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Effect of kenaf fiber in reinforced concrete slab

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Abstract. The effect of kenaf fibers in reinforced concrete slab with different thickness is discusses and presented in this paper. Kenaf fiber is a type of natural fiber and is added in the reinforced concrete slab to improve the structure strength and ductility. For this study, three types of mixtures were prepared with fiber volume fraction of 0%, 1% and 2%, respectively. The design compressive strength considered was 20 MPa. Six cubes were prepared to be tested at 7th and 28th day. A total of six reinforced concrete slab with two variances of thickness were also prepared and tested under four-point bending test. The differences in the thickness is to study the potential of kenaf fiber to serve as part of shear reinforcement in reinforced concrete slab that was design to fail in shear. It was observed that, addition of kenaf fiber in reinforced concrete slab improves the flexural strength and ductility of the reinforced concrete slab. In the slab with reduction in thickness, the mode of failure change from brittle to ductile with the inclusion of kenaf fiber.

1. Introduction

Reinforced concrete is widely used in the construction industry due to its advantages such as strong, robust, economical and durable. Even so, ongoing research was carried out to improve the characteristic of the concrete as concrete is known to be weak in tension. Amongst of the investigation is to add short discreet fiber into the concrete as fiber is known to have benefits of improving the shear and flexural strength, adding ductility, delaying cracking propagation, increasing energy absorption and altering the mode of failure of the concrete [1-5]. Fiber reinforced concrete have obtained recognition and is used in many types of structures and infrastructures such seismic building, pre-cast product, tunnel lining, shotcrete and pavement slab [6-7].

Kenaf fiber is seen as a promising green material as it reused natural resources in the concrete. Furthermore, owning to the benefits of fiber's tensile properties, inclusion of kenaf fiber in concrete resulted in better flexural and shear strength and ductility of the reinforced concrete structure [8-12]. However, to ensure good performance, kenaf fiber, similar like other type of natural fibers need to undergo some treatment to reduce high water absorption characteristic of the fiber. One of the treatments recommended is to use a chemical such as sodium hydroxide (NaOH) to reduce the hydrophobic characteristic of the fiber, thus enhancing the adhesion between the fiber surface and the matrix. This was done by removing the hydroxyl group in cellulose and increasing the surface roughness which resulted in the improvement of the tensile properties of kenaf fibers as compared to untreated kenaf fibers [13-15].

Previous work focused on the effect and behaviour of kenaf fiber in reinforced concrete beams. The potential of using kenaf fiber to serve as part of shear reinforcement is yet to be studied. Promising

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results was observed in kenaf fiber reinforced concrete and its benefit in concrete. Thus, present work aims to study the behaviour of reinforced concrete slab added with kenaf fiber and its potential in compensating the loss in concrete shear capacity.

2. Materials and Methods

For this study, the concrete mixture was designed in accordance to British Standard (BS EN 206-1, 2000) to achieved at least 20 MPa on the 28th day and is considered as the control mix. Three concrete mix designs were prepared as shown in Table 1. Three amounts of fibers in volume fraction of 0%, 1% and 2% were considered to study the effect of kenaf fiber content in the concrete. Mix 1 (C0) was taken as control mixture as the amount of fiber content is 0%.

Table 1. Concrete mix design.

Properties	Mix 1 (C0)	Mix 2 (K1)	Mix 3 (K2)
V_f (%)	0	1	2
Cement (kg/m^3)	280	280	280
Fine Aggregate (kg/m^3)	556	556	556
Coarse Aggregate (kg/m^3)	1292	1292	1292
Water (Liter/m^3)	162	162	162
W/C ratio	0.58	0.58	0.58
SP (Liter/m^3)	5.6	5.6	5.6
Kenaf fiber (kg/m^3)	0	6.5	13

Table 2 and Figure 1 shows the properties and picture of kenaf fiber, respectively, considered in this study. As kenaf fiber is obtained from the bast fiber in kenaf plant, it is considered as natural fiber and have high water absorption characteristic. This will cause the concrete mixture to have low workability. Therefore, to maintain water cement ratio of 0.58 and achieve the required slump, super plasticizer (SP) was added into the concrete mixtures. The super plasticizer used in this study was Sika ViscoCrete®-2199. Furthermore, the kenaf fiber was treated with 1% of NaOH in order to clean and remove impurities from the fiber surface as well as enhancing the tensile properties of kenaf fiber.

Table 2. Properties of kenaf fiber.

Properties	Kenaf Fiber
Length, L (mm)	30
Diameter, D (mm)	0.1-0.5
Aspect Ratio, L/D	-
Tensile Strength (MPa)	400-550
Unit Weight (kg/m^3)	650

Figure 1. Kenaf fiber.

Six cubes of 150 x 150 x 150 mm were casted for each mixture to study the effect of kenaf fiber on the compressive strength of the concrete. The test was conducted on 7th day and 28th day as recommended by British Standards BS EN 12390-3 (2009). Whereas, two series of slab with different thickness were prepared for this study. The slab has same length and width of 1000 mm and 500 mm, respectively. However, for the first series of slab, the thickness considered was 120 mm, and for the second series of the slab, was 100 mm. The slab thickness in the second series was reduced by 17% and was designed to fail in shear. A total of two slabs were casted for each mixture in both series and tested under four-point bending test. The loading arrangement on the slab is given in Figure 2.

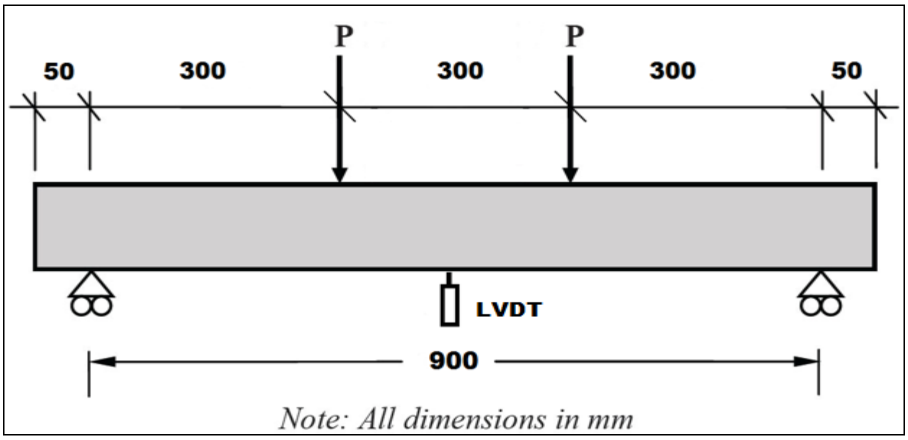

Figure 2. Loading arrangement for the slab.

3. Results and Discussion

This section presents the compressive strength results, load and deflection curve of the slab, cracking pattern and mode of failure.

3.1 Compressive Strength Test

Table 3 tabulates the average compressive strength results of concrete cubes added with kenaf fibers. As can be seen, addition of kenaf fiber decreased the compressive strength of the concrete at 7th and 28th days. At 28th day, the results observed a decrease of 17.5% and 24.0% in K1 and K2, respectively, in comparison to the concrete design strength of 20 MPa. This is due to the reduction in density of the concrete added with kenaf fibers, and potentially due to the cubes was not fully dry and hardened as it was cured inside the water for 7 days. Increasing the amount of kenaf fiber will reduce further the density of the concrete, therefore, the compressive strength results decreases with the increase of fiber content.

Table 3. Compressive strength of kenaf fiber concrete mixtures.

Mixture ID	Vf (%)	Compressive Strength (MPa) 7 Days	Compressive Strength (MPa) 28 Days
C0	0	17.40	22.30
K1	1	12.60	16.50
K2	2	11.30	15.20

3.2 Load versus Deflection Curves

Figure 3 shows the load versus deflection curve of the first series of slab tested under four-point bending test. RC1-0, KF1-1, and KF1-2 is the slab identification with 0%, 1% and 2% fiber content, respectively. RC1-0 was taken as the control slab for comparison. The key parameters extracted from the figure is presented in Table 4. Py and δy is the load at yield and its respective deflection, Pu and δu is ultimate load at failure and its respective deflection, whereas Pmax and δmax is maximum load carrying capacity and its respective deflection. The ductility ratio (μ) is calculated by dividing ultimate deflection and deflection at yield. The highest ductility was observed in slab KF1-1 with ductility ratio of 3.10. Whereas, in slab KF1-1 with lowest ductility, the structure became stiffer and failed in a sudden manner. From the results, addition of the kenaf fiber increases the load carrying capacity as higher loading is required to bridge the crack opening. The increase was up to 13% and 21% for KF-1 and KF-2, respectively. In the first series of the slab, addition of 2% of kenaf fiber caused the slab to become stiffer and failed suddenly after resisting higher load to produce larger crack opening width. The pattern of failure exhibits that the slab was over reinforced for KF1-2. For KF1-1, the structure had higher ductility and strength. Therefore, it can be justified that the optimum amount of fiber for this series can be taken at 1% as highest ductility ratio was observed at 3.10.

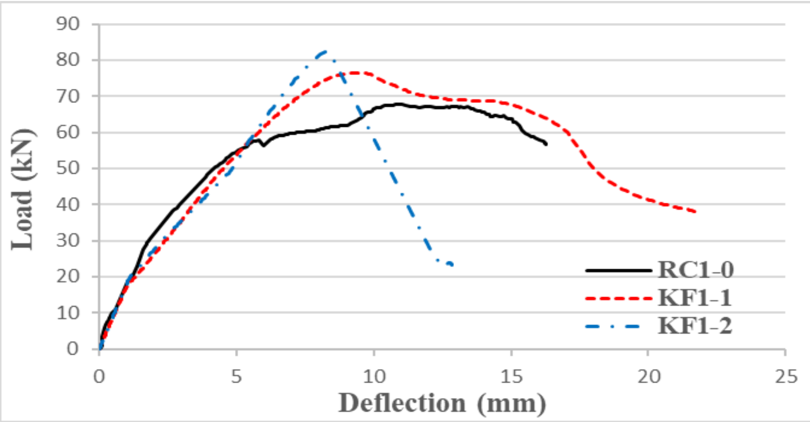

Figure 3. Load versus deflection curves for the first series of the slab.

Table 4. Critical data for first series of kenaf fiber reinforced concrete slab.

Specimen	Py (kN)	δy (mm)	Pu (kN)	δu (mm)	Pmax (kN)	δmax (mm)	μ= δu / δy
RC1-0	57.75	5.83	57.53	16.15	67.68	10.87	2.77
KF1-1	54.97	5.14	65.07	15.94	76.56	9.45	3.10
KF1-2	49.05	4.76	69.83	9.21	82.15	8.21	1.94

The load versus deflection curves for second series of slab and its respective key parameters are given in Figure 4 and Table 5, respectively. For this series, RC2-0 is considered as the control slab with 0% of fiber content and 20 mm reduction in slab thickness. KF2-1 and KF2-2 is the kenaf fiber reinforced concrete slab with 20 mm reduction in slab thickness added with 1% and 2% fiber content, respectively. From the figure, addition of fiber caused the slab to become stiffer as higher loading was required to induce first cracking and propagates the opening of the crack. As the amount of fiber increased, the load at yield and maximum load carrying capacity increases up to 26% and 9%, respectively. In term of ductility, an upward trend was observed with the incrementation of fiber content. The control slab failed in shear as designed, and inclusion of fiber improves the ductility of the slab, changing the failure mode to a more ductile manner.

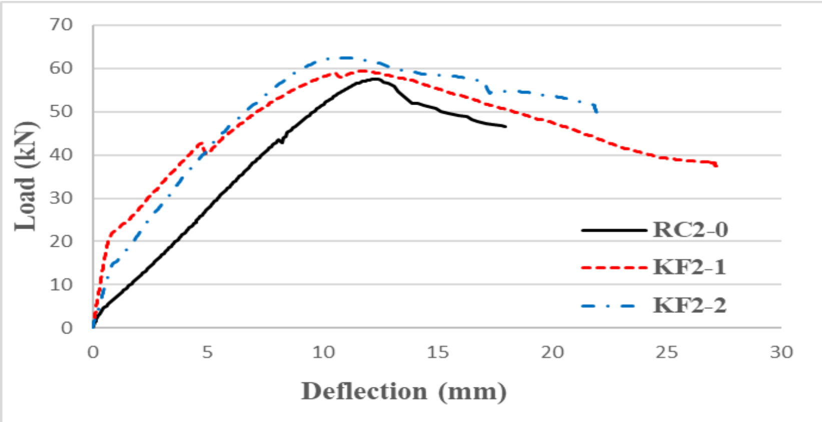

Figure 4. Load versus deflection curves for the second series of the slab.

Table 5. Critical data for second series of kenaf fiber reinforced concrete slab.

Specimen	Py (kN)	δy (mm)	Pu (kN)	δu (mm)	Pmax (kN)	δmax (mm)	μ= δu / δy
K2-0	43.53	8.12	49.21	15.93	57.50	12.46	1.96
K2-1	51.30	8.77	50.41	18.04	59.30	11.88	2.06
K2-2	54.80	8.68	52.70	19.98	62.53	10.68	2.30

Comparison of second series of slab with the control slab from the first series depicted that kenaf fiber was not able to fully compensate the loss in concrete shear capacity due to the thickness reduction. As can be seen in Table 5, the highest maximum load carrying capacity was 62.53 kN for KF2-2, which were about 8% lower than the control slab, RC1-0. Interestingly, the ultimate deflection of KF2-2 slab was 24% higher than the control slab (RC1-0), showing better ductility in the concrete structure.

3.3 Cracking pattern and mode of failure

Figure 7 shows the cracking pattern for the slabs at failure. In the first series of slab (K1), the cracking propagates at the mid-span, and for K1-2, due to higher dosage of fiber, the slab became stiffer and failed in shear-bending. For the second series of slab (K2), the slab failed in shear as intended design. This shows that, kenaf fiber have potential to improve the ductility of the structure and delayed the cracking propagation.

Specimen	Cracking pattern	Failure mode
K1-0		Bending
K1-1		Bending-Shear
K1-2		Shear-Bending
K2-0		Shear
K2-1		Bending
K2-2		Bending

Figure 5. Cracking pattern and failure mode of slab.

4. Conclusion

Based on the finding, it was observed that kenaf fiber have the capability to enhances the flexural strength of the slab, reduces the cracking propagation and improves the ductility of the reinforced concrete slab. However, the loss of the concrete shear capacity due to the reduction in the thickness of the slab was not compensate by the addition of kenaf fiber. This is probably due to insufficient treatment of the kenaf fiber. Further investigation can be carry out to improves the properties of the kenaf fiber so that it will performs better once added into concrete.

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References

[1] Hannant D J 2003 Fibre-reinforced concrete *Advanced Concrete Technology–processes* ed. J Newman and B S Choo (Oxford: Butterworth-Heinemann, Elsevier) chapter 6 pp 1 - 17
[2] Khaloo A R, Afshari M 2005 Flexural behaviour of small steel fibre reinforced concrete slabs, *Cem. and Concr. Compos.* **27** 141-149
[3] Ding Y, You Z, Jalali S 2011 The composite effect of steel fibres and stirrups on the shear behaviour of beams using self-consolidating concrete, *Eng. Struct.* **33** 107-117
[4] Minelli F, Conforti A, Cuenca E, Plizzari G 2014 Are steel fibres able to mitigate or eliminate size effect in shear?, *Mater. Struct.* **47** 459-473
[5] Baarimah A O, Syed Mohsin S M 2017 Behaviour of reinforced concrete slabs with steel fibers *IOP Conf. Ser.: Mater. Sci. Eng.* **271** 012099
[6] Swamy R N, Lankard D R 1974 Some practical applications of steel fibre reinforced Concrete, *Proc. of the Instit. of Civil Eng.* **56** 235-256
[7] Brandt A M 2008 Fibre reinforced cement-based (FRC) composites after over 40 years of development in building and civil engineering, *Compos. Struct.* **86** 3-9
[8] Mansur M A, Aziz M A 1982 A study of jute fibre reinforced cement composites, *Int. J. of Cem. Compos. and Lightweight Concrete* **4** 75-82
[9] Gouveia N D, Fernandes N A, Faria D M, Ramos A M, Lúcio V J 2014 SFRC flat slabs punching behaviour–Experimental research, *Compos. Part B: Eng.* **63** 161-171

[10] Elsaid A, Dawood M, Seracino R, Bobko C 2011 Mechanical properties of kenaf fiber reinforced concrete *Constr. and Build. Mater.* **25** 1991-2001
[11] Syed Mohsin S M, Azimi S J, Namdar A 2014 Behaviour of Oil Palm Shell Reinforced Concrete Beams Added with Kenaf Fibres. *In Appl. Mech. and Mater.* **567** 351-355
[12] Syed Mohsin S M, Manaf M F, Sarbini N N, Muthusamy K 2016 Behaviour of reinforced concrete beams with kenaf and steel hybrid fibre, *ARPN J. of Eng. and Appl. Sci.* **11** 5385-5390
[13] Li X, Tabil L G, Panigrahi S 2007 Chemical treatments of natural fiber for use in natural fiber-reinforced composites: a review *J. of Polym. and the Environ.* **15** 25-33
[14] Yousif B F, Shalwan A, Chin C W, Ming K C 2012 Flexural properties of treated and untreated kenaf/epoxy composites *Mater.and Des.* **40** 378-385
[15] Mahjoub R, Yatim J M, Sam A R M, Hashemi S H 2014 Tensile properties of kenaf fiber due to various conditions of chemical fiber surface modifications *Constr. and Build. Mater.* **55** 103-113