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Experimental Investigation of *Aloe barbadensis miller* and *Artocarpus heterophyllus* to Evaluate the Self-Curing Properties of Concrete

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Abstract:

Concrete performance is highly dependent on curing efficiency, and inadequate curing often leads to reduced strength, increased permeability, and durability loss. This study explored the feasibility of using natural self-curing materials such as Aloe Vera Gel (AVG) and Jackfruit Seed Powder (JSP) in M25 grade concrete. These materials are selected based on their moisture-retaining and bio-polymeric characteristics, which contribute to internal curing mechanisms. Aloe Vera Gel improves hydration by retaining water within the concrete matrix, while Jackfruit Seed Powder enhances particle bonding and reduces internal voids due to its starch-rich composition. Experimental results indicated improvements in workability, compressive strength, and split tensile strength when compared to conventional concrete. The optimum mix (2.5% AVG + 0.5% JSP) showed approximately 12.9% improvement in workability, 2.07% increase in compressive strength, 2.17% increase in split tensile strength, 6.1% in load-carrying capacity and 7.57% increase in cost compared to conventional concrete. The study concludes that natural admixtures can serve as sustainable alternatives to conventional curing practices while enhancing overall concrete performance.

Keywords — **self-curing concrete, compressive strength, aloe vera gel, jackfruit seed powder, internal curing, sustainable materials.**

I. INTRODUCTION

Concrete is one of the most extensively used construction materials because of its strength, durability, and wide range of applications. It consists of cement, fine aggregate, coarse aggregate, and water as its primary constituents. Among these components, the water–cement ratio significantly influences both the fresh and hardened properties of concrete. An increase in water content improves workability but generally reduces strength due to increased porosity in the cement matrix [18]. During hydration, excess mixing water may evaporate, leaving behind voids and capillary channels. These voids weaken the internal structure of concrete and contribute to shrinkage, cracking, and long-term durability issues. Conversely, a lower water–cement ratio enhances strength but may reduce workability, leading to compaction difficulties and poor finishing [6].

Conventional curing methods rely on external water supply to maintain hydration; however, these methods may not always ensure uniform moisture distribution in field conditions. This limitation has led to growing interest in internal or self-curing approaches using natural and chemical additives [4]. Recent studies highlight the potential of bio-based materials in improving concrete performance. Aloe Vera Gel contains polysaccharides and bound water that help sustain internal moisture, promoting continuous hydration of cement particles [1]. Similarly, Jackfruit Seed Powder, rich in natural starch, improves cohesion, reduces micro-voids, and contributes to a denser microstructure [15]. The integration of such natural materials supports environmentally sustainable construction practices by reducing dependency on chemical admixtures and external curing water [4], [7].

II. LITERATURE REVIEW

Earlier studies have highlighted curing as a critical factor influencing concrete performance. Research shows that inadequate curing can lead to a reduction in compressive strength and durability. Conventional curing methods, while effective, may not always be feasible in field applications. Research on Aloe Vera-based additives suggests that they improve internal curing by retaining moisture within the concrete system, resulting in enhanced hydration and strength development [1], [11]. Optimal replacement levels between 1.5% and 2.5% have been reported to improve both workability and mechanical properties [3]. Similarly, starch-based natural materials such as Jackfruit Seed Powder have been found to improve concrete density and reduce permeability due to better particle packing and enhanced hydration conditions [15]. Similar studies on starch-based admixtures have also reported improvements in the strength and durability of concrete systems [2]. Combined use of natural admixtures has shown promising results in improving compressive strength, tensile strength, and overall durability while promoting sustainable construction practices [4], [9].

III. MATERIALS

The materials used in this study include Ordinary Portland Cement (OPC 53 grade), fine aggregate (M sand), coarse aggregate, water, Aloe Vera Gel (AVG), and Jackfruit Seed Powder (JSP). All materials were selected based on availability and conformity with relevant IS standards. All constituent materials were tested as per relevant IS codes to ensure suitability for concrete production. Figure 1 shows the materials used in concrete.

Fig.1 Materials in Concrete

A. Cement Test

Cement was tested for fineness, standard consistency, and specific gravity as per IS 4031. The results are presented in Table 1.

Table 1 Cement Properties

S.NO.	TEST PERFORMED	RESULTS
1	Fineness (<90 microns)	3 %
2	Standard consistency value	31 %
3	Specific gravity	3.14

B. Fine Aggregate Test

Fine aggregate was tested for specific gravity, water absorption, and fineness modulus as per IS 2386 (Part III). The results are given in Table 2.

Table 2 Fine Aggregate Properties

S.NO	PROPERTY	RESULTS
1	Specific Gravity	2.62
2	Water Absorption	1%
3	Fineness Modulus	2.7

C. Coarse Aggregate Test

Coarse aggregate was tested for specific gravity and water absorption as per IS 2386 (Part III). The results are presented in Table 3.

Table 3 Coarse Aggregate Properties

S.NO.	PROPERTY	RESULTS
1	Specific Gravity	2.8
2	Water Absorption	0.5%

D. Natural Additives Test

Aloe Vera Gel and Jackfruit Seed Powder were tested for pH, fineness, and specific gravity to evaluate their suitability as natural admixtures. The results are shown in Table 4.

Table 4 Natural Additives Properties

S.NO.	PROPERTY	RESULTS
1	pH (AVG)	5.78
2	pH (JSP)	6.09
3	Fineness (JSP)	5%
4	Specific Gravity (JSP)	1.3

IV. METHODOLOGY

E. Mix Design

The mix design for M25 grade concrete was carried out as per IS 10262:2019 guidelines. The target mean strength was 31.6 MPa with a water– cement ratio of 0.45. The design mix was prepared using Ordinary Portland Cement (OPC 53 grade), M sand as fine aggregate, and crushed coarse aggregates. The mix was proportioned to achieve adequate workability and strength for experimental investigation of self-curing concrete.

F. Mix Proportions

The final mix proportions obtained for M25 grade concrete were:

- Cement: 394.32 kg/m³
- Water: 177.44 kg/m³
- Fine Aggregate: 676.64 kg/m³
- Coarse Aggregate: 1231.27 kg/m³
- Mix Ratio: 1 : 1.71 : 3.12 (C : FA : CA)
- Water–cement ratio: 0.45

For modified mixes, Aloe Vera Gel (AVG) and Jackfruit Seed Powder (JSP) were added in varying percentages (1.5%, 2%, 2.5% AVG and 1.5%, 1%, 0.5% JSP) by weight of cement.

G. Specimen Preparation

All materials were weighed accurately and dry mixed until uniform colour was achieved. Water mixed with Aloe Vera Gel was added gradually, followed by uniform mixing. Jackfruit Seed Powder was added in powdered form during dry mixing to ensure even distribution.

The concrete was cast into standard moulds:

- Cubes: 150 × 150 × 150 mm (compressive strength)
- Cylinders: 150 × 300 mm (split tensile strength)
- Beams: for load–deflection study

H. Curing Method

After 24 hours of casting, specimens were demoulded and subjected to self-curing conditions without external water curing. The internal curing effect was achieved through Aloe Vera Gel, which retains moisture within the concrete matrix and supports continuous hydration of cement particles. Jackfruit Seed Powder contributes to internal densification and moisture retention. Testing was carried out at 7, 14, and 28 days.

I. Experimental Work

The following tests were conducted as per relevant IS standards:

- Slump Test (IS 1199): To determine workability of fresh concrete.
- Compressive Strength Test (IS 516): Conducted on cube specimens at 7, 14, and 28 days.
- Split Tensile Strength Test (IS 5816): Conducted on cylindrical specimens to evaluate tensile behaviour.
- Load–Deflection Test: Conducted on beam specimens to study the structural performance.

V. RESULTS AND DISCUSSION

J. Slump Test

Workability of concrete was assessed using the slump cone test. The slump values obtained for different concrete mixes are presented in Table 5.

Table 5 Slump value

Type	Slump Value mm
M25	93
MIX 1	97
MIX 2	101
MIX 3	105

The results show a gradual increase in slump value with the incorporation of Aloe Vera Gel (AVG) and Jackfruit Seed Powder (JSP). The control mix exhibited a slump value of 93 mm, whereas the modified mixes showed improved workability, reaching a maximum of 105 mm for Mix 3 (2.5% AVG + 0.5% JSP), representing an increase of approximately 12.9%. This improvement is attributed to the moisture-retaining and lubricating properties of Aloe Vera Gel, which enhance internal flow characteristics [1]. Additionally, the fine particles of Jackfruit Seed Powder improve packing density and reduce inter-particle friction [6], [9].

Similar enhancements in flow behaviour due to plant-based polysaccharides have also been reported in recent studies [9], [16].

K. Compressive Strength Test

The compressive strength results for all mixes at 7, 14, and 28 days are summarized in Table 6.

At 28 days, the control mix achieved a compressive strength of 31.8 MPa, whereas Mix 3 (2.5% AVG + 0.5% JSP) recorded the highest value of 32.46 MPa. This represents an increase of approximately 2.07% compared to the control mix. This improvement is attributed to enhanced internal curing provided by Aloe Vera Gel, which supports continuous hydration, and the void-filling effect of Jackfruit Seed Powder, which increases matrix density [12], [15]. However, slight reductions in early-age strength in some mixes may be due to delayed hydration effects caused by natural organic compounds [8]. Overall, the observed trend aligns with previous research on bio-based admixtures improving long-term compressive strength in concrete systems [2], [4].

Table 6 Compressive Strength Test

Mix type	Compressive strength test											
	7 days				14 days				28 days			
	Trial 1	Trial 2	Trial 3	Mean	Trial 1	Trial 2	Trial 3	Mean	Trial 1	Trial 2	Trial 3	Mean
M25	21.5	23.1	22.9	22.5	24.9	26.5	26.1	25.83	31.7	32.3	31.4	31.8
MIX 1	19.7	19.2	20.9	19.93	24.8	23.9	25.4	24.7	29.2	30.1	29.9	29.73
MIX 2	21.1	21.5	22.5	21.7	25.8	25.1	24.6	25.16	30.4	31.3	29.8	30.5
MIX 3	23.1	22.3	23.3	22.9	26.6	25.8	26.1	26.2	32.7	33.2	31.5	32.46

Figure 2 shows the compressive strength variation of different mixes at 7, 14 and 28 days.

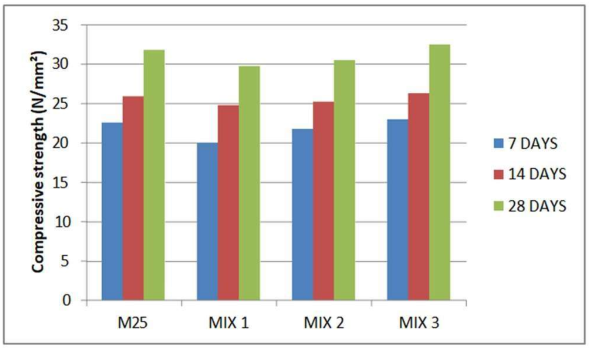

Fig. 2 Compressive Strength Variation

L. Split Tensile Test

The split tensile strength followed a similar trend to compressive strength, with consistent improvement as curing age increased. The control mix recorded a tensile strength of 3.23 MPa at 28 days, while Mix 3 achieved the highest value of 3.30 MPa.

This corresponds to an increase of approximately 2.17% compared to the control mix. This improvement is attributed to enhanced bonding between cement paste and aggregates due to internal curing, along with reduced micro-voids caused by the filler effect of JSP [11], [13]. Table 7 presents the split tensile strength values obtained for the various concrete mixes.

The combined effect leads to a denser and more continuous matrix structure. Similar enhancements in tensile strength using natural admixtures have been reported in sustainable concrete research [4], [17]. Furthermore, the reduction in capillary pores due to the filler effect of JSP enhances matrix compactness, which contributes to higher tensile strength and durability characteristics. Although the percentage increase in split tensile strength is comparatively moderate, it demonstrates the positive contribution of AVG and JSP towards improving the mechanical behaviour of concrete without adversely affecting structural performance. Figure 3 shows the Split tensile strength variation of different mixes at 7, 14 and 28 days.

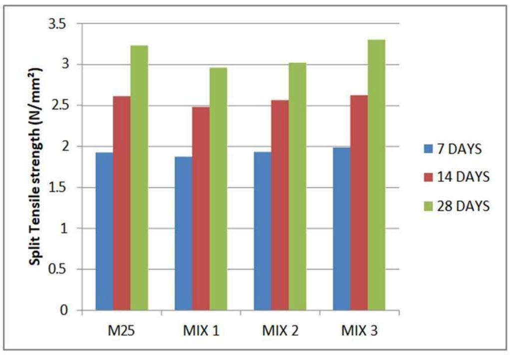

Fig. 3 Split Tensile Strength Variation

Table 7 Split Tensile Strength Test

Mix type	Split tensile strength test											
	7 days				14 days				28 days			
	Trial 1	Trial 2	Trial 3	Mean	Trial 1	Trial 2	Trial 3	Mean	Trial 1	Trial 2	Trial 3	Mean
M25	1.97	1.92	1.87	1.92	2.59	2.55	2.71	2.61	3.16	3.35	3.2	3.23
MIX 1	1.83	1.94	1.86	1.87	2.43	2.54	2.47	2.48	2.97	3.02	2.89	2.96
MIX 2	1.89	1.97	1.93	1.93	2.56	2.6	2.52	2.56	3.14	2.95	2.97	3.02
MIX 3	2.04	1.92	1.98	1.98	2.57	2.65	2.63	2.62	3.25	3.29	3.37	3.3

M. Load Deflection Behaviour of Beam

The structural performance of beams was evaluated using load–deflection behaviour. The results indicate that modified concrete mixes exhibit improved load-carrying capacity compared to conventional concrete. Mix 3 showed the highest first crack load of 39.25 kN and an ultimate load of 71.26 kN, indicating superior structural resistance. The first crack load increased from 37.6 kN to 39.25 kN, representing an improvement of approximately 4.38%**,** while the ultimate load increased from 67.16 kN to 71.26 kN, corresponding to an increase of about 6.1%. The first crack load, ultimate load, and corresponding deflection values are shown in Table 8.

Table 8 Crack Load, Ultimate Load, Deflection

	First Crack Load (kN)	Ultimate Load (kN)	Deflection (mm)
M25	37.6	67.16	2.2
MIX 1	29.4	61.78	1.9
MIX 2	35.7	66.72	2.1
MIX 3	39.25	71.26	2.5

This improvement is mainly due to enhanced bonding and densification of the cementitious matrix caused by Aloe Vera Gel, which supports internal curing and sustained hydration [12]. Jackfruit Seed Powder contributes to better particle packing and reduced micro-voids, improving overall structural integrity [15]. The detailed load–deflection response comparison between M25 and Mix 3 is presented in Table 9.

Table 9 Load Deflection value

Load (kN)	Deflection (mm)	
	M25	MIX 3
10	0.1	0.1
20	0.5	0.3
30	0.9	0.6
40	1.2	1.0
50	1.7	1.5
60	2.2	1.9
70	-	2.4

Fig. 4 shows the load–deflection response of M25 and MIX 3 beams.

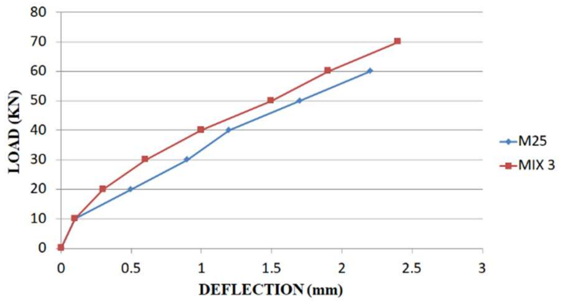

Fig. 4 Load-Deflection Response

Similar improvements in structural behaviour of concrete incorporating natural and bio-based admixtures have been reported in previous studies on sustainable concrete systems [10], [14]. Additional research also highlights improved stiffness and load resistance due to microstructural densification in modified cement composites [18].

N. Economic Comparison

The cost comparison of conventional and modified concrete mixes is presented in Table 10.

Table 10. Cost Comparison

TYPE	AVG (₹10/kg)	JSP (₹200/kg)	COST (per m^3)
M25	-	-	₹6500
MIX 1	₹59	₹1182	₹7741
MIX 2	₹78	₹788	₹7366
MIX 3	₹98	₹394	₹6992

The cost of the control mix was compared with the three modified mixes, and the results indicate a gradual increase in cost with the incorporation of Aloe Vera Gel (AVG) and Jackfruit Seed Powder (JSP). The control mix costs ₹6500 per cubic meter, whereas Mix 1 costs ₹7741, showing an increase of approximately 19.09%. Mix 2 costs ₹7366, which corresponds to a 13.33% increase, while Mix 3 costs ₹6992, representing the lowest increase of about 7.57% compared to the control mix. This variation is mainly due to the higher cost contribution of Jackfruit Seed Powder compared to Aloe Vera Gel, along with differences in dosage proportions among the mixes. However, Mix 3 demonstrates the most economical balance between cost and performance, as it achieves improved mechanical properties with minimal cost increase. Similar trends regarding cost sensitivity to natural admixture dosage have been reported in sustainable concrete studies, where material optimization plays a key role in balancing performance and economy [7], [13].

VI. CONCLUSION

The study on M25-grade self-curing concrete with Aloe Vera Gel (AVG) and Jackfruit Seed Powder (JSP) shows that natural admixtures improve both fresh and hardened properties. Workability improved by approximately 12.9%, while compressive strength and split tensile strength increased by about 2.07% and 2.17%. Structural performance also showed improvement, with increases of approximately 6.1% in load-carrying capacity. The optimum performance was observed for Mix 3 (2.5% AVG + 0.5% JSP), which is attributed to effective internal curing and improved microstructural densification. Although a moderate increase in cost (7.57%) was observed, the sustainability benefits and reduced dependency on external curing make this approach suitable for practical applications.

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