Behaviour of Isolated Footings Reinforced Randomly by Glass Fiber

Abstract

A fiber glass reinforced concrete (FGRC) is used for many structural elements due to its high mechanical properties, particularly flexural strength. As the concrete crack forming process accelerates and the probability of sudden fractures increases. There are various methods to strengthen this weakness of concrete. One of most common methods is use of randomly distributed fiber. Throughout this paper, two types of isolated footings were employed square and rectangular shape to experimentally investigate the tensile and fatigue properties of footings reinforced by fiber glass with a length of 18 mm. The reinforcements were utilized with a rate of (0.20, 0.30, 0.35, 0.40, 0.50 and 1.00%) of weight. The results of FGRC were compared with the reinforced steel concrete. The results revealed that FGRC has a positive effect on the tensile and fatigue properties of isolated footing, especially with higher percentage of used fiber glass.

Keywords: Fiber glass; Randomly distributed fibers; Tensile;Fatigue.

Introduction

Fiber glass reinforced concrete (FGRC) offered an economical alternative in situations where steel is expansive reinforcement. Such glass fibers can be used in a wide variety of end-use applications.

Several factors have contributed for the fiber glass, namely; manufacture facilities in terms of shape, size and finishing. In order to employ fiber glass material more efficiently to increase the elongation with a slight influence on stiffness the writers proposed an idea to reinforce concrete footings by fiber glass instead of steel bars.

Several researches have been reported in the literature to study the fiber glass reinforced concrete.

Ahmed H.Abdel-kareem. and et.al, (2019) presented an experimental study to investigate the behavior of reinforced concrete beams strengthened or repaired in flexure by adding thin lower concrete layer reinforced mainly by fiber reinforced polymers bars.

Rimvydas Moceikis and et.al, (2018) studied the long term strength retention of the glass fiber, existing experimental data of weathering tests and explained the main corrosion mechanisms.

S.A.Yildizel and et.al, (2018) studied glass fiber with the length of 6 mm during the mix design. Mechanical properties of micro glass fiber added concrete were investigated.

Asghar Vatani Oskouei and et.al, (2017) presented the results of an experimental study of structural lightweight concrete with glass fiber reinforcement bar for prefabricated single footing.

Sadik Alper Yildizel. (2017) replaced silica sand with barite sand and studied the mechanical properties of the composite in respect to flextural strength and resistance properties.

K.I.M.Ibrahim (2016) compared the results of GFRC with plain concrete and validated the positive effect of glass fibers with percentage increase in compression, splitting and flexure improvement of specimens.

Philipp Lober and Klaus Holschemacher (2014) studied the classification and specification of glass fiber reinforced concrete to deal if it is suited for use in load – bearing members.

Shrikant M. Harle (2014) studied the effect of glass fibers as reinforcement in the concrete for different proportions.

Pshtiwan N. Shakor and S. S. Pimplikar (2011) studied the trail tests for concrete with glass fibre and without glass fibre are conducted to indicate the differences in compressive strength and flexural strength by using cubes of varying sizes.

1. Material and Methods

Two types of isolated footings square and rectangular shape were used. For each type, a fiber glass was employed instead of steel bars with a percentage of 0.20, 0.30, 0.35, 0.40, 0.50, and 1.00% from the weight.

1.1 Fiber Glass

In this paper, one type named (E6-CR) with vinyl ester resin in size 18 mm lengths was used. The (E6-CR-18-M) is chopped from (E6-CR) glass fiber coated with silane-based sizing, and compatible with unsaturated polyester, vinyl ester, epoxy resin and systems and designed for compression molding process, Table (1). The (E6-CR) is low static, low fuzz, good dispersion in results, low viscosity, excellent flow ability of the prepreg, good processing and excellent mechanical properties, Fig. (1)

Table (1) Technical parameters of fiberglass

Chopped Strands	Chop Length (mm)	Moisture Content (%)	LOI Content (%)
CS	Q/JS J0351	ISO 3344	ISO 1887
	± 1.5	≤ 0.10	1.25 ± 0.15

Fig (1) Used fiber glass

1.2 Cement

Ordinary Portland cement has been used in this study.

1.3 Aggregates

The fine and coarse aggregates were used form the availability local, Fig. (2)

Fig (2) used coarse aggregate

1.4 Water

Normal drinking water that available in the laboratoryof concrete was utilized to cast the concrete samples.

1.5 Steel

In the present study, mild steel diameter of 8 mm was used.

1.6 Strain gauges

Strain gauges were used to estimate the strain in the tested footing under different loads. The applied strain gauges were branded as Tokyo Sokki Kenkyu Co., Ltd., Fig. (3).And its characteristics are given in Table (2).

Table (2) Strain gauges characteristics

Type	PL-6D-11-1L
Gauge Length	60 mm
Gauge Factor	2.13 ±1%
Gauge Resistance	120.3±0.5Ω
Transverse Sensitivity	0.8%

Fig (3) applied strain gauges

2. Concrete footing models

Models of square footings of (30.5 x 30.5 x 3.20) cm and rectangular footings of dimensions (30.5 x 45.5 x 3.20) cm were considered. Seven mixes were prepared for both square and rectangular footings. One mix reinforced by mild steel without using any fiber glass, Figs. (4) and (5). Six mixes reinforced by fiber glass with different percentage of footing volume as shown in Table (3).

Table (3) Casting schedule and details of tested models

Footing Shape	Model NO.	ReinforcedMaterial	Percentage of Reinforced Material
Square	S1	Steel	$3\phi8$ In two sides
Square	S2	Fiber	0.20%
Square	S3	Fiber	0.30%
Square	S4	Fiber	0.35%
Square	S5	Fiber	0.40%
Square	S6	Fiber	0.50%
Square	S7	Fiber	1.00%
Rectangular	R1	Steel	$3\phi8$ In two sides
Rectangular	R2	Fiber	0.20%
Rectangular	R3	Fiber	0.30%
Rectangular	R4	Fiber	0.35%
Rectangular	R5	Fiber	0.40%
Rectangular	R6	Fiber	0.50%
Rectangular	R7	Fiber	1.00%

Fig (4) Rectangular footing model with steel reinforcement

Fig (5) Square footing model with steel reinforcement

2. Experimental setup

A steel container with a dimension of (1.50 x 1.50 x1.50) m was used and filled by coarse aggregates, Fig. (6)

Fig (6) Steel Container

The concrete footing was placed in center of container and loaded by a hydraulic jack of steel frame in concrete laboratory of Benha faculty of Engineering, Benha university, Fig. (7)

All concrete footings were cast vertically in the formsand was mechanically compacted using vibrator to compact the concrete inside the forms.

After 28 days the models were tested by loading up to failure, Figs. (8) to (10)

Fig (7) Dial gauge of the hydraulic jack of loading

Fig (8) Test setup

Fig (9) Adjustment of load

Fig (10) Loading the model of footing

Fig (11) loading frame

Results and discussion

1. Strain-Load Relationship

The results of each reinforced footing model are depicted in Figs. (12) and (13).

1. For square and rectangular footing models, the carrying loads and strain values increased with increasing the fiber glass ratio. However, the results were more significant in rectangular footings than the square.
2. Results were approximately closed to (0.002) um/m` strain value in square footing and (0.005) um/m strain value in rectangular footing.

3. In square and rectangular footings, the steel reinforced produced more higher values of strength than the fiber glass with percentage of 0.30%.Whilst, the steel reinforced results were close to the fiber glass with a ratio of 0.35%.
4. For all considered footing models, the used fiber glass with a ratio more than 0.35%, gave results better than the models reinforced by the steel bars.

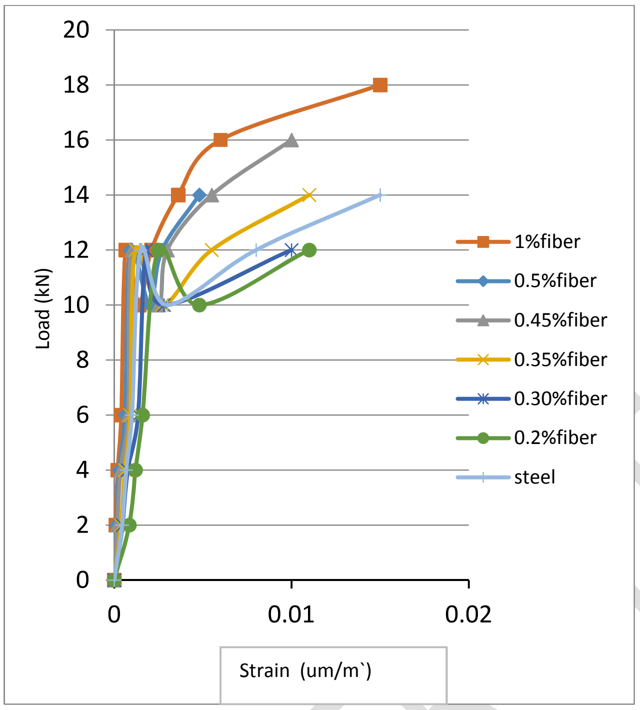

Fig (12.a) Square Footing

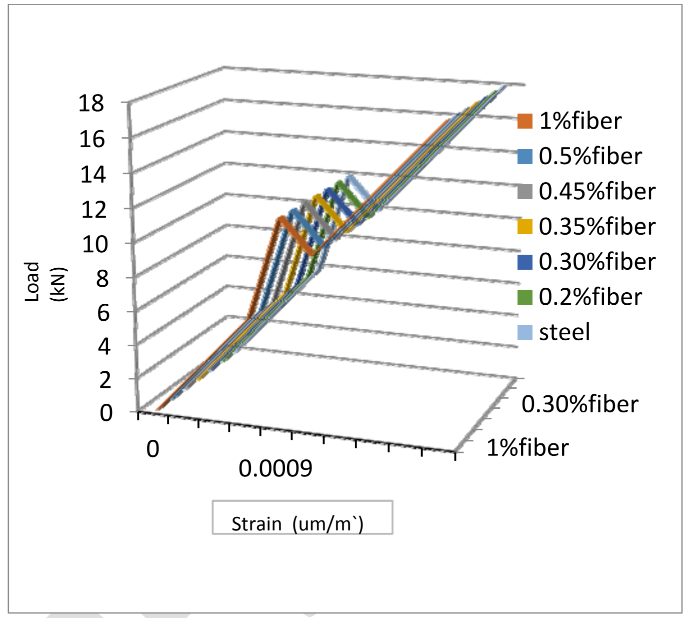

Fig (12.b) Square Footing

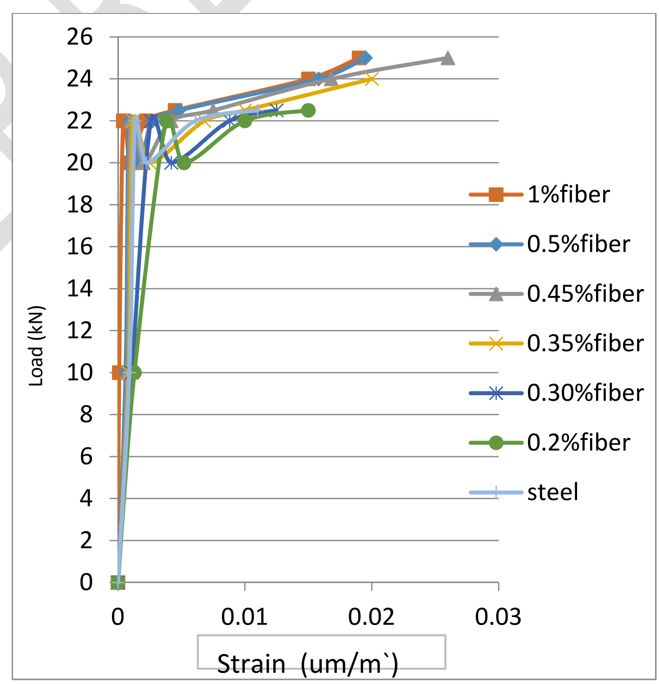

Fig (13.a) Rectangular Footing

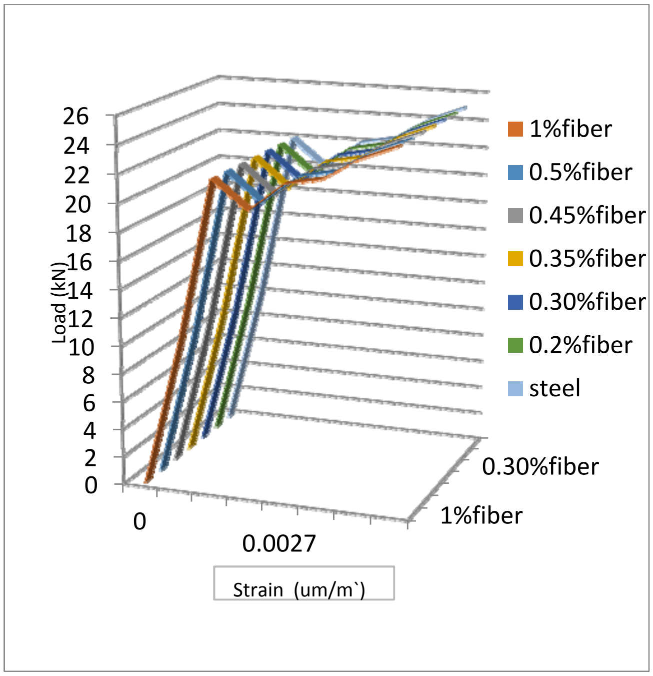

Fig (13.b) Rectangular Footing

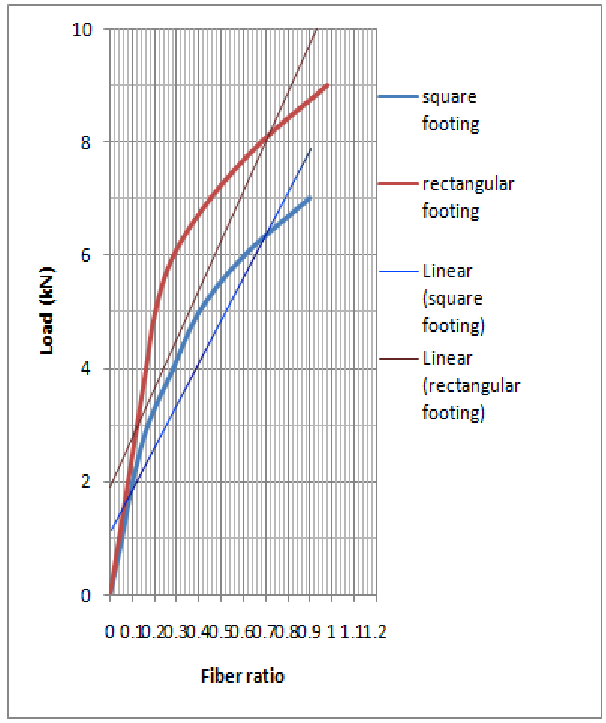

Fig (14) First Crack (start of failure) linear between load of first crack and fiber ratio

2. Starting of failure

Appearance of first crack is considered the starting of failure of footings. The results of first crack appearance for reinforced footing models are plotted in Fig. (14).

First cracks or starting of failure for square and rectangular footing models were appeared at a ratio of 0.2% fiber glass. For square and rectangular footings, the steel reinforcement produced higher values of strength than the fiber glass with percentage up to 0.30%.Whilst; the steel reinforced results were close to the fiber glass with a ratio of 0.35% of concrete volume.

3. Correlation between the carrying load and fiber ratio

Using the results of this study, the carrying load of footing and fiber ratio can be empirically correlated with experimental limitations as follows:

$y = (8.728x) + 1.890$ (for rectangular footing)

$y = (7.523x) + 1.148$ (for square footing)

where:

y = load (kN)

x = fiber ratio

Conclusion

In this study isolated footings randomly reinforced by different percentage of glass fiber have been evaluated. Based on experimental results, it is concluded that use of certain percentage glass fibers as reinforcement instead of steel increased the carrying load of footing. For square and rectangular footings, the steel reinforcement produced higher values of strength than the fiber glass with percentage up to 0.30%.Whilst; the steel reinforced results were close to the fiber glass with a ratio of 0.35%. The increase in compressive and flexural strengths obtained with the ratio of fiber more than 0.50% of concrete volume. An empirical formula between carrying load and fiber ratio were presented for both square and rectangular footings.

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