



# Experimental Investigation on Behaviour of Self Compacting Concrete Made With Agriculture Wastes As A Partial Replacement of Cement With Corncob Ash

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**Abstract:** Experimental Investigation on Behaviour of Self-Compacting Concrete Made with Agricultural Wastes as a Partial Replacement of Cement with Corncob Ash explores the use of Corn Cob Ash (CCA) as a sustainable alternative to partial cement replacement in Self-Compacting Concrete (SCC). SCC, known for its high workability without the need for mechanical compaction, can benefit from incorporating agricultural waste like CCA, which possesses pozzolanic properties. The study investigates the behaviour of SCC made with agricultural wastes as a partial replacement of cement with varying proportions of CCA (0%, 3%, 5%, 10%, and 15%) with a w/c ratio of 0.43 on the workability, compressive strength of M30 grade SCC. The findings reveal that replacing up to 10% of cement with CCA is the optimal percentage replacement. Workability of SCC was observed to decrease as the CCA content increased. This suggests the need for additional water or admixtures to maintain fluidity at higher CCA levels. Compressive strength tests show that SCC mixes with up to 10% CCA maintain adequate strength. At 28 days, the strength decreases from 42.45 MPa at 0% to 35.9 MPa at 15% replacement. Furthermore, this approach reduces the environmental impact of concrete production by lowering cement usage and repurposing agricultural waste. The optimal mix is found up to 10% CCA replacement, balancing performance and sustainability.

**Key Words** - Self Compacting Concrete (SCC), Corncob Ash (CCA), Cement, Compressive Strength.

## I. INTRODUCTION

The adoption of sustainable materials in construction is imperative to mitigate economic and environmental challenges, with self-compacting concrete (SCC) exemplifying advancements in high-performance concrete technology. SCC, characterized by its self-flowing and non-vibratory nature, enhances construction efficiency, reduces labor dependency, and achieves superior quality, particularly in intricate formworks. The incorporation of corncob ash (CCA), an agricultural byproduct with significant pozzolanic activity, as a partial cement substitute offers a dual advantage: mitigating the environmental burden of cement production and valorizing waste materials. Rich in reactive silica, CCA synergistically enhances the hydration process, generating additional calcium silicate hydrate (C-S-H) to improve concrete's mechanical and durability attributes while reducing permeability and susceptibility to chemical degradation. This study critically investigates the potential of SCC with CCA as a transformative solution for sustainable and resilient concrete infrastructure.

## LITERATURE REVIEW

S. Kavitha et al. (2024) emphasized the potential of agricultural by-products, including sugarcane bagasse ash and corncob ash, as sustainable partial cement replacements in self-compacting concrete (SCC). Their findings highlighted the pozzolanic properties of these materials, which not only improve workability but also reduce cement consumption, thereby enhancing the sustainability of SCC without compromising its performance[11]. R. Ramya Swetha and M. Swaroopa Rani (2023) explored the use of RHA and SBA in SCC for M30 grade concrete. Their optimal mix, combining 4% RHA and 10% SBA, demonstrated enhanced compressive strength and workability, affirming its suitability for applications requiring high durability and reduced environmental impact[4]. M.M. Lawan et al. (2022) investigated the efficacy of rice husk ash (RHA) and sugarcane bagasse ash (SBA) in enhancing the mechanical properties of SCC. Their results revealed that partial cement replacement at 5% significantly improved compressive and flexural strength, offering an economical and environmentally viable alternative for construction materials in developing countries[13]. Behailu Zerihun and Mitiku Damtie Yehualaw (2022) assessed various agro-wastes, including CCA, for their cementitious potential. These materials, rich in aluminosiliceous compounds, were found to enhance the mechanical and durability properties of concrete, particularly through the formation of denser reactive gels, thus meeting pozzolanic standards for sustainable construction[14]. Subahar Mohan and Chandrasekaran P. (2022) examined the incorporation of CCA and artificial fibers in high-performance concrete (HPC). They found that a 15% CCA replacement, combined with 0.4% artificial fibers, optimized mechanical properties, microstructure, and elasticity. However, excessive CCA content adversely affected strength and workability[15]. Naraindas Bheel et al. (2021) analyzed the combined use of CCA and ground granulated blast furnace slag (GGBFS) in concrete. The study demonstrated that a mix containing 10% GGBFS and 30% CCA improved compressive and tensile strengths while reducing density and water absorption, making it suitable for structural applications[17]. Jing He et al. (2020) reviewed the role of agricultural waste materials, such as palm oil fuel ash and sugarcane bagasse ash, in agro-cement production. Their work highlighted the enhanced sustainability and durability of concrete achieved through the incorporation of these pozzolanic materials, offering a pathway to reduced resource depletion and carbon emissions[20]. Narayana et al. (2017) explored the use of RHA in SCC, revealing that a 15% replacement significantly improved strength and durability while maintaining acceptable workability, making it a viable sustainable substitute in concrete[30]. Kamau et al. (2016) assessed the suitability of CCA as a supplementary cementitious material, finding its inclusion effective for improving concrete durability and reducing clinker consumption, which significantly mitigates environmental impact[32]. Owolabi et al. (2015) evaluated the impact of CCA as a partial cement replacement, identifying 5% CCA as optimal for achieving higher compressive strength while reducing environmental and material costs[33].

## MATERIALS

The materials used for producing Self-Compacting Concrete (SCC) include cement, fine aggregate, coarse aggregate, water, admixtures, and supplementary materials like Corn Cob Ash (CCA) as shown in below Figure 1,2 and 3. Ordinary Portland Cement (OPC) 43 grade is selected for its balanced strength and workability, adhering to IS 8112:2013 standards. Fine aggregate, typically clean and well-graded sand with a fineness modulus between 2.3 and 3.1, ensures the mix's flowability and reduces segregation. Coarse aggregate, usually gravel with sizes ranging from 4.75 mm to 20 mm, provides strength and durability while supporting the self-compaction properties. Water, free from impurities, is crucial for hydration and achieving the desired water-to-cement ratio for workability. Polycarboxylate-based superplasticizers enhance fluidity and reduce the water content while maintaining stability, cohesion, and durability. CCA, produced by burning dry maize cobs at 500–700°C, ground to a fine powder, and sieved through a 75 µm mesh, serves as a sustainable cement replacement due to its pozzolanic properties. Together, these materials are optimized to create SCC with excellent strength, durability, and environmental benefits.



Fig. 1. Cement, Fine aggregate, Coarse aggregate, Corncobs Fig. 2. Corncob Ash Fig. 3. Polycarboxylate

## II. METHODOLOGY

### Mix Design

This study formulates an M30-grade concrete mix design in accordance with IS 10262:2019, utilizing OPC 43-grade cement, 20 mm nominal maximum size angular aggregates, and a PCE- based superplasticizer to enhance rheological behavior under severe exposure conditions. The maximum cement content is restricted to  $450 \text{ kg/m}^3$ , with fine aggregates adhering to Zone II grading as per IS 383. The specific gravities for cement, fine aggregate, coarse aggregate, corncob ash (CCA), and superplasticizer are 3.15, 2.65, 2.74, 2.18, and 1.1, respectively.

**Target Mean Strength:-** The target mean strength ( $f'_{ck}$ ) was computed as  $38.25 \text{ N/mm}^2$ , accounting for severe exposure and adopting a standard deviation of  $5 \text{ N/mm}^2$  per IS 10262:2019 criteria.

**Water-Cement Ratio and Content:-** A water-cement ratio of 0.43 was selected, with a water content of  $180 \text{ kg/m}^3$  complemented by 0.8% superplasticizer (by cement weight) to achieve enhanced workability and durability.

**Cement and CCA Content:-** The baseline cement content of  $419 \text{ kg/m}^3$  complies with IS 456:2000, while cement replacement by CCA at 3%, 5%, 10%, and 15% results in CCA contents of 13, 21, 42, and  $63 \text{ kg/m}^3$ , respectively.

**Aggregate Proportions:-** Fine aggregate content is set at  $810 \text{ kg/m}^3$ , ensuring a particle fineness of 10% below  $0.125 \text{ mm}$ , while coarse aggregate content ranges from  $931.6 \text{ kg/m}^3$  to  $959 \text{ kg/m}^3$ , varying with CCA replacement levels.

**Powder Content and Water-to-Powder Ratio:-** The total powder content, encompassing cement, CCA, and fines  $<0.125 \text{ mm}$ , was maintained at  $500 \text{ kg/m}^3$ , with water-to-powder ratios between 0.85 and 1.10, satisfying self-compacting concrete (SCC) specifications.

### Final Mix Proportions:

- **0% CCA:** 1:1.93:2.22
- **3% CCA:** 1:2.27:2.79
- **5% CCA:** 1:2.03:2.46
- **10% CCA:** 1:2.14:2.54
- **15% CCA:** 1:2.27:2.61

### Mixing Procedure

The process begins with the careful preparation and inspection of all constituent materials, including cement, fine and coarse aggregates, CCA, water, and chemical additives, ensuring their compliance with quality standards. Initially, the dry components—cement, aggregates, and CCA—are combined and thoroughly blended in a mixing apparatus to achieve a uniform particulate distribution. Subsequently, the chemical admixtures are introduced in measured proportions to enhance the rheological properties of the mixture, followed by the gradual incorporation of water in precise quantities to maintain the prescribed

water-to-binder ratio. Wet mixing is then conducted to achieve a cohesive and uniform matrix, ensuring that the CCA is evenly dispersed throughout the blend. The freshly mixed SCC is subjected to workability evaluations such as the slump flow test, to validate its fluidity and L-Box test, V-Funnel Test and after hardening it is subjected to curing for 7, 14 and 28 days and Compression Strength evaluation is performed.

## Testing

### Fresh SCC Testing

Evaluations of fresh Self-Compacting Concrete (SCC) focus on flowability, passing ability, and stability. The following three workability tests are performed as shown in below Figure 4.

**Slump Flow Test:** Measures flowability by determining the spread diameter after lifting a filled slump cone. Ideal ranges are 550–800 mm, indicating excellent workability and filling ability without segregation.

**V-Funnel Test:** Assesses viscosity and flow speed by recording the time SCC takes to pass through a narrow V-shaped funnel. Shorter times indicate lower viscosity and superior flowability.

**L-Box Test:** Evaluates passing ability by measuring SCC's flow ratio through simulated reinforcement bars. The height ratio between vertical and horizontal sections reflects its capacity to flow around obstacles uniformly.



Fig. 4. Slump Flow Test, V- Funnel Test, L-Box Test

### Hardened SCC Testing

**Compressive Strength Test:** Cubical specimens with varying CCA replacements (0–15%) are cured for 7, 14, and 28 days, then tested under progressive loads to determine ultimate compressive strength as shown below in Figure 5. This test ensures the SCC mix achieves requisite load-bearing capabilities while evaluating CCA's impact on performance. These methods collectively validate SCC's suitability for demanding applications, ensuring optimal workability, strength, and durability.



Fig. 5. Compression Strength Test

### III. RESULTS AND DISCUSSION

#### Workability Test Results of SCC

The workability of SCC was evaluated through slump flow, V-funnel, and L-box tests, as shown in above Figure 4. Results revealed a decline in workability with increased CCA content is summarised in below Table 1. Slump flow tests indicated reduced flowability, suggesting stiffer concrete. Similarly, V-funnel tests showed prolonged flow times, while L-box tests demonstrated diminished passing ability, with higher CCA levels leading to reduced fill heights.

**Table 1. Workability Test Results of SCC**

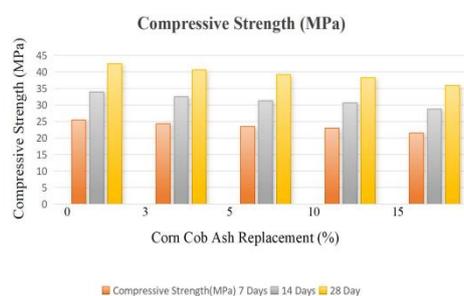
Corncob Ash Replacement (%)	Slump Flow (550mm-800mm)	V-funnel(8-12sec)	L-Box(0.8-1)
0	729	8	0.96
3	722	8.3	0.92
5	718	8.5	9
10	710	8.8	0.87
15	694	9	0.83

#### Compressive Strength Test Results

Compressive strength tests for SCC with varying CCA replacements showed a consistent decline in strength as CCA content increased, as shown in below Figure 6. At 7 days, strength decreased from 25.47 MPa (0% CCA) to 21.54 MPa (15% CCA), with similar trends observed at 14 and 28 days. By 28 days, maximum strength dropped from 42.45 MPa (0% CCA) to 35.9 MPa (15% CCA) is summarised in Table 2.

**Table 2. Compression test Results**

Corncob Ash Replacement (%)	Compressive Strength (MPa)		
	7 Days	14 Days	28 Days
0	25.47	33.96	42.45
3	24.35	32.47	40.58
5	23.39	31.33	39.16
10	22.97	30.62	38.28
15	21.54	28.72	35.9



**Fig. 6. Compressive Strength Vs. Varying % of Corncob Ash**

While all mixes exhibited strength gains over time, excessive CCA content (above 10%) significantly reduced structural strength, particularly during early curing. A balanced approach is advised for optimal cement substitution.

#### IV. CONCLUSIONS

The experimental investigation demonstrated that Corncob Ash (CCA) can be effectively used as a partial replacement for Cement in Self- Compacting Concrete (SCC).

- **Workability:** SCC's fluidity decreases with increasing CCA content, requiring additional water or admixtures to maintain workability.
- **Compressive Strength:** SCC with up to 10% CCA retains sufficient strength, with 28-day compressive strength decreasing from 42.45 MPa (0% CCA) to 35.9 MPa (15% CCA). The optimal replacement range is 3–10%.
- **Performance:** CCA at 3–10% replacement maintains structural integrity, while levels above 10% lead to significant strength reductions, suitable only for non-structural uses.
- **Eco-Efficiency:** CCA reduces construction costs and minimizes reliance on cement and aggregates by repurposing agricultural waste.
- **Sustainability:** Using CCA lowers CO<sub>2</sub> emissions, conserves resources, and addresses agricultural waste disposal challenges by converting waste into a functional construction material.

In conclusion, replacing cement with CCA up to 10% optimally balances compressive strength, cost-effectiveness, and environmental sustainability, offering a greener alternative for concrete production.

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