

Durability And Performance Investigation Of Concrete With Advanced Cement Reducing Materials

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ABSTRACT

This project investigates the use of Corn Cob Ash (CCA) as a partial replacement of cement along with Stainless Steel Fiber (SSF) in concrete to enhance strength and promote sustainable construction. The study aims to evaluate the mechanical properties of concrete by incorporating CCA at different replacement levels of 0%, 5%, 10%, and 15%, while adding SSF to improve crack resistance and ductility.

Concrete mixes were prepared and tested for compressive strength at 7, 14, and 28 days, along with split tensile strength. The results showed that the addition of CCA improves concrete properties up to an optimum level due to its pozzolanic nature, which enhances bonding and microstructure. Among all mixes, the 5% CCA replacement exhibited the highest compressive strength and split tensile strength compared to conventional concrete.

However, further increase in CCA content beyond 5% led to a reduction in strength due to lower cement content and slower hydration. The inclusion of Stainless Steel Fiber significantly improved tensile strength, controlled crack propagation, and enhanced the ductility of concrete.

The study concludes that the combined use of 5% Corn Cob Ash and Stainless Steel Fiber provides optimum performance in terms of strength and durability. This approach not only improves the mechanical properties of concrete but also contributes to sustainable construction by utilizing agricultural waste and reducing cement consumption.

Keywords:

Corn Cob Ash (CCA), Stainless Steel Fiber (SSF), Partial Replacement of Cement, Compressive Strength of Concrete, Split Tensile Strength, Fiber Reinforced Concrete, Sustainable Construction Materials, Pozzolanic Activity, Mechanical Properties of Concrete, Crack Resistance, Ductility Enhancement, Eco-friendly Concrete, Waste Material Utilization, Strength Optimization.

INTRODUCTION

1.1 General

Concrete is one of the most widely used construction materials in the world due to its strength, durability, and versatility. It is mainly composed of cement, fine aggregate, coarse aggregate, and water. However, the production of cement contributes significantly to environmental pollution and carbon dioxide emissions. To reduce these impacts, researchers are exploring alternative materials that can partially replace cement in concrete.

Agricultural waste materials such as corn

cob ash (CCA) are being studied as sustainable alternatives. When corn cobs are burned and processed into ash, they exhibit pozzolanic properties that allow them to react with cement components in concrete. Additionally, fibres such as stainless steel fibres can be added to improve the mechanical properties of concrete. The use of these materials helps in improving sustainability while maintaining acceptable strength characteristics.

1.2 Conventional Concrete (CC)

Conventional concrete is a mixture of cement, fine aggregates (sand), coarse aggregates

(gravel or crushed stone), and water. When water reacts with cement through hydration, it forms a hardened mass that binds the aggregates together, creating a strong and durable construction material.

Although conventional concrete has high compressive strength, it has relatively low tensile strength and is prone to cracking. To overcome these limitations, various modifications such as the addition of fibres or supplementary cementitious materials are used. These modifications help improve the durability, ductility, and overall performance of concrete in construction applications.

1.3 Corncob Ash and Stainless Steel Fiber Concrete

Corn cob ash (CCA) is obtained by burning corn cobs, which are an agricultural waste product. The ash contains silica and other compounds that can act as a pozzolanic material when used in concrete. When CCA is used as a partial replacement for cement, it can reduce the amount of cement required, thereby lowering environmental impact and construction costs.

Stainless steel fibres (SSF) are small, thin fibres added to concrete to enhance its tensile strength, crack resistance, and toughness. The fibres help in distributing stresses throughout the concrete matrix, reducing crack propagation and improving durability.

The combined use of corn cob ash and stainless steel fibres in concrete results in a sustainable and improved construction material. While corn cob ash contributes to environmental sustainability by reducing cement usage, stainless steel fibres enhance the mechanical performance of the concrete. This combination is increasingly being studied for applications in sustainable and high-performance concrete structures.

1.3.1 Applications of Corncob Ash & Stainless Steel Fiber

Corn cob ash and stainless steel fibre (SSF) concrete is used in various construction applications due to its improved strength and sustainability. Corn cob ash acts as a partial replacement for cement, which helps reduce cement consumption and promotes environmentally friendly construction. When combined with stainless steel fibres, the concrete gains better tensile strength, crack resistance, and durability compared to conventional concrete.

This type of concrete is commonly used in road pavements, footpaths, parking areas, and other surface works where resistance to cracking and long-term durability are important. It can also be used in precast concrete products such as paving blocks, kerbstones, and concrete tiles. The addition of stainless steel fibres improves toughness and reduces the chances of crack formation during handling and service.

Corn cob ash and SSF concrete is also suitable for non-structural building elements such as partition walls and floor screeds. Since corn cobs are agricultural waste materials, their use in concrete is beneficial for rural and low-cost construction projects. The improved impact resistance provided by stainless steel fibres also makes this concrete useful for industrial floors and repair works.

1.4 Objectives

- To develop sustainable concrete with reduction of cement with Corn Cob Ash with 5% 10% 15% and Stainless Steel Fiber.
- To study the feasibility of using corn cob ash (CCA) as cement-reducing materials in concrete.
- To evaluate the fresh properties and hardened properties of concrete with partial replacement of cement by corn cob ash.
- To assess the durability characteristics of corn cob ash modified concrete under different environment conditions.
- To utilize agricultural waste effectively.

- To analyze the effect of partial cement replacement with corn cob ash on workability , strength.
- To identify the optimum percentage of CCA replacement that provide improved strength.

1.5 Scope

The use of corn cob ash and stainless steel fibre in concrete has a wide scope in the field of sustainable construction. Corn cob ash is an agricultural waste material that can be effectively utilized as a partial replacement for cement in concrete. Its use helps in reducing the amount of cement required, thereby lowering the environmental impact associated with cement production and promoting eco-friendly construction practices.

The addition of stainless steel fibres improves the mechanical properties of concrete. These fibres enhance the tensile strength, toughness, and crack resistance of concrete. As a result, the concrete becomes more durable and capable of withstanding various stresses, which increases the lifespan of concrete structures.

Another important scope of using corn cob ash and stainless steel fibre is in reducing construction costs. Since corn cobs are widely available agricultural by-products, their ash can be used as a low-cost supplementary material in concrete. This makes the concrete more economical while also helping in the effective utilization of agricultural waste.

Corn cob ash and stainless steel fibre concrete also have scope in various construction applications such as pavements, precast concrete products, and non-structural building elements. The improved durability and crack resistance provided by fibres make the concrete suitable for areas where long-term performance is required.

Furthermore, there is significant scope for future research on this material. By studying different replacement percentages of corn cob ash

and varying amounts of stainless steel fibres, researchers can optimize the concrete mix to achieve better strength, durability, and sustainability in modern construction.

1.6 CODAL PROVISIONS.

1. IS 456:2000 – Plain and Reinforced Concrete. This code provides the basic guidelines for concrete design, durability, and strength requirements. It ensures proper safety and serviceability of concrete structures. It is the main reference for all concrete works.

2. IS 10262:2019 – Concrete Mix Proportioning. This code is used for designing the concrete mix proportions. It helps in selecting the correct water-cement ratio and material quantities. It ensures the required strength and workability of concrete.

3. IS 383:2016 – Coarse and Fine Aggregates. This code specifies the quality and grading of aggregates used in concrete. It ensures proper strength and durability of concrete. It also defines limits for impurities in aggregates.

4. IS 3812 (Part 1):2013 – Fly Ash as Pozzolana. This code provides guidelines for using pozzolanic materials in concrete. It is referred for corn cob ash as it has similar properties. It helps in understanding replacement levels and usage.

5. IS 1489 (Part 1):2015 – Portland Pozzolana Cement. This code deals with blended cement containing pozzolanic materials. It helps in understanding the behavior of cement when mixed with ash. It is useful for CCA-based concrete mix concepts.

6. IS 16481:2022 – Fibre Reinforced Concrete. This code provides specifications for fibre-reinforced concrete. It includes guidelines for fibre content and performance. It is useful for using stainless steel fibres in concrete.

7. IS 516:2018 – Methods of Tests for Concrete, This code explains the procedures for testing concrete strength. It includes compressive strength and other important tests. It ensures accurate evaluation of concrete performance.

LITERATURE REVIEW

2.1 General

The chapter deals with literature papers collected regarding corn cob ash and stainless steel fiber. Material used, methodology carried out, tests carried and their results are examined also discussed in this chapter.

2.2 Literature Review

1. Gradinaru et al. (2019)-Utilization of Corn Cob Ash in Cement Concrete :-

This study investigated the feasibility of using corn cob ash as a partial replacement of cement in concrete. Cement was replaced with CCA at levels of 5%, 10%, and 15%. Mechanical properties such as compressive strength, split tensile strength, and density were evaluated. Results indicated a reduction in strength with increasing CCA content; however, concrete with up to 10% replacement showed acceptable performance for non-structural applications. The study concluded that CCA has potential as an eco-friendly cement substitute when used in controlled proportions.

2. Fadele&Otieno (2022)-Early Age Effect of Corn Cob Ash as Partial Replacement for Portland Cement in Concrete:-

This research focused on the early-age behavior of concrete incorporating corn cob ash at replacement levels of 15% and 30%. Tests were conducted on compressive strength, water absorption, and permeability. The findings revealed that higher CCA content significantly reduced early-age strength due to slower pozzolanic reaction. However, long-term

performance showed improvement with extended curing. The study emphasized the importance of curing duration and optimum replacement levels for effective utilization of CCA.

3. Kumar &Pareek (2023)-Strength and Durability Characteristics of Concrete Containing Corn Cob Ash:-

This experimental study evaluated the strength and durability properties of M20 grade concrete incorporating corn cob ash and rice husk ash. Cement replacement levels ranged from 0% to 15%. Compressive strength, water absorption, and resistance to chemical attack were studied. Results showed that 7.5% CCA replacement yielded optimum strength, while higher percentages led to strength reduction. The study concluded that CCA can be effectively used in blended systems for sustainable concrete production.

4. Otieno et al. (2023)-Influence of Corn Cob Ash–Silica Fume Blends on Concrete Properties:-

This study examined the combined effect of corn cob ash and silica fume as partial cement replacements in concrete. Replacement levels varied from 5% to 20%. Mechanical properties and durability characteristics were evaluated. The blended mix containing 10% replacement exhibited improved compressive strength and reduced permeability compared to control concrete. The study concluded that blending CCA with highly reactive pozzolans enhances its performance and compensates for its low early-age reactivity.

5. Umasabor&Daderie (2025)-Performance of Sandcrete Blocks with Corn Cob Ash as Cement Replacement:-

This research evaluated the use of corn cob ash as a partial replacement of cement in sandcrete blocks. Replacement levels of 10% and 20% were examined. Compressive strength and

water absorption tests were conducted. Results showed that blocks with 10% CCA met minimum strength requirements for non-load-bearing masonry units. The study concluded that CCA is suitable for low-cost and sustainable block production.

6. Ren, J. (2025)-Performance Characteristics of Steel Fiber Reinforced Concrete and Its Application in Different Fields:-

This study explores performance characteristics and applications of SFRC across fields such as pavement repair and industrial structures. SFRC shows significant improvements in strength, crack resistance, and impact resistance — e.g., tensile strength up to +50% and crack reduction up to 75%. However, the review notes limitations in research scope and experimental setups.

7. Amin et al. (2022)-Steel Fiber-Reinforced Concrete: Systematic Review and Knowledge Mapping:-

By examining bibliometric data, this paper identifies global trends and research gaps in SFRC. It highlights the geographic distribution of research, most active authors, and the most studied subtopics (e.g., mechanical response, durability).

8. Ahmad, J., Zhou, Z., &Deifalla, A. F. (2023)- Steel Fiber Reinforced Self-Compacting Concrete:-

Self-compacting concrete (SCC) is a fluid concrete that flows under its own weight without vibration. Like normal concrete, SCC is brittle in tension; the addition of steel fibers (SF) can significantly increase tensile capacity and ductility. The review compiles research on fresh properties (slump flow, passing ability), and mechanical properties — compressive, tensile, flexure, and elastic modulus — of SF-reinforced SCC. Failure modes of steel fiber-reinforced SCC are also summarized. Results generally show that

SF improves tensile strength and reduces brittle failure, though it can decrease fresh concrete flowability. The review suggests that secondary cementitious materials may help counteract compressive strength reductions.

9.Amin, M. N., Ahmad, W., Khan, K., & Ahmad, A. (2022)-Steel Steel Fiber-Reinforced Concrete:-

Self-compacting concrete (SCC) is a fluid concrete that flows under its own weight without vibration. Like normal concrete, SCC is brittle in tension; the addition of steel fibers (SF) can significantly increase tensile capacity and ductility. The review compiles research on fresh properties (slump flow, passing ability), and mechanical properties — compressive, tensile, flexure, and elastic modulus — of SF-reinforced SCC. Failure modes of steel fiber-reinforced SCC are also summarized. Results generally show that SF improves tensile strength and reduces brittle failure, though it can decrease fresh concrete flowability. The review suggests that secondary cementitious materials may help counteract compressive strength reductions.

10.Ren et al. (2024)-Steel Fiber Reinforced Concrete: A Systematic Review of Usage in Shield Tunnel Segment:-

This systematic review surveys steel fiber reinforced concrete use in shield tunnel segments — key aspects include composition, performance, and constitutive models. SFRC's crack control and fracture toughness make it suitable for tunnel applications. Note: although not strictly about stainless steel fibres, the principles apply to fibre performance in high-stress contexts.

The literature review shows that corn cob ash (CCA) can be used as a partial replacement for cement because of its pozzolanic properties and ability to reduce cement consumption. Studies indicate that small percentages (about 5–10%) maintain acceptable concrete strength.

Stainless steel fibres (SSF) improve tensile strength, crack resistance, and durability. Therefore, the combination of CCA and SSF helps produce more sustainable and stronger concrete

METHODOLOGY

3.1 General

The methodology of this study involves using corn cob ash (CCA) as a partial replacement for cement and adding stainless steel fibres (SSF) in concrete. The required materials such as cement, aggregates, corn cob ash, fibres, and water are collected and prepared. Concrete mix design is carried out with different percentages of corn cob ash such as 0%, 5%, 10%, and 15%. Concrete cubes are cast, compacted, and cured for required curing periods. Tests like compressive strength and split tensile strength are conducted to evaluate the performance of the concrete.

3.2 Methodology



Fig 3.1 Methodology

3.3 Problem Identification

The construction industry faces issues like high cement cost, environmental pollution, and waste disposal. Corn cob ash, an agricultural waste, can be used as a partial cement replacement, while stainless steel fibers improve strength and crack resistance. The study focuses on developing sustainable and durable concrete.

3.4 Literature Review

Previous studies show that CCA has pozzolanic properties and can replace cement up to a certain percentage (usually 5–10%) without major strength loss. SSF enhances tensile strength, ductility, and crack control. This step helps identify research gaps and optimal mix ranges.

3.5 Selection and Collection of Material

Materials used include:

- Ordinary Portland Cement (OPC)
- Corn Cob Ash (processed and sieved)
- Fine aggregate (M-sand)
- Coarse aggregate (20 mm)
- Stainless Steel Fibers
- Water

3.6 Studying Physical and Chemical Properties

Tests are conducted to determine:

- Specific gravity
- Sieve analysis
- Chemical composition of CCA (silica content)
- Water absorption

This ensures suitability of materials for concrete production.

3.7 Mix Design (M25 Grade Concrete)

Concrete mix is designed as per IS 10262:2019. Cement is partially replaced with CCA and SSF is added in fixed proportions.

Water-cement ratio is maintained for required workability and strength.

3.8 Casting & Curing

Concrete specimens (cubes, cylinders) are cast using prepared mixes. After 24 hours, specimens are demoulded and cured in water for 7, 14, and 28 days.

3.9 Fresh Concrete Properties

Tests conducted on fresh concrete:

- Slump test (workability)

3.10 Mechanical Properties

Hardened concrete is tested for:

- Compressive strength
- Split tensile strength
- Flexural strength

3.11 Analysis and Result

Results of all mixes are compared based on:

- Strength
- Workability
- Durability

3.12 Conclusion

All results, graphs, and analysis are compiled into a final report. Conclusions and recommendations are provided regarding the use of CCA and SSF in sustainable concrete.

MATERIALS USED

4.1 General

The materials used for preparing Corn Cob Ash (CCA) concrete are similar to those used in conventional concrete with the addition of supplementary materials. The main materials include cement, fine aggregate (M-sand), coarse aggregate, water, Corn Cob Ash, and stainless steel fibers. Cement acts as the primary binding material, while fine and coarse aggregates

provide strength and bulk to the concrete mix. Corn Cob Ash is used as a partial replacement of cement and is obtained by burning corn cobs and grinding the ash into a fine powder. It possesses pozzolanic properties which help improve the strength and durability of concrete. Stainless steel fibers are added to the concrete to enhance tensile strength, crack resistance, and ductility. Clean water is used for proper hydration of cement and to provide the required workability of the concrete mix. Proper proportioning of these materials results in improved performance of the concrete.

4.2 Cement

Ordinary Portland Cement (OPC) is used as the primary binding material in Corn Cob Ash (CCA) concrete. It is manufactured by grinding clinker with a small amount of gypsum and is widely used in construction due to its good strength and durability. In Corn Cob Ash concrete, OPC is partially replaced with Corn Cob Ash in different percentages to study its effect on the strength and performance of concrete. When water is added, OPC undergoes hydration and forms a strong binding paste that holds the aggregates together. The presence of Corn Cob Ash reacts with the calcium hydroxide produced during hydration and contributes to the pozzolanic reaction, which can improve the long-term strength and durability of the concrete. In this study, Ordinary Portland Cement conforming to relevant Indian Standard specifications was used as the main binder for preparing the Corn Cob Ash concrete mixes.



Figure 4.2 Cement

| S. No | Parameters (Unit) | Results | Requirements as per IS 269:2015 | Test Method |
|-------|---|---------|---------------------------------|-----------------|
| 1 | Standard Consistency (%) | 29 | — | IS 4031 Part 4 |
| 2 | Fineness (m ² /kg) (Blaine) | 310 | ≥ 225 m ² /kg | IS 4031 Part 2 |
| 3 (a) | Setting Time – Initial (Minutes) | 95 | ≥ 30 min | IS 4031 Part 5 |
| 3 (b) | Setting Time – Final (Minutes) | 210 | ≤ 600 min | IS 4031 Part 5 |
| 4 | Density (g/cc) | 3.15 | — | IS 4031 Part 11 |
| 5 (a) | Compressive Strength @ 3 days (N/mm ²) | 34 | ≥ 27 MPa | IS 4031 Part 6 |
| 5 (b) | Compressive Strength @ 7 days (N/mm ²) | 45 | ≥ 37 MPa | IS 4031 Part 6 |
| 5 (c) | Compressive Strength @ 28 days (N/mm ²) | 55 | ≥ 53 MPa | IS 4031 Part 6 |

Table 4.2 Physical Properties of Cement

4.3 Fine Aggregate

Manufactured sand (M-sand) was used as the fine aggregate in the preparation of Corn Cob Ash concrete. M-sand is produced by crushing

hard stones such as granite into fine particles that pass through a 4.75 mm sieve. It is widely used as a replacement for natural river sand in concrete due to its consistent quality, availability, and environmental benefits.

In Corn Cob Ash concrete, M-sand acts as a filler material that fills the voids between coarse aggregate particles and improves the workability of the concrete mix. The angular shape and rough texture of M-sand particles provide better bonding with cement paste and Corn Cob Ash, which helps in improving the strength and stability of the concrete.

The M-sand used in this study was clean, well graded, and free from organic impurities, clay, and silt. Important properties such as particle size distribution, specific gravity, and water absorption were checked through standard laboratory tests to ensure its suitability for concrete. The use of M-sand along with Corn Cob Ash helped in producing a dense and durable concrete mix.

| S. No | Tests | Results | Requirements as per IS 383:2016 | Test Method |
|-------|---------------------------------|---------|---------------------------------|----------------|
| 1 (a) | Bulk Density – Loose (kg/l) | 1.65 | — | IS 2386 Part 3 |
| 1 (b) | Bulk Density – Compacted (kg/l) | 1.85 | — | IS 2386 Part 3 |
| 2 | Specific Gravity | 2.65 | 2.5 – 3.0 | IS 2386 Part 3 |
| 3 | Water Absorption (%) | 1.5 | ≤ 2% | IS 2386 Part 3 |
| 4 | Silt Content (%) | 3 | ≤ 8% | IS 2386 Part 2 |

Properties of M-sand

Table 4.3 Physical Properties of M-sand

| Sieve Size | % Passing | Requirements (Zone II) |
|------------|-----------|------------------------|
| 4.75 mm | 95 | 90 – 100 |
| 2.36 mm | 85 | 75 – 100 |
| 1.18 mm | 65 | 55 – 90 |
| 600 micron | 50 | 35 – 59 |
| 300 micron | 25 | 8 – 30 |
| 150 micron | 8 | 0 – 10 |

Table 4.3.1 Sieve Analysis of M-sand



Figure 4.3 M-sand

4.4 Coarse Aggregate

20 mm coarse aggregate was used in the preparation of Corn Cob Ash concrete. It consists of crushed stone particles that pass through a 20 mm sieve and are retained on a 4.75 mm sieve. These aggregates form the major portion of the concrete mix and provide strength, stability, and durability to the concrete.

In Corn Cob Ash concrete, 20 mm coarse aggregate helps in improving the compressive strength and load-bearing capacity of the concrete. The angular shape and rough surface texture of the crushed aggregates provide good bonding with the cement paste and Corn Cob Ash particles. This improves the overall strength and

performance of the concrete.

The coarse aggregates used in this study were obtained from crushed granite stones and were clean, hard, and durable. They were free from dust, clay, and other harmful impurities. Important properties such as specific gravity, water absorption, and grading were checked through standard laboratory tests to ensure their suitability for concrete production.

Table 4.4 Physical Properties of Coarse Aggregate

| S.No | Tests | Results | Requirements as per IS 383:2016 | Test Method |
|------|---------------------|---------|---------------------------------|----------------|
| 1 | Bulk Density, Kg/l | | | IS 2386 Part 3 |
| | a) Loose | 1.6 | — | |
| | b) Compacted | 1.75 | — | |
| 2 | Specific Gravity | 2.7 | 2.5 – 3.0 | IS 2386 Part 3 |
| 3 | Water Absorption, % | 0.5 | ≤ 2% | IS 2386 Part 3 |



Figure 4.4 20mm Coarse Aggregate

4.5 Corn Cob Ash

Corn Cob Ash (CCA) is an agricultural waste material obtained by burning corn cobs at high temperatures and grinding the resulting ash into a fine powder. It is used as a supplementary cementitious material in concrete and can partially replace cement in the mix. Due to its

pozzolanic properties, Corn Cob Ash reacts with calcium hydroxide produced during the hydration of cement and forms additional cementitious compounds, which contribute to the strength and durability of concrete.

The use of Corn Cob Ash in concrete helps in reducing the consumption of cement, lowering construction costs, and minimizing environmental pollution caused by agricultural waste disposal. It also improves certain properties of concrete such as long-term strength and durability when used in appropriate proportions. However, excessive replacement of cement with Corn Cob Ash may reduce the strength of concrete due to its lower cementitious content.

In this study, Corn Cob Ash was used as a partial replacement of cement in different percentages such as 5%, 10%, and 15% to evaluate its effect on the mechanical properties of concrete. The ash used was properly burnt, finely ground, and sieved to obtain suitable particle size before being used in the concrete mix.

| S. No | Parameters (Unit) | Results | Requirements (Typical for Pozzolanic Materials) | Test Method |
|-------|---|---------|---|-----------------|
| 1 | Standard Consistency (%) | 30 | — | IS 4031 Part 4 |
| 2 | Fineness (m ² /kg) (Blaine) | 320 | ≥ 300 m ² /kg (recommended) | IS 4031 Part 2 |
| 3 (a) | Setting Time – Initial (Minutes) | 110 | ≥ 30 min | IS 4031 Part 5 |
| 3 (b) | Setting Time – Final (Minutes) | 220 | ≤ 600 min | IS 4031 Part 5 |
| 4 | Specific Gravity | 2.2 | 2.0 – 2.5 (typical) | IS 4031 Part 11 |
| 5 (a) | Compressive Strength @ 3 days (N/mm ²) | 20 | — | IS 4031 Part 6 |
| 5 (b) | Compressive Strength @ 7 days (N/mm ²) | 28 | — | IS 4031 Part 6 |
| 5 (c) | Compressive Strength @ 28 days (N/mm ²) | 38 | — | IS 4031 Part 6 |

Table 4.5 Physical Properties of Corn Cob Ash



Figure 4.5 Corn Cob Ash

4.6 Stainless Steel Fiber

Stainless Steel Fiber (SSF) is used as a reinforcing material in Corn Cob Ash concrete to improve its mechanical properties. These fibers are small, thin, and strong metallic strands that are randomly distributed in the concrete mix. When added to concrete, stainless steel fibers help in controlling cracks, improving tensile strength, and increasing the toughness and durability of the concrete.

In Corn Cob Ash concrete, the addition of stainless steel fibers compensates for the possible reduction in strength caused by the partial replacement of cement with Corn Cob Ash. The fibers bridge the micro-cracks formed in concrete and prevent them from propagating, thereby improving the overall performance of the concrete. Stainless steel fibers also enhance the impact resistance, ductility, and resistance to shrinkage cracking.

In this study, stainless steel fibers were added in a fixed proportion to the concrete mix along with different percentages of Corn Cob Ash as a partial replacement of cement. The fibers were uniformly mixed with the concrete to ensure proper distribution and to achieve improved strength and durability of the Corn Cob Ash fiber reinforced concrete.



Figure 4.6 Stainless Steel

4.7 Water

Water is an important ingredient in the preparation of Corn Cob Ash (CCA) concrete. It is used for mixing cement, Corn Cob Ash, fine aggregate, and coarse aggregate to form a workable concrete mix. Water plays a vital role in the hydration process of cement, which is the chemical reaction that allows the concrete to harden and gain strength. In CCA concrete, water also helps in activating the pozzolanic reaction between Corn Cob Ash and the calcium hydroxide produced during cement hydration.

The quality of water used in concrete significantly affects the strength and durability of the concrete. Generally, clean and potable water that is free from harmful substances such as oils, acids, alkalis, salts, organic matter, and other impurities is suitable for concrete mixing. Impure water may affect the setting time of cement and reduce the strength of concrete.

Water is also used for curing the concrete after casting. Proper curing ensures continuous hydration of cement and improves the strength and durability of Corn Cob Ash concrete. In this study, clean potable water was used for both mixing and curing of the concrete, satisfying the requirements of relevant Indian Standard specifications.

| S.No | Test | Result | LoQ | Limit as per IS 456:2000 | Test Method |
|------|-------------------------------|--------|-----|--|-----------------|
| 1 | pH Value | 7.2 | — | ≥ 6 | IS 3025 Part 11 |
| 2 | Total Dissolved Solids (mg/L) | 450 | — | ≤ 2000 mg/L | IS 3025 Part 16 |
| 3 | Chloride Content (mg/L) | 200 | — | ≤ 2000 (plain concrete) / ≤ 1000 (RCC) | IS 3025 Part 32 |
| 4 | Sulphate Content (mg/L) | 250 | — | ≤ 400 mg/L | IS 3025 Part 24 |
| 5 | Organic Impurities | Nil | — | Should be absent | IS 3025 |

Table 4.7 Properties of Water

MIX PROPORTION

5.1 General

M25 grade concrete is widely used in structural construction such as beams, slabs, columns, and foundations. The designation M25 indicates that

the concrete achieves a characteristic compressive strength of 25 MPa after 28 days of curing. It is prepared using basic materials such as cement, fine aggregate (M-sand or river sand), coarse aggregate, and water in suitable proportions. In general practice, the mix proportion for M25 concrete is about 1 : 1.5 : 2.6 (cement : fine aggregate : coarse aggregate) with a water–cement ratio of around 0.45 to achieve the required strength and workability. Proper mixing, placing, compaction, and curing are necessary to ensure the strength, durability, and overall performance of the concrete.

5.2 Mix Design

Given Data

- Grade = M25
- Cement = PPC (Specific gravity = 3.10)
- Fine Aggregate = Zone II
Specific gravity = 2.50
- Coarse Aggregate = 20 mm
Specific gravity = 2.65
- Exposure condition = Moderate
- Slump = 75 mm (standard structural work)
- Method = Machine mixing
- No admixture used

STEP 1: TARGET MEAN STRENGTH

$$f_{ck} = 25 \text{ MPa}$$

$$\text{Standard deviation (IS 10262)} = 4 \text{ MPa}$$

$$\text{Target Mean Strength} = f_{ck} + 1.65 \times S$$

$$[= 25 + (1.65 \times 4)]$$

$$[= 31.6 \text{ MPa}]$$

STEP 2: WATER–CEMENT RATIO

For M25, from IS recommendations:

$$= 0.328 \text{ m}^3$$

Adopt

Volume of aggregates:

$$[w/c = 0.45]$$

$$= 1 - 0.328$$

(Maximum allowed for moderate exposure = 0.50 → OK)

$$= 0.672 \text{ m}^3$$

STEP 3: WATER CONTENT

STEP 6: AGGREGATE PROPORTION

For 20 mm aggregate

For Zone II sand & 20 mm aggregate

Base water content = 186 kg/m³ (for 25–50 mm slump)

Volume of coarse aggregate = 0.62

For 75 mm slump → increase 3%

$$CA = 0.672 \times 0.62$$

$$= 0.417 \text{ m}^3$$

$$[186 + (3\% \text{ of } 186)]$$

$$FA = 0.672 - 0.417$$

$$= 0.255 \text{ m}^3$$

$$[= 191 \text{ kg/m}^3]$$

STEP 7: CONVERT INTO WEIGHT

Adopt:

Coarse Aggregate

$$[\text{Water} = 191 \text{ kg/m}^3]$$

$$[= 0.417 \times 2.65 \times 1000$$

$$= 1105 \text{ kg}]$$

STEP 4: CEMENT CONTENT

Fine Aggregate

$$[\text{Cement} = \{\text{Water}\} \{\text{w/c}\}]$$

$$[= 0.255 \times 2.50 \times 1000$$

$$= 637 \text{ kg}]$$

$$[= \{191\} \{0.45\}]$$

$$[= 424 \text{ kg/m}^3]$$

FINAL MIX DESIGN (PER 1 m³)

Check minimum cement (IS 456 moderate exposure):

| Material | Quantity |
|------------------|----------|
| Cement | 424 kg |
| Water | 191 L |
| Fine Aggregate | 637 kg |
| Coarse Aggregate | 1105 kg |

$$\text{Minimum} = 300 \text{ kg/m}^3$$

$$424 > 300$$

STEP 5: VOLUME CALCULATION

MIX RATIO (by weight)

Volume of Cement

$$[424 : 637 : 1105]$$

$$= \{424\} \{3.10 \times 1000\}$$

$$= 0.137 \text{ m}^3$$

Volume of Water

Divide by cement:

$$= \{191\} \{1000\}$$

$$= 0.191 \text{ m}^3$$

$$\{1 : 1.5 : 2.6\}$$

Total volume:

Water–cement ratio = 0.45

| S.NO | Mix Name | Cement | | Corn Cob Ash | | Fine Aggregate/ m ³ | Coarse Aggregate/ m ³ | Water/ Cement Ratio | Stainless Steel Fibre Kg/m ³ |
|------|----------|--------|-------------------|--------------|-------------------|-----------------------------------|-------------------------------------|---------------------------|--|
| | | % | Kg/m ³ | % | Kg/m ³ | | | | |
| 1 | CC | 100 | 4.24 | 0 | 0 | 6.36 | 11.05 | 0.45 | 0 |
| 2 | CCASSF 1 | 95 | 3.8 | 5 | 0.2 | 6.36 | 11.05 | 0.45 | 0.24 |
| 3 | CCASSF 1 | 90 | 3.6 | 10 | 0.4 | 6.36 | 11.05 | 0.45 | 0.24 |
| 4 | CCASSF 2 | 85 | 3.4 | 15 | 0.6 | 6.36 | 11.05 | 0.45 | 0.24 |

**Table 5.1 Mix Design
FRESH CONCRETE PROPERTIES**

6.1 General

Fresh concrete properties refer to the behavior of concrete in its plastic (unhardened) state, immediately after mixing and before setting. These properties are important to ensure easy mixing, transportation, placing, compaction, and finishing without segregation or bleeding.

The main properties of fresh concrete include workability, consistency, flowability, and cohesiveness. Workability is the most important property and is commonly measured using tests like slump test, compaction factor test, and flow table test.

6.2 Workability

Workability of fresh concrete is the property that determines the ease with which concrete can be mixed, transported, placed, compacted, and finished while maintaining uniformity and without segregation or bleeding. It is a key factor in achieving good quality concrete, as highly workable concrete can be placed and compacted with less effort, ensuring proper filling of formwork and full encapsulation of reinforcement. Workability is influenced by several factors such as water-cement ratio, aggregate size, shape and grading, cement content, and the presence of admixtures. Too little workability makes concrete difficult to handle and may lead to voids or honeycombing, while too much workability can cause

segregation and reduce strength. Therefore, an optimum level of workability is essential to ensure durability, strength, and ease of construction. Common methods used to measure workability include the slump test, compaction factor test, and flow table test.

6.2.1 Factors Affecting Workability of Concrete

- Water Cement Ratio
- Aggregate Size
- Shape of aggregate
- Mix proportion
- Use of admixtures
- Time and temperature
- Mixing method and duration
- Air Entrainment

6.3 Slump Cone Test

The slump cone test is a simple and widely used method to determine the workability of fresh concrete. It helps to assess the consistency and ease with which concrete can be mixed, placed, and compacted. The test is performed using a standard slump cone, which is a frustum-shaped mold placed on a rigid, non-absorbent surface. Fresh concrete is filled into the cone in three equal layers, and each layer is compacted by giving 25 blows with a tamping rod to ensure proper packing. After filling, the top surface is leveled, and the cone is carefully lifted vertically upward without any lateral movement. Once the cone is removed, the concrete subsides or “slumps,” and the vertical difference in height between the cone and the slumped concrete is measured. This value is known as the slump and is expressed in millimeters. The slump indicates the workability

of the mix, where a low slump represents a stiff mix and a high slump indicates a more fluid mix. The test is quick, economical, and suitable for site conditions. It is commonly used for quality control of concrete during construction. The test also helps in maintaining uniformity between different batches of concrete. It is particularly useful for checking consistency before placing concrete in structures. However, it is not suitable for very dry or very wet mixes. Different types of slump such as true slump, shear slump, and collapse slump may be observed. Proper execution of the test is essential to obtain accurate and reliable results.

concrete.



Figure 6.3 Slump Cone Test

| Mix Type | Cement Replacement (%) | Slump Value (mm) | Slump Type |
|----------|------------------------|------------------|------------|
| CC | 0% | 75 | True Slump |
| CCASSF 1 | 5% | 75 | True Slump |
| CCASSF 2 | 10% | 78 | True Slump |
| CCASSF 3 | 15% | 78 | True Slump |

Table 6.3 Slump Cone Test

6.3.1 Procedure for Slump Cone Test

- Clean the slump cone and place it on a level, non-absorbent surface. Hold it firmly to prevent movement during filling.
- Fill the cone with fresh concrete in three equal layers. Each layer should be about one-third the height of the cone.
- Compact each layer with 25 blows using a tamping rod. Distribute the blows evenly over the entire surface.
- Strike off the excess concrete after the top layer is compacted. Level the surface properly with the tamping rod.
- Lift the cone slowly in a vertical direction without disturbance. Measure the slump as the difference in height between the cone and

6.4 Casting

Casting of concrete containing Corn Cob Ash (CCA) and Stainless Steel Fiber (SSF) is carried out in a similar manner to conventional concrete, with slight care due to the presence of fibers and ash. First, all materials such as cement, CCA, fine aggregate, and coarse aggregate are dry mixed thoroughly to ensure uniform distribution. Stainless steel fibers are then added gradually to avoid balling and ensure even dispersion throughout the mix. Water is added slowly and the concrete is mixed until a uniform and workable consistency is achieved. The fresh concrete is then placed into molds (cubes, cylinders, or beams) in layers. Each layer is compacted properly using a tamping rod or vibrating table to remove air voids and ensure proper compaction. After filling, the top surface is leveled and finished smoothly. The specimens are left undisturbed for 24 hours at room temperature. After demoulding, they are transferred to a curing tank for further strength development.



Figure 6.3 Casting

6.5 Curing

Curing of concrete containing Corn Cob Ash (CCA) and Stainless Steel Fiber (SSF) is essential to achieve proper strength and durability. After casting, the specimens are left undisturbed for about 24 hours at room temperature. Once hardened, the specimens are carefully demoulded and immediately placed in a curing tank filled with clean water. The curing is carried out for specified periods such as 7, 14, and 28 days. Proper curing helps in maintaining moisture within the concrete, which is necessary for the hydration process of cement and pozzolanic reaction of CCA. Continuous curing improves strength, reduces shrinkage, and prevents surface cracking. In CCA concrete, curing is especially important as it enhances the long-term strength development. The specimens are removed from water before testing and wiped to remove excess moisture.



Figure 6.5 Curing

MECHANICAL PROPERTIES

7.1 Introduction

The primary objective of this study is to evaluate the effect of varying percentages of CCA and SSF on the properties of concrete in both fresh and hardened states. Various tests such as workability, compressive strength, split tensile strength, and other relevant properties were conducted as per standard procedures. The results obtained from different mix proportions are analyzed and compared with conventional concrete to determine the optimum percentage of CCA and SSF. Graphs, tables, and discussions are included to clearly present the performance of each mix. This chapter helps in understanding the behavior of modified concrete and provides a basis for drawing conclusions regarding its suitability for construction applications.

7.2 Concrete Mix Proportion

| S.NO | Mix Name | Cement | | Corn Cob Ash | | Fine Aggregate Kg/m ³ | Coarse Aggregate Kg/m ³ | Water/Cement Ratio | Stainless Steel Fibre Kg/m ³ |
|------|----------|--------|-------------------|--------------|-------------------|----------------------------------|------------------------------------|--------------------|---|
| | | % | Kg/m ³ | % | Kg/m ³ | | | | |
| 1 | CC | 100 | 4.24 | 0 | 0 | 6.36 | 11.05 | 0.45 | 0 |
| 2 | CCASSF 1 | 95 | 3.8 | 5 | 0.2 | 6.36 | 11.05 | 0.45 | 0.24 |
| 3 | CCASSF 1 | 90 | 3.6 | 10 | 0.4 | 6.36 | 11.05 | 0.45 | 0.24 |
| 4 | CCASSF 2 | 85 | 3.4 | 15 | 0.6 | 6.36 | 11.05 | 0.45 | 0.24 |

Table 7.2 Concrete Mix Proportion

7.3 Compressive Strength of Concrete

| S.No | Mix Name | CCA Replacement | 7 Days (MPa) | 14 Days (MPa) | 28 Days (MPa) |
|------|----------|-----------------|--------------|---------------|---------------|
| 1 | CC | 0% | 16.5 | 21.2 | 25.1 |
| 2 | CCASSF 1 | 5% | 17.8 | 22.7 | 27.6 |
| 3 | CCASSF 2 | 10% | 16.9 | 21.8 | 26.2 |
| 4 | CCASSF 3 | 15% | 15.3 | 20.1 | 23.8 |

Table 7.3 Compressive Strength of Concrete

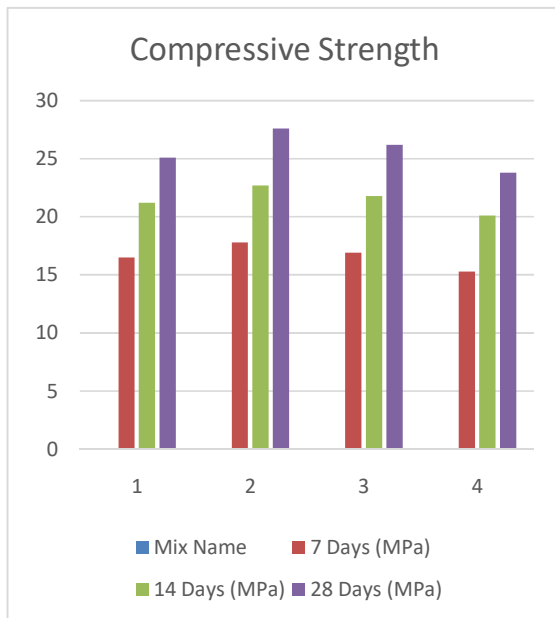


Fig 7.3 Compressive Strength of Concrete

7.4 Split Tensile Strength of Concrete

| S.No | CCA Replacement | Split Tensile Strength (MPa) |
|----------|-----------------|------------------------------|
| CC | 0% CCA | 2.05 MPa |
| CCASSF 1 | 5% CCA | 2.33 MPa |
| CCASSF 2 | 10% CCA | 2.19 MPa |
| CCASSF 3 | 15% CCA | 1.98 MPa |

Table 7.4 Compressive Strength of Concrete

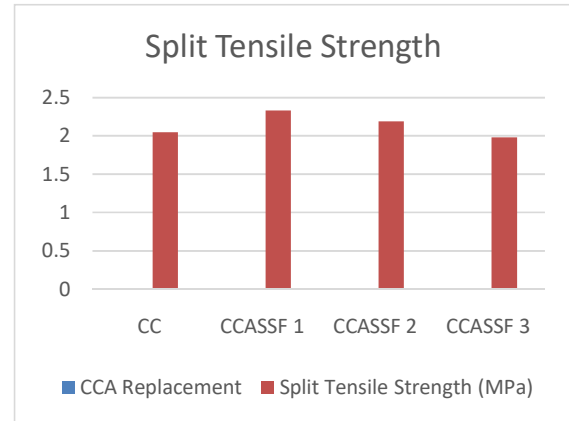


Fig 7.4 Split Tensile Strength of Concrete

ANALYSIS AND RESULT

8.1 Observation

The experiment evaluates the effect of corn cob ash (CCA) as a partial replacement of cement (0%, 5%, 10%, 15%) with stainless steel fiber on concrete strength. Compressive strength at 7, 14, and 28 days and split tensile strength were measured to determine the optimum CCA percentage.

- The conventional concrete (0% CCA) shows steady strength gain from 7 to 28 days. It reaches 25.1 MPa compressive strength at 28 days. This indicates normal hydration and strength development.
- The mix with 5% CCA (CCASSF 1) shows the highest compressive strength. It achieves 27.6 MPa at 28 days, higher than conventional concrete. This suggests optimum replacement improves strength.
- The 10% CCA mix shows slightly lower strength than 5% but higher than control. It reaches 26.2 MPa at 28 days. This indicates acceptable performance up to 10% replacement.
- The 15% CCA mix shows a noticeable reduction in strength. The 28-day strength drops to 23.8 MPa. Higher CCA content negatively

affects bonding and hydration.

- Split tensile strength follows a similar trend as compressive strength. The 5% CCA mix gives the highest value of 2.33 MPa. This indicates improved tensile performance at optimum dosage.
- At 10% CCA, split tensile strength slightly decreases to 2.19 MPa. However, it is still higher than conventional concrete. This shows moderate improvement with controlled replacement.
- The 15% CCA mix shows the lowest tensile strength of 1.98 MPa. It is even lower than the control mix (2.05 MPa). This confirms that excess CCA reduces overall concrete strength.

8.2 Discussion

The results show that strength increases with CCA replacement up to 5% and then gradually decreases. The 5% CCA mix exhibits the highest compressive and split tensile strength among all mixes. At 10% replacement, strength remains acceptable but slightly lower than the optimum mix. A significant reduction in strength is observed at 15% CCA due to reduced cementitious content. Overall, 5% CCA is identified as the optimum level for improved concrete performance.

8.3 Role of Corn Cob Ash and Stainless Steel Fiber in Strength Enhancement

- Corn Cob Ash (CCA) improves strength through pozzolanic reaction forming additional cementitious compounds. The 5% replacement shows maximum compressive strength in the given data.
- At optimum level (5%), CCA enhances both compressive and tensile strength effectively. This indicates better bonding and improved microstructure of concrete.
- Higher CCA content (10% and 15%) reduces

strength due to lower cement availability. Excess replacement leads to weaker hydration and reduced performance.

- Stainless Steel Fiber (SSF) increases tensile strength by bridging cracks. It controls crack propagation and improves ductility of concrete.
- The combined use of CCA and SSF at 5% gives the best overall performance. It enhances both compressive and split tensile strength compared to normal concrete.

CONCLUSION

This project successfully investigated the use of Corn Cob Ash (CCA) as a partial replacement of cement along with Stainless Steel Fiber (SSF) in concrete. The study focused on evaluating the mechanical properties of concrete by conducting compressive strength tests at 7, 14, and 28 days, along with split tensile strength tests. The aim was to enhance strength performance while promoting sustainable use of agricultural waste materials.

Concrete mixes were prepared with varying percentages of CCA (0%, 5%, 10%, and 15%) combined with SSF. The results indicated that partial replacement of cement with CCA improves the properties of concrete up to an optimum level. The addition of SSF further contributed to crack resistance and improved tensile behavior of concrete.

The optimum compressive strength was observed at 5% CCA replacement, achieving higher strength than conventional concrete, indicating effective pozzolanic activity and better bonding.

- The split tensile strength also showed maximum improvement at 5% CCA with SSF, demonstrating enhanced crack resistance due to fiber reinforcement.
- At 10% CCA replacement, the strength remained satisfactory but slightly lower than the

optimum mix, indicating limited effectiveness beyond optimum dosage.

- The 15% CCA mix showed a reduction in both compressive and tensile strength due to decreased cement content and weaker hydration.
- The inclusion of SSF improved ductility, reduced crack propagation, and enhanced overall structural performance of concrete.

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