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Study on the Performance of Kenaf Fiber to Strengthening of Reinforced Concrete Beams: Review Paper

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Abstract: This paper presents the findings of studies that were conducted on the effects of kenaf fiber on the mechanical properties of kenaf fiber reinforced concrete beams. In recent years, kenaf fiber reinforced concrete have been widely used as reinforcement system for concrete structures. Fibers are generally used as resistance of cracking and strengthening of concrete, therefore, kenaf fiber as material mainly used to strengthening the reinforced concrete. The aim of this paper is to review the work carried out using kenaf fiber as reinforcement in reinforced concrete to improving the strength properties of the concrete structures.

Keywords: RC Beams, Kenaf Fiber, Mechanical Properties, Concrete Strengthening

1. Introduction

Concrete has become one of the most important construction materials commonly used in many types of engineering structures. Generally, concrete is a material that is strong in compression and weak in tension. Recently the use of natural fiber in reinforced concrete has increased tremendously. The environmental issue requires materials which are biodegradable. For example, incorporation of natural fibers in reinforced concrete promotes green and sustainable concrete. Moreover, due to increase in the environmental awareness and the needs to reduce environmental waste, some researcher opts the use of eco-friendly materials and their positive environmental impact led to further research and verification in the use of green and renewable materials rather than using synthetic fibers with a negative environmental impact [8]. Kenaf fiber an important plant, received much attention due to certain attributes such as low in cost and density and its biodegradability feature. This work reviews several previous studies on the usage kenaf fibers as reinforcement in reinforced concrete beam and their effects on the mechanical properties of concrete. Other topic, addressed the advantages of using kenaf fibers to improve the strength properties. The general aim of the research is to summarize the previous studies on reinforced concrete beams containing of kenaf fibers in order to highlight and illustrate the investigations of some published research regarding use of kenaf fibers in reinforced concrete beam and the results obtained for provide outline suggestions for future investigations.

2. Fiber in Reinforced Concrete

Reinforced concrete is one of the most widely used modern building materials. Fiber reinforced concrete has been successfully used in many applications such as, hydraulic structures, precast products, architectural panels and others applications. Due to the fiber's capability of enhancing the load carrying capacity and ductility of the concrete structures as well as changes the mode of failure, control cracking propagation make it a unique new construction material. It also has been given due attention by researchers over the past few decades [1, 3].

3. Kenaf Fiber in Reinforced Concrete

The development of high-performance engineering products made from natural resources is increasing worldwide, due to renewable and environmental issues. Kenaf fiber has high potential to be used for composite reinforcement in construction material. Kenaf is a species of Hibiscus that can be found in southern Asia. Kenaf is a warm season annual fiber crop closely related to cotton and jute [7]. Kenaf stalk content two types of fiber, an inner woody core and outer fibrous bast around the core. Several studies have been conducted to identify the basic properties of kenaf bast fiber [1, 2]. The finding of the studies show that the average tensile strength of kenaf fibers range from 157 MPa to 600 MPa. Some investigations have been carried out on various mechanical properties of concrete materials using natural fibers. Kenaf fibers are coming into interest to use in reinforced concrete elements in recent years due to its attractive properties such as lightweight and renewable these properties are dependent on several numbers of factors including the type, length and volume fraction of fibers.

Natural fibers has been given due attention by researchers over the past decades. Kenaf fibers have demonstrated its capability in improving the structural behavior of reinforced concrete beams [4, 10, 6] the finding have been indicated that the addition of kenaf fibers enhances the flexural strength of beam and also the compressive strength has been improved as well as enhances the load carrying capacity, ductility apart from altering the failure mode of the beams from brittle shear mode to flexural ductile mode, [5, 3] controlled crack propagation more than plain concrete. Elsaid et al. [1] studied the mechanical properties of a natural fiber reinforced concrete (FRC) which is made using the bast fibers of the kenaf plant. The research showed that the kenaf fiber reinforced concrete (KFRC) generally exhibits more distributed cracking and higher toughness than plain concrete, also demonstrated the KFRC is a promising 'green' construction material which could potentially be used in a number of different structural applications. Lam et al. [5] studied on the effects of fiber content and fiber length on the mechanical properties of kenaf fiber reinforced concrete. The results indicate that the compressive strength decreased with increase in fiber content also the results indicate that the workability of kenaf fiber reinforced concrete is reduced compared to plain concrete. Table 1 summarizes of some properties of kenaf fiber.

Table 1. *Properties of kenaf fiber.*

Fiber	Diameter (mm)	Ultimate stress (Mpa)	Density (kg/m^3)	Specific stress	Water absorption (%) for 24 hours
Kenaf	0.15 - 0.30	350 - 600	1500	0.22 - 0.44	0.95

Source: [12]

In order to investigate the effect of kenaf fiber on the reinforced concrete beam, several concrete tests need to be carried out such as workability, compressive strength and flexural strength (bending strength).

Table 2. *Influence of kenaf fiber on the workability.*

Authors	Year	Percentage of fiber	Finding
Lam et al., 2015	2015	(0.5, 0.75, 1.0, 1.5, 2.0)%	workability of KFRC is reduced
Hasan et al., 2015	2015	1%	decreased the workability of concrete due to the water absorption characteristics of kenaf fiber

3.1. Compressive Strength

Compressive strength represents the ability of the material to resist pressure applied by the compression machine test, where the cubes crushing when it exceed the limits of compressive strength.

Table 3. *Influence of kenaf fiber on the compressive strength.*

Authors	Year	Percentage of fiber	finding
Hasan et al., 2015	2015	1%	slightly reduced the ultimate load of the concrete cubes The additions of fiber decreased the ultimate load of the concrete for compressive strength.
Lam et al., 2015	2015	(0.5, 0.75, 1.0, 1.5, 2.0)%	Compressive strength decreased with increase in fiber content.
Azimi et al., 2014	2014	1%	The compressive strength has been improved
Elsaid et al., 2011	2011	1.2%, 2.4%	The compressive of KFRC is considerably lower than that of plain concrete.

3.2. Flexural Strength

Flexural strength can be described as a concrete beam's ability to withstand applied loads without failure. In most previous studies, specimens with dimensions of (100 × 100 × 500) mm were typically used, with the length designated to be four to five times the depth of the section.

Table 4. *Influence of kenaf fiber on the flexure strength of concrete.*

Authors	Year	Percentage of fiber	finding
Mohsin et al., 2014	2014	(10, 20) kg/m^3	Enhances the load carrying capacity, ductility. Restraining the crack propagation Changes the mode of failure into a ductile manner.
Lam et al., 2015	2015	(0.5, 0.75, 1.0, 1.5, 2.0)%	The flexural strength and indirect tensile strength of concrete can increase. More resistance to cracking and toughness. Improvement of the cracking leads to enhance the durability of concrete.
Hasan et al., 2015	2015	1%	Exhibited a more ductile failure mode. The additions of fiber decreased the modulus of rupture.
Azimi et al., 2014	2014	1%	Enhances flexural strength.

Table 5. *Influence of kenaf fiber on the some properties of concrete.*

Authors	Year	Percentage of fiber	finding
Mohsin et al., 2016	2016	(0%, 1%, 2%)	The mode of failure was changes. The load carrying capacity and ductility were enhanced. Crack propagation was controlled.
Lam et al., 2015	2015	(0.5, 0.75, 1.0, 1.5, 2.0)%	To improve mechanical properties of kenaf fiber concrete should be added 0.75% or lower and 50 mm of kenaf fiber in concrete.
Azimi et al., 2015	2015	(0, 0.5, 1, 1.5, 2, 2.5)%	Improve the structure properties of OPS-RC beam by addition of kenaf fiber.
Hasan et al., 2015	2015	1%	KFRC exhibited more ductile behavior with greater energy absorption and more well power of attacking the cracking pattern. High strength with a vital toughness to concrete with 1% of kenaf fiber content. The mechanical and fresh properties of KFRC are decreased when the increased of kenaf fiber content. Increase of fibers in the concrete mixture decreased the density of concrete then provided light weight concrete. The lower amount of fiber content leads to the increased strength of KFRC.
Azimi et al., 2014	2014	1%	Failure has not considerably been changed. The shear crack converts to flexural crack, due to increase time to failure. The proposed concrete beam has acceptable effect on minimizing environment pollution.
Elsaid et al., 2011	2011	1.2%, 2.4%	The KFRC exhibits more distributed cracking and higher toughness than plain concrete. Improvement of the cracking behavior enhances the durability of concrete at relatively low cost.
Masoud, 2013	2013	(0.5, 1, 1.5, 2)%	increased the short term compressive strength while reduced the compressive strength after 28 days

Kenaf fiber reinforced concrete has been given due attention by researchers over the past few decades. Some researcher attempted adding fibers into the concrete mixture in order to add ductility to the concrete and improve strength of concrete. For instance, Mohsin et al. [3] investigated the influence of kenaf and steel fiber reinforcement on the mechanical behavior of reinforced concrete beams. The major parameters are the volume fraction of kenaf and steel fiber and shear reinforcement arrangement. The beams subjected to four-point symmetrically placed vertical loads. The tests result indicated that suggests promising enhancement of the load carrying capacity, ductility, controlled crack propagation for the beams. Additionally, it was observed that addition of fibers changes the mode of failure of the beam from brittle to a more ductile manner.

Furthermore, Mohsin et al. [4] studied the behavior of oil palm shell reinforced concrete beams with the addition of kenaf fibers to examining the potential of kenaf fibers to improve the strength and ductility of the beams as well as observing potential kenaf fibers in serving as part of shear reinforcement in the beams. The results show that the addition of kenaf fibers enhances the load carrying capacity, ductility and altering the failure mode of the beams from brittle shear mode to flexural ductile mode.

Another research by Elsaid et al. [1] experimental study carried out on 101 specimens to evaluate the basic material properties of KFRC. The findings of the experimental program indicate that at lower fiber contents, the strength of KFRC is similar to plain concrete, contrariwise at higher fiber contents; the compressive strength of KFRC is somewhat lower than plain concrete with a similar w/c ratio. In general the specimens exhibited more ductile behavior, distributed cracking patterns, greater energy absorption and impact resisting. Thus, this study indicates that kenaf is a promising material.

In another study, Lam et al. [5] discussed the findings of an experimental research conducted on the effects of fiber content and fiber length on the mechanical properties of kenaf fiber reinforced concrete. The results indicate that the workability is reduced compared to plain concrete, compressive strength decreased with increase in fiber content. In generally, the KFRC exhibits more resistance to cracking and toughness, increase the flexural strength and indirect tensile strength. As the results suggest that the volume and length of kenaf fiber were to improve its mechanical properties should be 0.75% or lower and 50 mm. Future study about the fiber content should be conducted.

Hasan et al. [9] investigated to study the effect of natural

kenaf fiber on concrete. The experimental results indicate that the mechanical and fresh properties, ultimate load, modulus of rupture and direct shear test are decreased with the increased of kenaf fiber content. However, additions of fiber contents in concrete reduced the density of the concrete and provided light weight concrete, it also exhibited more ductile behavior with greater energy absorption and more well power of attacking the cracking pattern.

4. Conclusion

Based on this brief review, it can be seen that the addition of kenaf fiber into reinforced concrete beams in order to enhance the strength of the concrete structures is highly plausible with both lightweight and low cost. Many studies have been conducted to study the strength properties of kenaf fibers reinforced concrete to investigate the influence of kenaf fibers on strength of reinforced concrete beam. According to many researchers, the addition of kenaf fiber into concrete creates low workable or inadequate workability to the concrete; therefore Superplasticizer without any affecting on other properties of concrete may be its addition for solve this issue. Conversely, addition kenaf fiber into concrete with volume fractions from 0% - 2% may increases the load carrying capacity of kenaf fibers reinforced concrete beam and change the mode of failure from brittle to ductile. This review study is an attempt of giving some highlights for incorporation of kenaf fibers to produce several of concrete members. The findings for this paper indicated that KFRC is a promising 'green' construction material which could potentially be used in a number of different the concrete structures.

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