EFFECT OF ACIDIC ATTACK ON THE BEHAVIOR OF STEEL FIBRE REINFORCED CONCRETE PRODUCED WITH SELF CURING TECHNIQUES

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Abstract: *Concrete curing is one of the most important processes in achieving the desired properties of the concrete. Curing plays a major role in developing the concrete microstructure and pore structure. Prevention of loss of moisture is important not only for strength development but also to prevent plastic shrinkage, for decreased permeability and to improve resistance to abrasion. This study investigates behavior of steel fiber reinforced concrete produced with different self curing techniques when subjected to acidic attack. The behaviour is studied by immersing the specimens for a period of 90 days in H_2SO_4 solution of pH 2.0 concentration. The strength parameters namely compressive strength, and split tensile strength are determined using SAP and pumice aggregate.*

Key words: *Self Curing Concrete, water retention, hydration, absorption, light weight aggregates, permeable pores, internal curing, super absorbing polymers, autogenous shrinkage, etc.*

1.1 Introduction.

Self-curing concrete is one of the special concretes in mitigating insufficient curing due to human negligence, in desert regions where scarcity of water is a major problem, paucity of water in arid areas, in case of high rise buildings, in remote places. Also, there are some circumstances where there is a scaricity of water, or the structure may be inaccessible or non-availability of labour or in some other such situations where curing is not possible, it becomes essential to go for an alternative solution for curing of concrete. This thought gave rise to a concept called self curing of concrete.

Further, these benefits include reduced autogenous shrinkage [6] and a lower propensity for early-age cracking.

The use of self curing technique or internal curing is very important from the point view that water resources are getting valuable every day.

1.2 Materials used.

- **Cement:** Ordinary Portland cement [OPC]-53 grade is used throughout the experimental programme. The specific gravity is found to be 3.15 and cement is conforming to IS: 8112-1989.
- **Fine aggregate:** Natural river sand is used in this experimentation programme with specific gravity 2.63 and confirming to zone II of IS: 383-1970.
- **Coarse aggregate:** Locally available angular crushed aggregates having size 20 mm and lesser size conforming to IS: 383-1970 with specific gravity 2.72 is used.
- **Water:** Potable water fit for drinking with a pH 7 is used.
- **Steel fibres:** Flat crimped steel fibres with aspect ratio 35, density 7850 kg/m^3 and ultimate tensile strength 1395 MPa are used. [Figure 1.]

Fig. 1: Steel fibers.

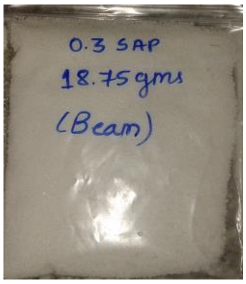

Fig. 2: SAP

- **Superabsorbent Polymer:** Sodium salt of polyacrylic compound is used as superabsorbent polymer which has chemical formula; $[CH2\text{-}CH\ (COONa)\text{-}]_n$. [Figure 2.]
- **Pumice stone aggregate:** Pumice stone aggregate in dry state [Fig. 3] and wet state [Fig. 4] which is a light weight aggregate having specific gravity less than one with density 0.25 g / cm^3 is used as partial replacement of coarse aggregate.

Fig.3: Dry Pumice

Fig.4: Wet Pumice

- **Sulphuric acid:** Sulphuric acid (H_2SO_4) solution of pH 2.0 concentration is used for the experimentation to study the effect of acidic attack.

1.3 Experimental procedure

The mix proportion for M30 grade concrete as per mix design is found to be 1:1.55:2.74 with w/c ratio 0.45. Required quantity of cement, fine aggregates, coarse aggregates are dry mixed. Then the known quantity of steel fibers [2% by volume fraction] are added to the dry mix and once again mixed in dry condition. Before adding water to the mix, Superabsorbent polymer having percentages 0%, 0.1%, 0.2%, 0.3% and 0.4% by weight of cement for different sets is added to cement in dry condition. The additional quantity of water needed for different percentages of SAP is computed and is added during mixing along with the water requirement as per water-cement ratio.

In another case, the natural coarse aggregate is partially replaced by Pumice stone aggregates which are used as self curing agents having percentages such as 0%, 10%, 20%, 30%, 40% and 50%. Pumice stone aggregates are used in concrete with soaking [wet state] in water and without soaking [dry state]. The specimens' caste using dry pumice stone aggregates [without soaking in water] are cured in water; whereas saturated pumice stone aggregates [with soaking in water] specimens are air cured for a normal period of 28 days. Pumice stone aggregates are saturated for a period of 60 to 90 minutes before adding to the mix.

Required quantity of water is added to the above said cases of dry mix. This fresh green concrete is placed in three different layers in the moulds which are thoroughly oiled. The moulds are vibrated by keeping them on table vibrator. Hand compaction is also adopted simultaneously. After compaction the specimens are covered by wet gunny bags. The specimens are demoulded after 15±0.5 hours and transferred to curing process either in water curing or air curing as the case may be. The period of curing is 28 days under normal temperature for strength properties. For durability characteristics, after 28 days curing [water curing or air curing as the case may be] the specimens are shifted to H_2SO_4 acidic solution of pH 2.0 concentration for a period of 90 days.

The concentration of solution is monitored at regular intervals to keep the pH value constant. After 90 days of immersion in acidic media the specimens are removed out of tank, washed and weighed to assess the percentage loss in weight. Then these specimens are tested for their respective strength parameters.

1.4 Test Results:

1.4.1 Compressive strength test results:

Table 1, 2 and 3 give the compressive strength tests results of steel fiber reinforced concrete with SAP and pumice aggregates when subjected to acidic attack. Figure 7 and 8 show the variation of compressive strength.

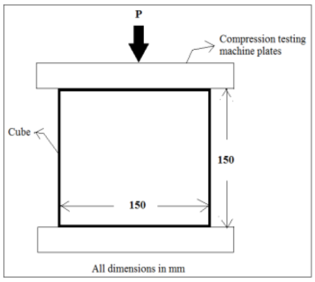

Fig.5: Line diagram of cube.

Fig. 6: Testing of cube.

Table 1: Compressive strength test results of concrete with SAP subjected to acidic attack.

Percentage addition of superabsorbent polymer	Average compressive strength (N/mm^2)	Percentage increase or decrease of compressive strength w.r.t. reference mix.
0 [Ref.]	27.11	---
0.1	27.85	+2.73
0.2	28.44	+4.91
0.3	28.74	+6.01
0.4	27.70	+2.18

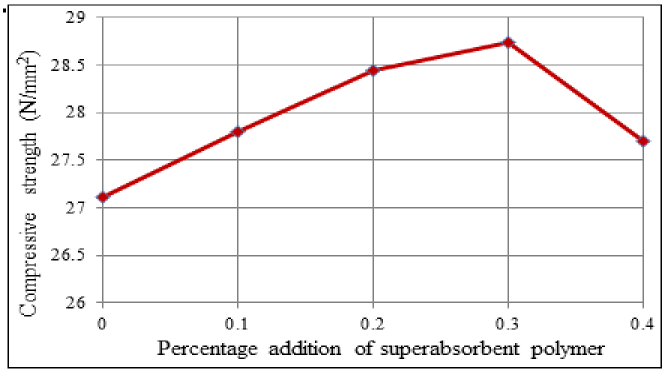

Fig. 7: Variation of compressive strength of concrete with SAP subjected to acidic attack.

Table 2: Compressive strength test results of concrete with wet pumice aggregates subjected to acidic attack. [with soaking]

Partial replacement of coarse aggregates by pumice aggregates (%)	Average compressive strength (N/mm²)	Percentage increase or decrease of compressive strength w.r.t. reference mix.
0 [Ref.]	27.11	---
10	27.85	+2.73
20	28.30	+4.39
30	28.44	+4.91
40	28.30	+4.39
50	26.37	-2.73

Table 3: Compressive strength test results of concrete with dry pumice aggregates subjected to acidic attack. [without soaking]

Partial replacement of coarse aggregates by pumice aggregates (%)	Average compressive strength (N/mm²)	Percentage increase or decrease of compressive strength w.r.t. reference mix.
0 [Ref.]	27.11	---
10	28.15	+3.83
20	28.74	+6.01
30	29.04	+7.12
40	28.44	+4.91
50	26.96	-0.55

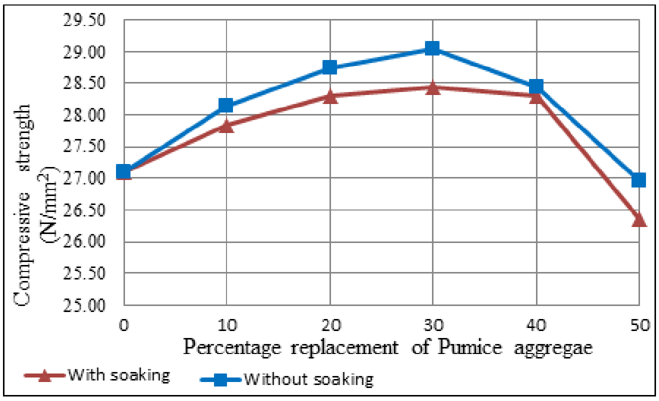

Fig. 8: Variation of compressive strength of concrete with pumice aggregates subjected to acidic attack.

1.4.2 Split tensile strength test results:

Table 4, 5 and 6 give the split tensile strength tests results of steel fiber reinforced concrete with SAP and pumice aggregates when subjected to acidic attack. Figure 11 and 12 show the variation of compressive strength.

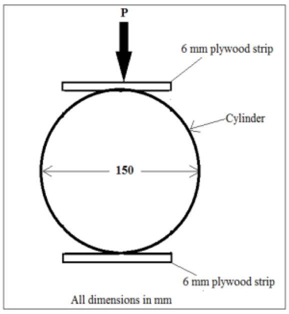

Fig. 9: Line diagram of cylinder.
Fig. 10: Testing of cylinder.

Table 4: Split tensile strength test results of concrete with SAP subjected to acidic attack.

Percentage addition of superabsorbent polymer	Average split tensile strength (N/mm²)	Percentage increase or decrease of split tensile strength w.r.t. reference mix.
0 [Ref.]	2.69	---
0.1	2.74	+1.86
0.2	2.93	+8.92
0.3	2.97	+10.41
0.4	2.67	-1.86

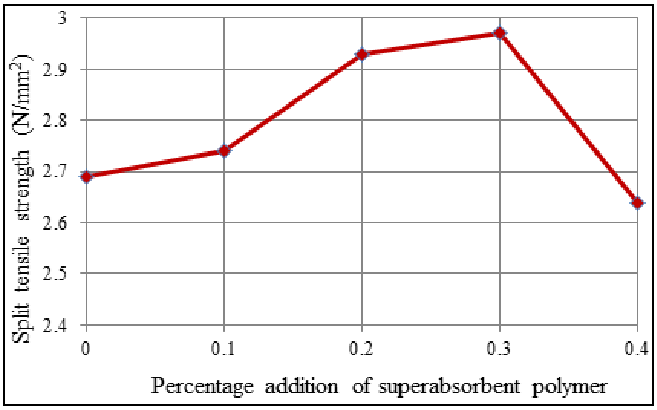

Fig. 11: Variation of split tensile strength of concrete with SAP subjected to acidic attack.

Table 5: Split tensile strength test results of concrete with wet pumice aggregates subjected to acidic attack. [with soaking]		
Partial replacement of coarse aggregates by pumice aggregates (%)	Average split tensile strength (N/mm^2)	Percentage increase or decrease of split tensile strength w.r.t. reference mix.
0 [Ref.]	2.69	---
10	2.73	+1.49
20	2.83	+5.20
30	2.95	+9.67
40	2.90	+7.81
50	2.59	-3.72

Table 6: Split tensile strength test results of concrete with dry pumice aggregates subjected to acidic attack. [without soaking]		
Partial replacement of coarse aggregates by pumice aggregates (%)	Average split tensile strength (N/mm^2)	Percentage increase or decrease of split tensile strength w.r.t. reference mix.
0	2.69	---
10	2.85	+5.95
20	2.95	+9.67
30	3.04	+13.01
40	2.92	+8.55
50	2.62	-2.60

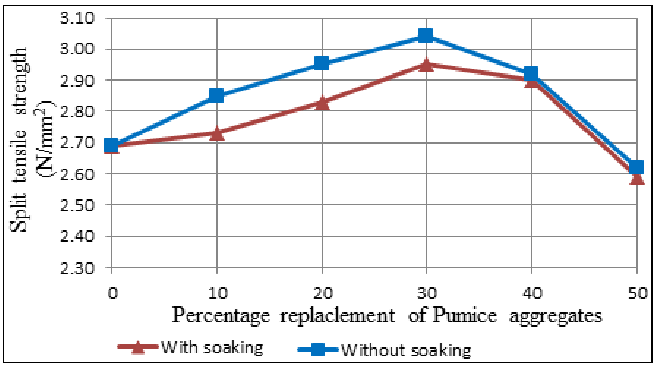

Fig. 12: **Variation of split tensile strength of concrete with pumice aggregates subjected to acidic attack.**

1.5. Observations and discussions.

Based on the experimentations conducted, following observations are made.

1. The compressive strength of steel fiber reinforced concrete with superabsorbent polymer subjected to acidic attack shows an increasing trend as the percentage of superabsorbent polymer in it increases up to 0.3%. A compressive strength of 28.74 MPa is obtained when 0.3% superabsorbent polymer is used. After 0.3% addition of superabsorbent polymer, compressive strength shows a decreasing trend. The percentage increase in the compressive strength is found to be 6.01% when 0.3% of superabsorbent polymer is added as compared to reference concrete.

2. Compressive strength of steel fibre reinforced concrete produced by replacing coarse aggregates by soaked pumice aggregates subjected to acidic attack goes on increasing up to 30% replacement. There after the compressive strength decreases. A compressive strength 28.44 MPa is obtained when 30% coarse aggregates are replaced by soaked pumice aggregates. The percentage increase in the compressive strength is found to be 4.91% as compared to reference concrete when 30% coarse aggregates are replaced by soaked pumice aggregates.

3. Compressive strength of steel fibre reinforced concrete produced by replacing coarse aggregates by unsoaked pumice aggregates subjected to acidic attack goes on increasing up to 30% percentage replacement. Thereafter, compressive strength decreases. A compressive strength of 29.04 MPa is obtained when 30% coarse aggregates are replaced by unsoaked pumice aggregates. The percentage increase in the compressive strength is found to be 7.12% as compared to reference concrete when 30% coarse aggregates are replaced by unsoaked pumice aggregates.

4. It is observed that the compressive strength of steel fibre reinforced concrete produced by unsoaked pumice aggregates subjected to acidic attack is more as compared to that produced by soaked pumice aggregates. This is true for all percentage replacements of coarse aggregates by pumice aggregates. This is due to the fact that the steel fibre reinforced concrete which is cured in water gets all recommended ambiance for curing.

5. It is observed that the tensile strength of steel fiber reinforced concrete with superabsorbent polymer subjected to acidic attack shows an increasing trend as the percentage of superabsorbent polymer in it increases up to 0.3%. A tensile strength of 2.97 MPa is obtained when 0.3% superabsorbent polymer is used. After 0.3% addition of superabsorbent polymer, tensile strength shows a decreasing trend. The percentage increase in the tensile strength is found to be 10.41% when 0.3% of superabsorbent polymer is added as compared to reference concrete.

6. It is observed that the tensile strength of steel fibre reinforced concrete produced by replacing coarse aggregates by soaked pumice aggregates subjected to acidic attack goes on increasing up to 30% replacement. There after the tensile strength decreases. A tensile strength of 2.95 MPa is obtained when 30% coarse aggregates are replaced by soaked pumice aggregates. The percentage increase in the tensile strength is found to be 9.67% as compared to reference concrete when 30% coarse aggregates are replaced by soaked pumice aggregates.

7. It is observed that the tensile strength of steel fibre reinforced concrete produced by replacing coarse aggregates by unsoaked pumice aggregates subjected to acidic attack goes on increasing up to 30% replacement. Thereafter, tensile strength decreases. A tensile strength of 3.04 MPa is obtained when 30% coarse aggregates are replaced by unsoaked pumice aggregates. The percentage increase in the tensile strength is found to be 13.01% as compared to reference concrete when 30% coarse aggregates are replaced by unsoaked pumice aggregates.

8. It is observed that the tensile strength of steel fibre reinforced concrete produced by unsoked pumice aggregates subjected to acidic attack is more as compared to that produced by soaked pumice aggregates. This is true for all percentage replacement of coarse aggregates by pumice aggregates. This is due to the fact that the steel fibre reinforced concrete which is cured in water gets all recommended ambiance for curing.

1.6. Conclusions:

- Compressive strength of steel fiber reinforced concrete with superabsorbent polymer subjected to acidic attack show an increasing trend up to 0.3% addition of superabsorbent polymer. Beyond this percentage the compressive strength will get affected.

- Steel fibre reinforced concrete produced with 30% replacement of coarse aggregates by soaked pumice aggregates subjected to acidic attack will yield higher compressive strength.

- Steel fibre reinforced concrete produced with 30% replacement of coarse aggregates by unsoaked pumice aggregates yield higher compressive strength when subjected to acidic attack.

- Compressive strength of steel fibre reinforced concrete produced by unsoaked pumice aggregates is more as compared to that produced by soaked pumice aggregates.

- Tensile strength of steel fiber reinforced concrete with superabsorbent polymer subjected to acidic attack show an increasing trend up to 0.3% addition of superabsorbent polymer. Beyond this percentage the tensile strength will get affected.

- Steel fibre reinforced concrete produced with 30% replacement of coarse aggregates by soaked pumice aggregates subjected to acidic attack will yield higher tensile strength.

- Steel fibre reinforced concrete produced with 30% replacement of coarse aggregates by unsoaked pumice aggregates subjected to acidic attack will yield higher tensile strength.

- Tensile strength of steel fibre reinforced concrete produced by unsoaked pumice aggregates subjected to acidic attack is more compared to that produced by soaked pumice aggregates.

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