Experimental Investigation on the Compressive Strength of Kenaf Fibre Reinforced Concrete

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Abstract — The present study focuses on the experimental investigation of kenaf fibre–reinforced concrete as a sustainable alternative to conventional concrete. Kenaf fibre was used as a reinforcing material in concrete, and three test cubes were cast along with normal concrete cubes for comparison. After adequate curing, all specimens were tested using a compression testing machine to determine their compressive strength. The experimental results showed that concrete incorporated with kenaf fibre achieved higher compressive strength than normal concrete. In addition to strength improvement, the presence of kenaf fibre contributed to better crack control and ductile behavior of concrete. Since kenaf fibre is a natural, renewable, and environmentally friendly material, its uses in concrete promotes sustainable construction practices. The results of this study demonstrate that kenaf fibre–reinforced concrete is a promising and eco-friendly material, and its application in construction should be encouraged.

Keywords: Kenaf Fibre, Fibre Reinforced Concrete, Compressive Strength, Sustainable Concrete, Crack Resistance, Eco-Friendly Construction

I. INTRODUCTION

Concrete is one of the most widely used construction materials across the world due to its high compressive strength, durability, versatility, and availability of constituent materials. Conventional concrete, which consists of cement, fine aggregate, coarse aggregate, and water, has been extensively used in infrastructure and building construction for several decades. Despite its advantages, normal concrete exhibits certain inherent limitations such as low tensile strength, brittle nature, poor crack resistance, and limited energy absorption capacity. These shortcomings lead to the formation of micro-cracks under service loads, shrinkage, and temperature variations, which may further propagate and adversely affect the durability and service life of concrete structures. To address these deficiencies, the concept of fiber-reinforced concrete has been developed, wherein discrete fibers are uniformly distributed within the concrete matrix to enhance its mechanical and durability properties. The inclusion of fibers improves tensile strength, controls crack development, and enhances ductility and toughness of concrete. Traditionally, synthetic fibers such as steel, glass, carbon, and polypropylene have been used for this purpose. However, increasing environmental concerns, high production costs, and energy consumption associated with synthetic fibers have encouraged researchers to explore sustainable and eco-friendly alternatives. In this context, natural fibers have gained considerable attention due to their biodegradability, renewability, low density, and reduced environmental impact. Kenaf fibre, obtained from the plant Hibiscus cannabinus, is one such natural fiber that has shown promising potential for use in reinforced concrete. Kenaf is a fast-growing plant with a short cultivation cycle and high fiber yield, making it an economically viable and sustainable resource. The fiber is mainly composed of cellulose, hemicellulose, and lignin, which contribute to its mechanical strength, flexibility, and toughness. Due to its favorable physical and mechanical properties, kenaf fiber has been increasingly studied as a reinforcing material in cementitious composites and concrete. The incorporation of kenaf fiber into concrete aims to improve the overall performance of conventional concrete by overcoming its brittle behavior. Normal concrete fails suddenly once the tensile stress exceeds its capacity, leading to rapid crack propagation and structural damage. Kenaf fibers act as crack-bridging elements within the concrete matrix, restraining the initiation and growth of micro-cracks. This mechanism enhances the post-cracking behavior of concrete and provides a more ductile and gradual mode of failure. As a result, kenaf fibre–reinforced concrete exhibits improved tensile strength, flexural strength, impact resistance, and energy absorption capacity compared to normal concrete. Another significant advantage of using kenaf fiber in reinforced concrete is the improvement in durability performance. Cracks in conventional concrete allow the ingress of water, chlorides, and other aggressive agents, which may lead to reinforcement corrosion and longterm deterioration. The presence of kenaf fibers reduces crack width and distribution, thereby limiting permeability and enhancing resistance to shrinkage and thermal cracking. This contributes to improved durability and extended service life of concrete structures, particularly in aggressive environmental conditions. From a sustainability perspective, the use of kenaf fiber in reinforced concrete aligns with the principles of green construction and sustainable development. Cement production is a major contributor to carbon dioxide emissions, and the construction industry is under increasing pressure to reduce its environmental footprint. Kenaf fiber, being a natural and renewable material, offers an environmentally responsible alternative to synthetic fibers. Its use not only reduces dependency on non-renewable resources but also promotes the utilization of agricultural products in construction applications, thereby supporting rural economies. However, the inclusion of kenaf fiber in concrete also presents certain challenges. The hydrophilic nature of natural fibers may affect the workability and water absorption characteristics of concrete. Improper fiber dispersion can lead to balling effects and reduced uniformity in the mix. These issues can be effectively addressed through proper mix design, fiber treatment methods, and controlled fiber dosage. With appropriate precautions, kenaf fibre–reinforced concrete can achieve satisfactory workability and consistent performance.

II. OBJECTIVES

1) To study the effect of kenaf fibre on the compressive strength of concrete cubes.
2) To prepare concrete cubes with different percentages of kenaf fibre and compare their strength with normal concrete cube.
3) 3.To establish a comparative understanding between kenaf fibre–reinforced concrete and conventional concrete based on experimental results.

III. LITERATURE REVIEW

The literature review presents an overview of previous research carried out on kenaf fibre–reinforced concrete and its influence on the mechanical and durability properties of concrete. Various researchers have investigated the effectiveness of kenaf fibre as a sustainable and eco-friendly reinforcing material and reported improvements in strength, crack resistance, ductility, and overall concrete performance.

M. Ramesh and K. Rajesh (2019) investigated the mechanical properties of kenaf fibre–reinforced concrete by incorporating different percentages of kenaf fibre into concrete mixes. Their study reported that the inclusion of kenaf fibre improved tensile and flexural strength, enhanced crack resistance, and increased the ductility of concrete while promoting sustainable construction practices.

A. Das and P. Roy (2018) evaluated the performance of kenaf fibre in concrete mixes and observed that the addition of kenaf fibre effectively controlled crack propagation, improved toughness, and enhanced the overall durability of concrete. The authors concluded that kenaf fibre is a suitable natural reinforcement for sustainable concrete applications.

S. Joseph and T. Thomas (2017) studied the durability characteristics of kenaf fibre–reinforced concrete under different environmental conditions. Their findings indicated that optimum fibre content reduced crack width, improved resistance to water penetration, and increased the service life of concrete structures.

X. Li and H. Wang (2019) investigated the mechanical behaviour of natural fibre–reinforced concrete, including kenaf fibre. The experimental results showed improvements in tensile strength, impact resistance, and energy absorption, demonstrating the potential of natural fibres for green and sustainable construction.

A. Kumar and R. Singh (2020) examined the use of kenaf fibre in reinforced concrete and reported that optimum fibre dosage enhanced compressive, tensile, and flexural strength while reducing brittle failure and crack development. The authors recommended kenaf fibre as an effective and environmentally friendly alternative to synthetic reinforcing fibres.

IV. METHODOLOGY

A. Materials Used

1) Cement

Ordinary Portland Cement (OPC) – 43 Grade Function: Acts as a binding material that holds aggregates together
Properties:

- Good early strength
- Uniform consistency

Importance in project:
Provides required compressive strength to concrete cubes

2) Fine Aggregate (Sand)

Natural river
sand Size: Less than 4.75 mm Function: Fills voids between coarse aggregates and improves workability Properties: • Clean and free from clay, silt, and organic matter Importance in project: Improves bonding and surface finish of concrete

3) Coarse Aggregate

Type: Crushed stone aggregate Maximum size: 20 mm
Function: Provides strength and bulk to concrete
Properties:

- Hard, strong, and durable
- Angular shape improves interlocking

Importance in project: Major contributor to compressive strength

4) Water

Type: Clean potable water
Function:

- Hydration of cement
- Improves workability of concrete Properties:
- Free from acids, oils, salts, and organic substances

Importance in project: Essential for setting and hardening of concrete

5) Kenaf Fibre

Source: Natural fibre obtained from kenaf plant
Method of addition: Added as a percentage of cement weight
Properties: • Lightweight

- Eco-friendly and biodegradable
- Good tensile strength
- High water absorption capacity
- Role in Concrete
- Reduces crack propagation
- Improves toughness and ductility
- Acts as crack-bridging material
- Enhances compressive strength up to optimum percentage

6) Concrete Cube Moulds

- Size: 150 mm × 150 mm × 150 mm Material: Cast iron or steel
- Function: Used to cast standard concrete cubes for strength testing

B. Selection Of Materials:

Ordinary Portland Cement, fine aggregate, coarse aggregate, potable water, and kenaf fibre were used for the preparation of concrete cubes. The concrete mix was designed for M20 grade concrete.

C. Mix Design

Concrete mix proportion adopted was 1: 1.5: 3 with a water–cement ratio of 0.50. Kenaf fibre was added as a percentage of cement weight. Three different fibre percentages were used, namely 0.25 percent, 0.50 percent, and 0.75 percent. One normal concrete cube without fibre was also prepared for comparison.

D. *Preparation Of Concrete Cubes*

- The materials were weighed accurately as per the mix design.
- Cement, fine aggregate, and coarse aggregate were first mixed in dry condition until a uniform colour was obtained.
- Required quantity of kenaf fibre was added to the dry mix and mixed thoroughly to ensure uniform distribution
- Water was then added gradually and the concrete was mixed until a workable and homogeneous mix was obtained.
- The prepared concrete was placed into cube moulds of size 150 mm x 150 mm x 150 mm in three layers
- Each layer was compacted properly using a tamping rod to remove air voids.
- The top surface was finished smoothly. A total of four cubes were cast:
- One normal concrete cube (0 percent fibre)
- Three kenaf fibre reinforced concrete cubes with 0.25 percent, 0.50 percent, and 0.75 percent fibre content.

E. *Curing of Concrete Cubes*

- After casting, the cubes were kept undisturbed for 24 hours.
- The cubes were then demoulded carefully.
- All the cubes were immersed in clean water for curing.
- Curing was carried out for 14 days to ensure proper hydration and strength development.

F. *Compression Testing Machine – Mechanism*

The Compression Testing Machine works on the principle of applying gradually increasing compressive load on the concrete specimen until failure occurs. The load is applied uniformly through steel platens. As the load increases, the concrete cube resists the compressive force. When the applied load exceeds the compressive strength of the concrete, the cube fails. The maximum load at failure is recorded, and compressive strength is calculated.

G. *Procedure For Compressive Strength Test*

- After 14 days of curing, the cubes were removed from water and wiped dry.
- The dimensions of remember of the cube were checked.
- Each cube was placed centrally on the lower platen of the Compression Testing Machine.
- Load was applied gradually and uniformly without shock.
- The load at which the cube failed was noted.
- The compressive strength was calculated using the formula: Compressive strength = Load at failure / Area of cube
- The same procedure was followed for all cubes, including the normal cube and fibre-added cubes.

H. *Mix Design*

Concrete Mix Design for Kenaf Fibre Reinforced Concrete (M20 Grade)

1) *Specimen Details*

- Type of specimen: Concrete cube
- Size of cube: 15 cm × 15 cm × 15 cm

Volume of one cube V=0.15×0.15×0.15=0.003375m

2) *Concrete Mix Details*

- Grade of concrete: M20
- Mix proportion (C : FA : CA) = 1 : 1.5 : 3
- Water–cement ratio: 0.50
- Cement content: 400 kg/m³

3) *Material quantity calculation (per cube)*

- Cement quantity: 400 x 0.003375 = 1.35 kg
- Water quantity: 0.50 x 1.35 = 0.675 litres (675 ml)
- Total aggregate: 1800 x 0.003375 = 6.075 kg
- Fine aggregate: (1.5 / 4.5) x 6.075 = 2.025 kg
- Coarse aggregate: (3 / 4.5) x 6.075 = 4.05 kg

4) *Kenaf fibre content calculation Cube1 (0.25 percent kenaf fibre): 0.25 x 1.35 / 100 = 0.003375 kg = 3.38 g*

Cube 2 (0.50 percent kenaf fibre): 0.50 x 1.35 / 100 = 0.00675 kg = 6.75 g

Cube 3 (0.75 percent kenaf fibre): 0.75 x 1.35 / 100 = 0.010125 kg = 10.13 g

Cube No.	Fibre (%)	Cement (Kg)	Fine aggregate (Kg)	Coarse aggregate (Kg)	Water (mL)	Kenaf fibre (g)
1	0.25	1.35	2.03	4.05	675	3.38
2	0.50	1.35	2.03	4.05	675	6.75
3	0.75	1.35	2.03	4.05	675	10.13

V. Results and Discussions

Graph Description: Effect of Kenaf Fibre on Compressive Strength of Concrete

The graph represents the variation of compressive strength of concrete with increase in kenaf fibre percentage.

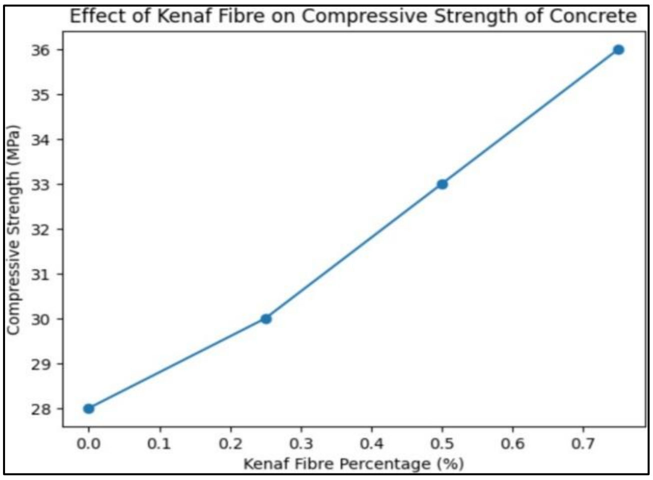
The X-axis shows the kenaf fibre content (%), where 0% represents normal concrete without fibre, and the Y-axis shows the compressive strength of concrete.

From the graph, it is observed that normal concrete (0% kenaf fibre) shows the lowest compressive strength.

As the kenaf fibre percentage increases from 0.25% to 0.75%, the compressive strength of concrete increases gradually. This increase in strength is due to the presence of kenaf fibres, which help in crack arresting, better bonding, and improved load transfer within the concrete matrix.

Hence, it can be concluded that kenaf fibre–reinforced concrete shows better compressive strength compared to conventional concrete.

Specimen no.	Weight(kg)	Max load(kN)	Compressive strength(N/mm^2)
Cube 1(0.25%)	8.165	625.0	27.78
Cube 2(0.50%)	8.195	630.0	28.00
Cube 3(0.75%)	8.210	645.0	28.67
Normal cube	7.705	317.1	14.09



VI. CONCLUSION:

The present study investigated the feasibility and performance of kenaf fibre–reinforced concrete in comparison with conventional concrete. Concrete cubes were prepared by incorporating kenaf fibres, cast, cured, and tested under a compression testing machine, and their results were compared with normal concrete cubes. The experimental results demonstrated that the inclusion of kenaf fibre improved the compressive strength, ductility, and crack resistance of concrete. The fibres effectively controlled micro-crack formation, while the coarse aggregate provided bulk, structural stability, and load-bearing capacity to the concrete mix. It was observed that kenaf fibre–reinforced concrete exhibits better post-cracking behavior and higher tensile and flexural performance than conventional concrete. In addition to mechanical improvements, the use of kenaf fibre promotes sustainability by utilizing a natural, renewable, and biodegradable material, reducing environmental impact compared to synthetic fibres. Overall, the study concludes that kenaf fibre–reinforced concrete is a viable and eco-friendly alternative to normal concrete, with significant potential for use in both structural and non-structural applications. Its adoption can lead to more durable, sustainable, and environmentally responsible construction practices.

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