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Durability Enhancement of Concrete Using Super Absorbent Polymer and Foundry Sand

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Abstract: Concrete durability is often compromised by autogenous shrinkage and insufficient internal curing, leading to cracking and reduced service life. This study investigates the effectiveness of Super Absorbent Polymer (SAP) as an internal curing agent in improving the durability characteristics of concrete. Sodium polyacrylate was incorporated at dosages of 0.2%, 0.3%, 0.4%, and 0.5% by weight of cement, while foundry sand was used as a partial replacement for fine aggregate to enhance sustainability. Mechanical and durability properties were evaluated through compressive strength, split tensile strength, flexural strength, water absorption, sorptivity, rapid chloride penetration, acid resistance, sulphate attack, and abrasion resistance tests. Results indicate significant improvement in durability and strength properties with SAP inclusion. The optimum performance was observed at 0.4% SAP, which exhibited reduced permeability, improved resistance to chemical attack, and enhanced overall durability.

Keywords: *Component; Super Absorbent Polymer; Foundry Sand; Durability; Internal Curing**;** Steel Fibers; Concrete.*

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I. INTRODUCTION

Concrete is the most widely used construction material; however, its long-term durability is often affected by shrinkage-induced cracking and permeability-related issues. Autogenous shrinkage occurs due to self-desiccation during hydration, particularly in low water-cement ratio concrete. Internal curing using Super Absorbent Polymer (SAP) has emerged as an effective solution to mitigate such issues. SAP can absorb and retain large quantities of water and release it gradually, thereby enhancing hydration and reducing shrinkage. Additionally, the utilization of industrial by-products such as foundry sand contributes to sustainable construction practices. This study aims to evaluate the combined effect of SAP and foundry sand on the durability performance of concrete.

II. MATERIALS AND METHODS

➢ *Materials*

- Ordinary Portland Cement (OPC 53 Grade)
- Fine Aggregate (River Sand)
- Coarse Aggregate (20 mm size)
- Super Absorbent Polymer (Sodium Polyacrylate)
- Foundry Sand (partial replacement of FA)
- Potable Water

➢ *Mix Proportions*

- CC (Control Mix – 0% SAP)
- SAP 0.2%
- SAP 0.3%
- SAP 0.4%
- SAP 0.5%

➢ *Specimen Preparation*

Concrete cubes (150 mm), cylinders, and beams were cast and cured for 28 days under standard conditions.

➢ *Testing Program*

- *Mechanical Properties*

✓ Compressive Strength
✓ Split Tensile Strength
✓ Flexural Strength

- *Durability Tests*

✓ Water Absorption

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- ✓ Sorptivity
- ✓ Rapid Chloride Penetration Test (RCPT)
- ✓ Acid Resistance
- ✓ Sulphate Attack
- ✓ Abrasion Resistance

III. RESULTS AND DISCUSSION

➢ *Compressive Strength*

Compression test on cube is done by placing the specimen centrally on the location marks of compression testing machine and load is applied continuously and gradually. Rate of load application for screw power machine with moving head operating at 0.05 in (1.3mm) per minute when the machine is running idle is acceptable. In case of shear slump, the slump value is measured as the difference of height of mould and average value of subsidence. Shear slump also indicates that the concrete is non-cohesive and shows the characteristic of segregation. Rate of load application for screw power machine with moving head operating at 0.05 in (1.3mm) per minute when the machine in the form of concrete to be is running idle is acceptable.

Fig 1 Compressive Strength Test

Table 1 Compressive Strength Test Results of SAP Concrete

% of SAP	Compressive strength @ 7 days (N\mm^2)	Compressive strength @ 28 days (N\mm^2)
0.2%	27.13	29.63
0.3%	26.1	32.13
0.4%	31.87	33.30

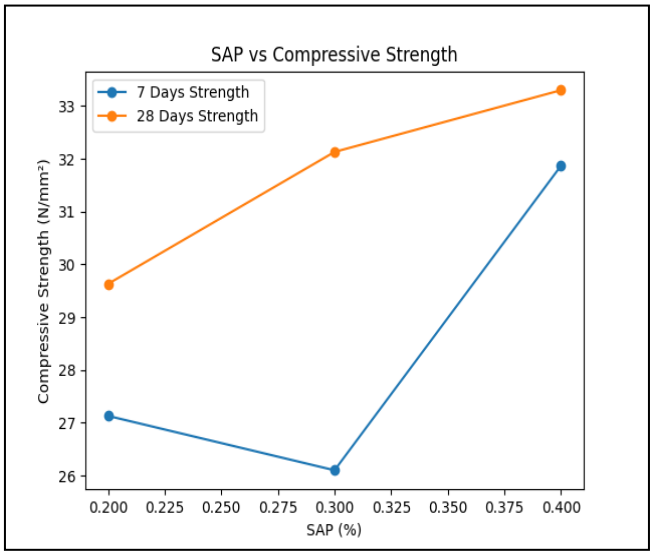

Fig 2 SAP vs Compressive Strength

- The average compressive strength at 7 days = 27.8 N/mm²
- The average compressive strength at 28 days = 32.03 N/mm²

The compressive strength increased with the addition of SAP up to 0.4%, after which it slightly decreased due to excess polymer content.

➢ *Flexural Test on Beam*

The standard size for concrete beam samples (specimens) used to test flexural strength is 150 mm x 150 mm x 700 mm (or 6" x 6" x 21"), according to ASTM/AASHTO standards.

Fig 3 Flexural Strength Test

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Table 2 Flexural Strength Test Results of SAP Concrete

S. No	SAP %	Ultimate Load (kN)	Flexural Strength (N/mm²)
1	0%	18.2	4.55
2	0.2%	19.6	4.90
3	0.3%	21.0	5.25
4	0.4%	20.3	5.07

➢ *Tensile Strength*

Table 3 Tensile Strength Test Results of SAP Concrete Beam

Mix	Average Tensile Strength (N/mm²)
Conventional Concrete	2.97
SAP 0.2%	3.11
SAP 0.3%	3.32
SAP 0.4%	3.53

➢ *Durability Performance*

- *Water Absorption*
  Water absorption decreased with increase in SAP content, indicating reduced porosity.

Table 4 Water Absorption Test Observation Table

Sample No	Dry Weight (kg)	Wet Weight (kg)	Water Absorption (%)
1	8.10	8.32	2.71
2	8.05	8.26	2.61
3	8.12	8.34	2.71

✓ Average Water Absorption = 2.67%

- *Sorptivity*
  Sorptivity values reduced due to improved internal curing and pore structure.

Table 5 Sorptivity Test Observation Table

Time (min)	Water Absorption (mm)
5	0.8
10	1.2
15	1.5
30	2.0

✓ Sorptivity coefficient = 0.35 mm/min^0.5

- *Rapid Chloride Penetration Test*
  Charge passed decreased significantly, indicating lower permeability and improved resistance to chloride attack.

- *Moderate Chloride Permeability*

Table 6 Rapid Chloride Penetration Test Observation Table

Mix Type	SAP %	Charge Passed (Coulombs)	Chloride Permeability
Conventional Concrete(CC)	0%	1800	Moderate
SAP Concrete	0.2%	1500	Moderate
SAP Concrete	0.3%	1200	Low
SAP Concrete	0.4%	950	Very Low
SAP Concrete	0.5%	980	Very Low

- *Acid Resistance*
  SAP concrete showed lower weight loss compared to conventional concrete.

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Table 7 Acid Resistance Test Observation Table

Sample No	Initial Weight (kg)	Final Weight (kg)	Weight Loss (%)
1	8.20	7.95	3.05
2	8.15	7.92	2.82
3	8.18	7.94	2.93

✓ Average Weight Loss = 2.93%

- *Sulphate Attack*
  Reduced expansion and strength loss were observed.

- *Abrasion Resistance*
  Surface wear resistance improved with SAP addition.

Table 8 Abrasion Resistance Test Observation Table

Sample No	Initial Thickness (mm)	Final Thickness (mm)	Loss (mm)
1	150	148.5	1.5
2	150	148.7	1.3
3	150	148.6	1.4

✓ Average Loss = 1.4 mm

➢ *Optimum Mix*

The optimum performance was observed at 0.4% SAP, which provided the best balance of strength and durability.

➢ *Discussion*

- The mix design for M30 grade of concrete was found by using IS 10262:2009and the mix ratio of concrete found is 1:1.5:2.52.
- The concrete mix was of low workability.
- The average compressive strength of conventional concrete was found 2 2 to be 21.2 N/mm^2 and 35.5 N/mm^2 at 7 days and 28 days of curing respectively.
- The average compressive strength of SAP concrete at 0.25% was found 2 to be 21.6 N/mm^2, 31.25 N/mm^2 at 7 and 28 days respectively.
- The average compressive strength of SAP concrete at 0.5% was found to be 28.1 N/mm^2, 36.5 N/mm^2 at 7 and 28 days respectively.
- The average flexural strength of conventional concrete was found to be 6.75 N/mm^2 and 8.05 N/mm^2 at 7days and 28 days of curing respectively.
- The average flexural strength of SAP concrete at 0.25% was found to be 2.75 N/mm^2, 6.6 N/mm^2 at 7 and 28 days respectively.
- The average flexural strength of SAP concrete at 0.5%was found to be 2 N/mm^2, 7.4 N/mm^2 at 7 and 28 days respectively.
- The average impact strength of conventional concrete and SAP concrete at 0.25%, 0.5%was found to be 7.5joule at 7days and 28 days of curing. It shows that the addition of SAP do not affect the impact strength of concrete.

IV. CONCLUSION AND FUTURE SCOPE

➢ *Conclusion*

- Material required for the project has been collected.
- Basic material investigation has been done to know the properties of the materials.
- Based on the material investigations mix design for the M30 grade concrete has been arrived.
- Fresh concrete test has to be carried out in order to find the properties of concrete.
- The SAP is to be added to the concrete in the order of 0.2%,0.3% and 0.4% by weight of cement.
- Concrete Beam to be casted to find out the compressive strength of concrete.
- Concrete cylinder to be casted to find out the split tensile strength of concrete.
- Concrete Beam to be casted to find out the flexural strength of concrete.
- Test results of conventional concrete and SAP induced foundry sand concrete are compared and the optimum percentage of SAP will be found.
- Super Absorbent Polymer improves internal curing of concrete
- Durability properties such as permeability and resistance to chemical attack are enhanced
- Foundry sand contributes to sustainable construction
- The optimum dosage of SAP is 0.4%
- SAP concrete is suitable for aggressive environmental conditions

➢ *Future Scope*

- Use in marine and coastal structures
- Study long-term durability performance
- Combination with other admixtures like fly ash and silica fume

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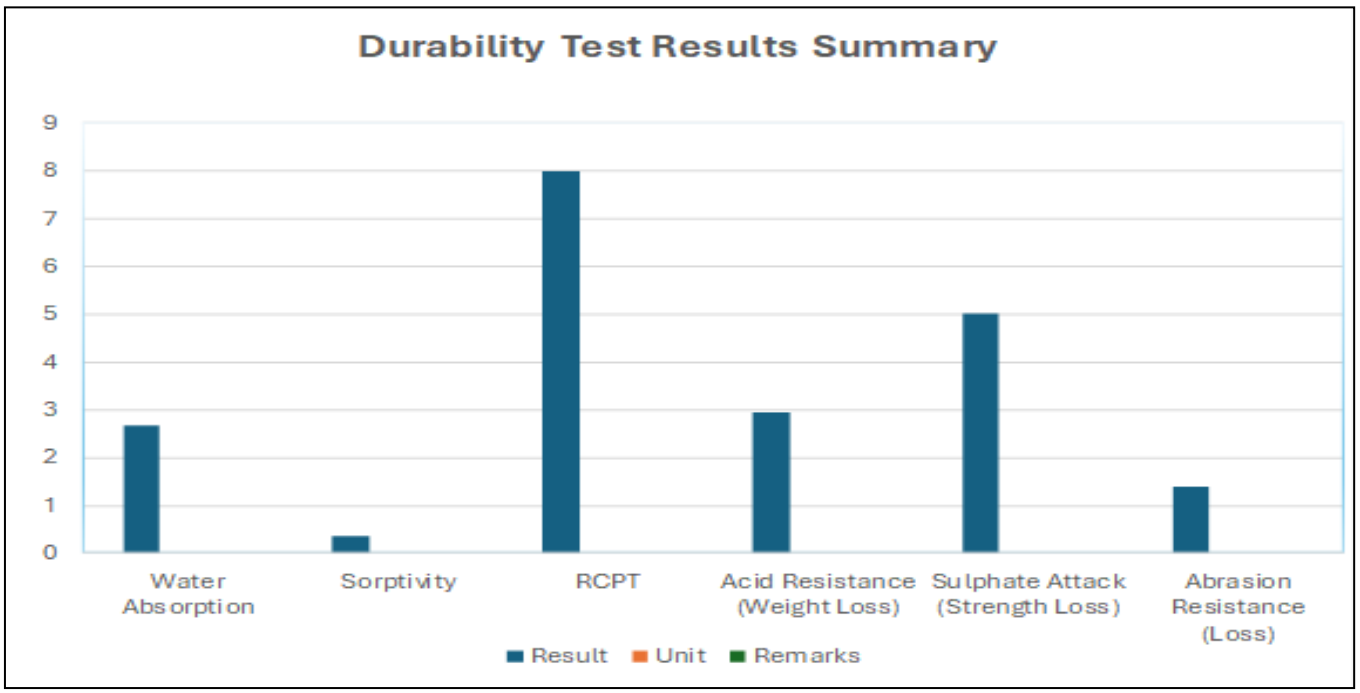

Fig 4 Durability Test Result Summary.

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