressive strength of concrete with air curing goes on increasing up to 30% replacement of coarse aggregates by pumice aggregates. Their after the compressive strength decreases. A compressive strength 34.22 MPa is obtained when 30% of coarse aggregates are replaced by pumice aggregates. This may be due to the fact that 30% replacement of coarse aggregates by pumice aggregates may hold water just sufficient to carry out the internal curing of concrete. Thus it can be concluded that the self cured steel fibre reinforced concrete produced with 30% replacement of coarse aggregates by pumice aggregates will yield higher compressive strength.
2. It is observed that the compressive strength of concrete with water curing goes on decreasing replacement of coarse aggregates by pumice aggregates. This may be due to the fact that without replacement of coarse aggregates by pumice aggregates and with water curing may show perfect compatibility.

3. It is observed that the tensile strength of concrete with water curing at 0% replacement of coarse aggregates by pumice aggregates. Their after the tensile strength decreases. A tensile strength 3.70 MPa is obtained when 0% of coarse aggregates are replaced by pumice aggregates.
4. It is observed that the flexural strength of concrete with air curing goes on increasing up to 30% replacement of coarse aggregates by pumice aggregates. Their after the flexural strength decreases. A flexural strength of 7.06 MPa is obtained when 30% of coarse aggregates are replaced by pumice aggregates. This may be due to the fact that 30% replacement of coarse aggregates by pumice aggregates may hold water just sufficient to carry out the internal curing of concrete.
5. It is observed that the flexural strength of concrete with water curing at 0% replacement of coarse aggregates by pumice aggregates. Their after the flexural strength decreases. A flexural strength 7.73 MPa is obtained when 0% of coarse aggregates are replaced by pumice aggregates.
6. It is observed that the shear strength of concrete with air curing goes on increasing up to 30% replacement of coarse aggregates by pumice aggregates. Their after the shear strength decreases. Shear strength of 5.64 MPa is obtained when 30% of coarse aggregates are replaced by pumice aggregates.
7. It is observed that the shear strength of concrete with water curing goes on decreasing by replacement of coarse aggregates by pumice aggregates. A shear strength 6.38 MPa is obtained when 0% of coarse aggregates are replaced by pumice aggregates. This may be due to the fact that at 0% replacement of coarse aggregates by pumice aggregates and with water curing may show perfect compatibility with coarse aggregates.

4. Conclusion

1. The self cured steel fibre reinforced concrete produced with 30% replacement of coarse aggregates by pumice aggregates will yield higher compressive strength.
2. The concrete produced without replacement of coarse aggregates by pumice aggregates and with water curing show higher compressive strength.
3. It can be concluded that the compressive strength of self cured steel fibre reinforced concrete will be slightly affected.
4. The self cured steel fibre reinforced concrete produced with 30% replacement of coarse aggregates by pumice aggregates will yield higher tensile strength.
5. The concrete produced without replacement of coarse aggregates by pumice aggregates with water curing show higher tensile strength.
6. It can be concluded that the tensile strength of self cured steel fibre reinforced concrete will be slightly affected.
7. The self cured steel fibre reinforced concrete produced with 30% replacement of coarse aggregates by pumice aggregates will yield higher flexural strength.
8. The concrete produced without replacement of coarse aggregates by pumice aggregates show higher flexural strength.
9. It can be concluded that the flexural strength of self cured steel fibre reinforced concrete will be slightly affected.
10. The self cured steel fibre reinforced concrete produced with 30% replacement of coarse aggregates by pumice aggregates will yield higher shear strength.
11. The concrete produced without replacement of coarse aggregates by pumice aggregates show higher shear strength.
12. It can be concluded that the shear strength of self cured steel fibre reinforced concrete will be slightly affected.

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