E-ISSN No : 2581-6195 | Volume : 9 | Special Issue | May 2026

A STUDY ON STRENGTH OF HVFA CONCRETE WITH COCONUT FIBRE

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ABSTRACT

This study investigates the strength characteristics of High Volume Fly Ash (HVFA) concrete reinforced with coconut fibre. HVFA concrete is an eco-friendly alternative to conventional concrete due to reduced cement usage and lower carbon emissions. However, it suffers from low early-age strength and brittle behavior. To overcome these limitations, coconut fibre, a natural and sustainable material, was incorporated as reinforcement. Concrete mixes were prepared with high fly ash replacement and varying fibre contents. Standard specimens were tested for compressive and split tensile strength at different curing periods. The results indicate that the addition of coconut fibre improves tensile strength, ductility, and crack resistance. An optimum fibre content was observed at around 1%, beyond which workability and strength decreased due to fibre agglomeration. The study concludes that coconut fibre enhances the mechanical performance of HVFA concrete and contributes to sustainable construction practices.

KEYWORDS: HVFA Concrete, Coconut Fibre, Fly Ash, Sustainable Concrete, Mechanical Properties

How to Cite: Shivashankar B C, Abhishek, Jyoti, Kratika & Santosh (2026), A Study on Strength of Hvfa Concrete With Coconut Fibre, International Educational Journal of Science & Engineering (IEJSE),Vol: 9, Special Issue, May 2026 373-376

1. INTRODUCTION

Concrete is the most widely used construction material and forms the backbone of modern infrastructure, including buildings, bridges, pavements, and other civil engineering structures. However, the increasing demand for concrete has led to a significant rise in cement production, which is a major contributor to global carbon dioxide (CO_2) emissions and environmental degradation. In response to these challenges, there is a growing need to develop sustainable construction materials that reduce cement consumption without compromising performance.

High Volume Fly Ash (HVFA) concrete has emerged as a promising solution, wherein a substantial portion of cement is replaced with fly ash, an industrial by-product from coal-based thermal power plants. The utilization of fly ash not only addresses disposal issues but also reduces environmental pollution and enhances sustainability in the construction industry. HVFA concrete offers several advantages, including improved workability, reduced heat of hydration, enhanced durability, and better long-term strength development. However, a major limitation of HVFA concrete is its low early-age strength, which restricts its application in structures requiring rapid construction and early load-bearing capacity.

To overcome this drawback, the incorporation of fibres in concrete has gained considerable attention. Fibre reinforcement improves the toughness, ductility, crack resistance, and overall mechanical performance of concrete. Among various fibre types, coconut fibre (coir fibre) has emerged as an effective natural reinforcement due to its low cost, availability, biodegradability, and favourable mechanical properties such as high tensile strength and elasticity.

Research Paper

Additionally, coconut fibre exhibits good resistance to moisture and environmental degradation, making it suitable for construction applications.

The integration of coconut fibre into HVFA concrete provides a synergistic approach to enhance both sustainability and structural performance. Coconut fibres act as micro-reinforcement elements that bridge cracks and improve post-cracking behaviour, thereby increasing the ductility and toughness of concrete.

In this context, the present study aims to investigate the mechanical properties of HVFA concrete reinforced with coconut fibre. The evaluation is carried out through experimental analysis of compressive strength and split tensile strength. The study seeks to determine the effectiveness of coconut fibre in

improving the performance of HVFA concrete and to identify the optimum fibre content for practical applications. This research contributes to the development of sustainable and eco-friendly construction materials by promoting the use of industrial by-products and natural fibres.

2. MATERIALS AND METHODS

2.1 Materials Used

2.1.1 Cement

Portland Pozzolana Cement (PPC) conforming to IS: 456–2000 was used in this study. The use of blended cement enhances durability and reduces heat of hydration. The mix design was carried out based on relevant IS codes to ensure suitability for HVFA concrete.

2.1.2 Coarse Aggregate

Well-graded coarse aggregates of nominal size 12.5 mm were obtained from a local crushing unit. The aggregates were sieved through standard IS sieves (20 mm, 16 mm, 12.5 mm, 10 mm, and 4.75 mm), and the fraction passing through the 12.5 mm sieve was used for the investigation.

2.1.3 Fine Aggregate

Natural river sand conforming to IS specifications was used as fine aggregate. The sand was sieved through standard sieves (4.75 mm to 150 µm), and the fraction passing through the 4.75 mm sieve was used.

2.1.4 Coconut Fibre

Coconut fibre (coir fibre), a natural and biodegradable material obtained from coconut husk, was used as reinforcement. It possesses high tensile strength, low density, and good resistance to moisture and microbial attack. The fibre acts as micro-reinforcement, improving crack resistance and ductility of concrete.

2.1.5 Fly Ash (Class F)

Class F fly ash conforming to IS: 3812 (Part 1)–2013 was used as a partial replacement for cement. It is a fine, pozzolanic material rich in silica and alumina, contributing to improved workability, reduced heat of hydration, enhanced durability, and long-term strength development.

2.1.6 Water

Potable water free from impurities such as acids, oils, and organic matter was used for mixing and curing, conforming to IS: 456–2000.

2.2 Mix Proportion

HVFA concrete was prepared by replacing 70% of cement with fly ash. Coconut fibre was added at varying percentages (0%, 0.5%, 1.0%, and 1.5%) by weight of cementitious material. The mix design was carried out as per IS: 10262–2019.

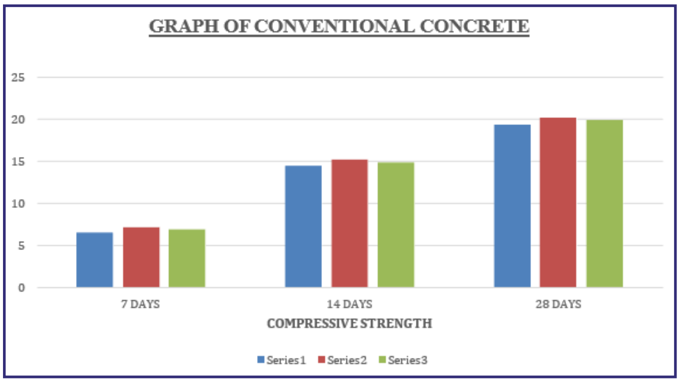
3. RESULTS

Results show HVFA has lower early strength. Fibre addition improves tensile strength. Optimum fibre ~1%.

TABLE 01: COMPRESSIVE STRENGTH OF CONVENTIONAL CONCRETE

COMPRESSIVE STRENGTH OF CONVENTIONAL CONCRETE			
SL.NO	7 DAYS	14 DAYS	28 DAYS
1	6.48 N/mm^2	14.44N/mm^2	19.33N/mm^2
2	7.10 N/mm^2	15.12 N/mm^2	20.10 N/mm^2
3	6.85 N/mm^2	14.80 N/mm^2	19.8519 N/mm^2

GRAPH 01: COMPRESSIVE STRENGTH OF CONVENTIONAL CONCRETE

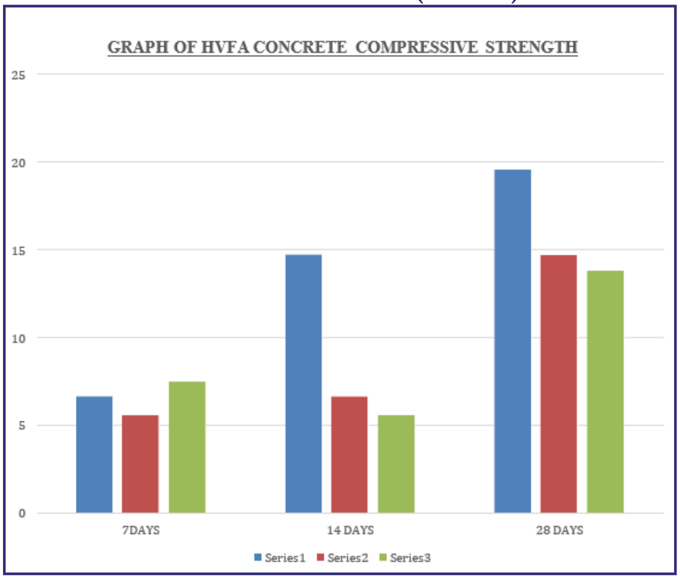


Hvfa Concrete Compressive Strength Test (Hvfa)

TABLE 02: HVFA CONCRETE COMPRESSIVE STRENGTH TEST (HVFA)

HVFA CONCRETE COMPRESSIVE STRENGTH			
SL.NO	7DAYS	14 DAYS	28 DAYS
1	6.6N/mm^2	14.68N/mm^2	19.51N/mm^2
2	5.55N/mm^2	13.77N/mm^2	17.6N/mm^2
3	7.45N/mm^2	16.50N/mm^2	`22.4N/mm^2

GRAPH 02: HVFA CONCRETE COMPRESSIVE STRENGTH TEST (HVFA)

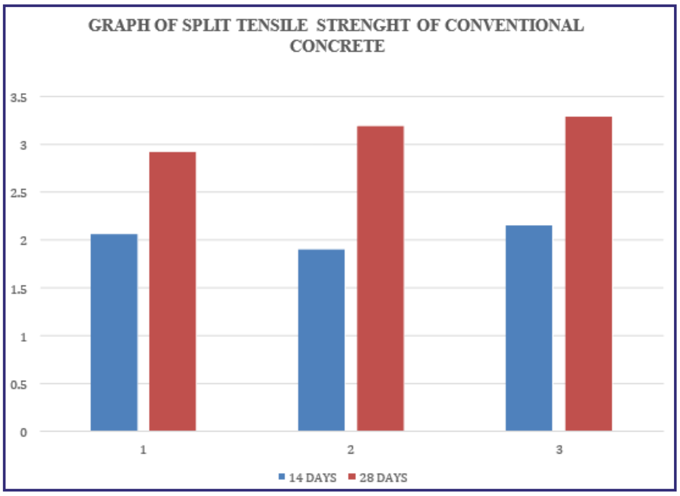


Split Tensile Strenght Of Conventional Concrete

Table 03: Split Tensile Strenght Of Conventional Concrete

SPLIT TENSILE STRENGHT			
SL.NO	14 DAYS	28 DAYS	28 DAYS
1	2.06N/mm^2	2.91N/mm^2	19.51N/mm^2
2	1.90N/mm^2	3.18N/mm^2	17.6N/mm^2
3	2.15N/mm^2	3.28N/mm^2	`22.4N/mm^2

GRAPH 03: SPLIT TENSILE STRENGHT OF CONVENTIONAL CONCRETE

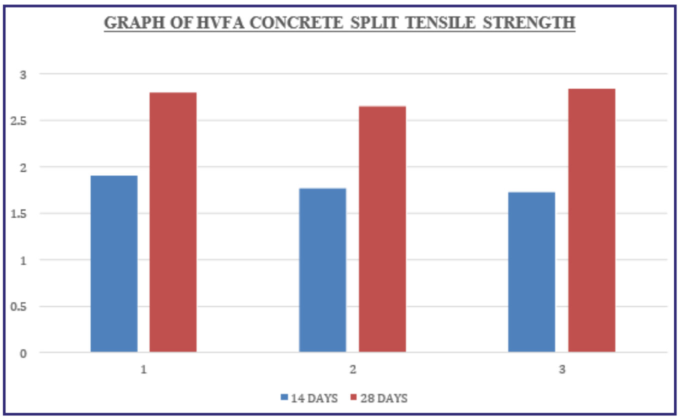


HVFA CONCRETE SPLIT TENSILE STRENGTH

Table 04: Hvfa Concrete Split Tensile Strenght

HVFA CONCRETE SPLIT TENSILE STRENGHT			
SL.NO	14 DAYS	28 DAYS	28 DAYS
1	1.90N/mm^2	2.8N/mm^2	19.51N/mm^2
2	1.76 N/mm^2	2.65 N/mm^2	17.6N/mm^2
3	1.72 N/mm^2	2.84 N/mm^2	`22.4N/mm^2

GRAPH 04: HVFA CONCRETE SPLIT TENSILE STRENGHT



4. DISCUSSION

Table 1: Conventional Compressive Strength

- Strength increases with curing time (7 → 28 days).
- 28-day strength ≈ 19–20 N/mm².
- Consistent results → good quality.
- Used as reference/base mix.

Table 2: HVFA Compressive Strength

- Lower early strength (7 days).
- Improves at 14 & 28 days.
- Max ≈ 22.4 N/mm² (higher than conventional).

- Shows delayed strength gain due to fly ash.
- Optimum fibre improves strength, excess reduces it.

Table 3: Conventional Split Tensile Strength

- Increases from 14 → 28 days.
- 28-day ≈ 2.9 - 3.3 N/mm^2.
- Moderate tensile strength.
- Brittle behavior (no fibres).

Table 4: HVFA Split Tensile Strength

- Slightly lower than conventional.
- 28-day ≈ 2.65 - 2.84 N/mm^2.
- Fibres improve:
  - Crack resistance
  - Ductility
- Excess fibre - poor bonding.

5. CONCLUSIONS

- HVFA concrete is **eco-friendly** due to reduced cement usage.
- It shows **low early strength** but improves at later ages.
- Addition of coconut fibre **enhances tensile strength**.
- Fibre improves:
  - **Ductility**
  - **Crack resistance**
  - **Optimum fibre content ≈ 1%** gives best performance.
- Excess fibre causes:
  - **Fibre agglomeration**
  - **Reduction in strength and workability**
- HVFA with fibre can achieve **comparable or higher long-term strength**.
- Overall, the combination is **suitable for sustainable and durable construction**.

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