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Performance of Isolated Footings Reinforced Randomly by Glass Fiber

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Authors' contributions

This work was carried out in collaboration between both authors. Author EEK designed the study concept, wrote the protocol and revised the paper. Author MFAB discussed the study concept, executed the experiments, managed the analyses of the study, managed the literature searches and wrote the paper. Both authors read and approved the final manuscript.

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ABSTRACT

Fiber glass reinforced concrete (FGRC) is used form any 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 were various methods to eliminate this weakness of concrete. One of most common methods was employed of randomly distributed fiber. In this paper, two types of isolated footings were utilized, square and rectangular shape reinforced by a fiber glass with a length of 18 mm and having a rate of (0.20, 0.30, 0.35, 0.40, 0.50 and 1.00%) of weight, to experimentally investigate the tensile and fatigue properties of footings 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.

1. INTRODUCTION

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

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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 authors proposed an idea to reinforce concrete footings with fiber glass instead of steel bars.

Several articles have been reported in the literature in this regard. Abdel-kareem et al. [1] 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.

Moceikis et al. [2] studied the long-term strength retention of the glass fiber, existing experimental data of weathering tests and explained the main corrosion mechanisms.

Yildizel et al. [3] studied glass fiber with the length of 6 mm during the mix design. Mechanical properties of micro glass fiber added concrete were investigated.

Oskouei et al. [4] presented the results of an experimental study of structural lightweight concrete with glass fiber reinforcement bar for prefabricated single footing.

Yildizel [5] replaced silica sand with barite sand and studied the mechanical properties of the composite in respect to flexural strength and resistance properties.

Ibrahim [6] 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.

Lober and Holschemacher [7] studied the classification and specification of glass fiber reinforced concrete to deal if it is suited for use in load – bearing members.
Harle [8] studied the effect of glass fibers as reinforcement in the concrete for different proportions.

Shakor and Pimplikar [9] studied the trail tests for concrete with glass fibre and without glass fiber are conducted to indicate the differences in compressive strength and flexural strength by using cubes of varying sizes.

2. MATERIALS AND METHODS

Two types of isolated footings square and rectangular shapes 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% of weight.

In this investigation, a type named (E6-CR) with vinyl ester resin of 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 flowability, good processing and excellent mechanical properties, Fig. 1.

Normal drinking water of 95 ppm salt content that available in the laboratory of concrete was utilized to cast the concrete samples.

In the present study, mild steel diameter of 8 mm was used. Ordinary Portland cement has been used in this study. The fine and coarse aggregates were used form the availability local, Fig. 2.

Fig. 1. Used fiber glass

Fig. 2. Used coarse aggregate

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.

2.1 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. Concrete mix containing (350 kg cement + 0.80 m^3 coarse aggregate + 0.40 m^3 fine aggregate/m^3). One mix reinforced by mild steel without using any fiber glass, Figs. 4-5. Six mixes reinforced by fiber glass with different percentage of footing volume as shown in Table 3.

Fig. 3. Applied strain gauges

2.2 Experimental Setup

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

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 forms and 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 -10.

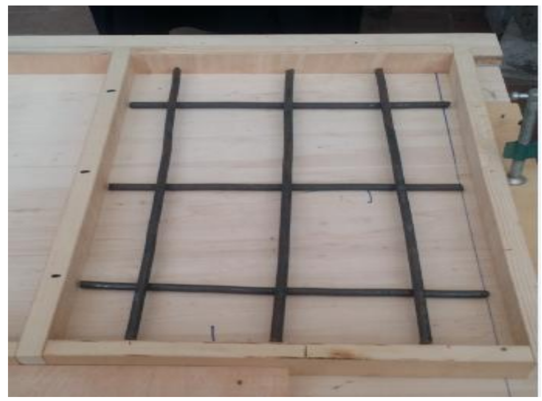

Fig. 4. Rectangular footing model with steel reinforcement

Fig. 5. Square footing model with steel reinforcement

Table 1. Technical parameters of fiberglass

Chopped strands	Chop length(mm)	Moisture content(%)	LOI content (%)
CS	Q/JS J0351 ± 1.5	ISO 3344 ≤ 0.10	ISO 1887 1.25 ± 0.15

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%

Table 3. Casting schedule and details of tested models

Footing Shape	Model NO.	Reinforced Material	Percentage of Reinforced Material
Square	S1	Steel	3ϕ8 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	3ϕ8 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. 6. Steel container

Fig. 7. Dial gauge of the hydraulic jack of loading

Fig. 8. Test setup

Fig. 9. Loading the model of footing

Fig. 10. loading frame

3. RESULTS AND DISCUSSION

3.1 Strain-load Relationship

The results of each reinforced footing model are depicted in Figs. 11 and 12.

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% with absolute error of AE = 2.8 %. Whilst, the steel reinforced results were close to the fiber glass with a ratio of 0.35%.

For all considered footing models, the used fiber glass with a ratio more than 0.35% with AE of 3.3%, gave results better than the models reinforced by the steel bars.

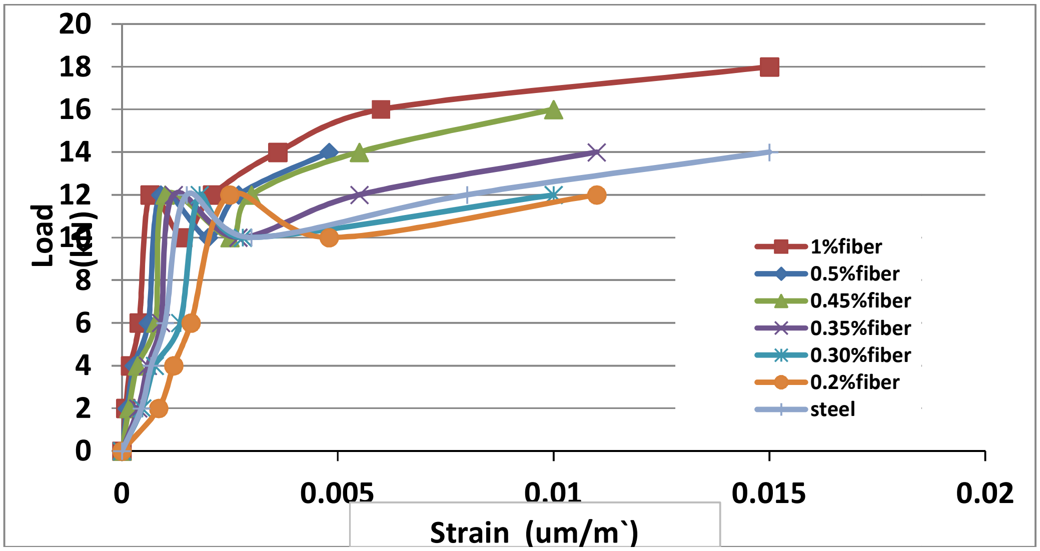

Fig. 11.a. Square footing

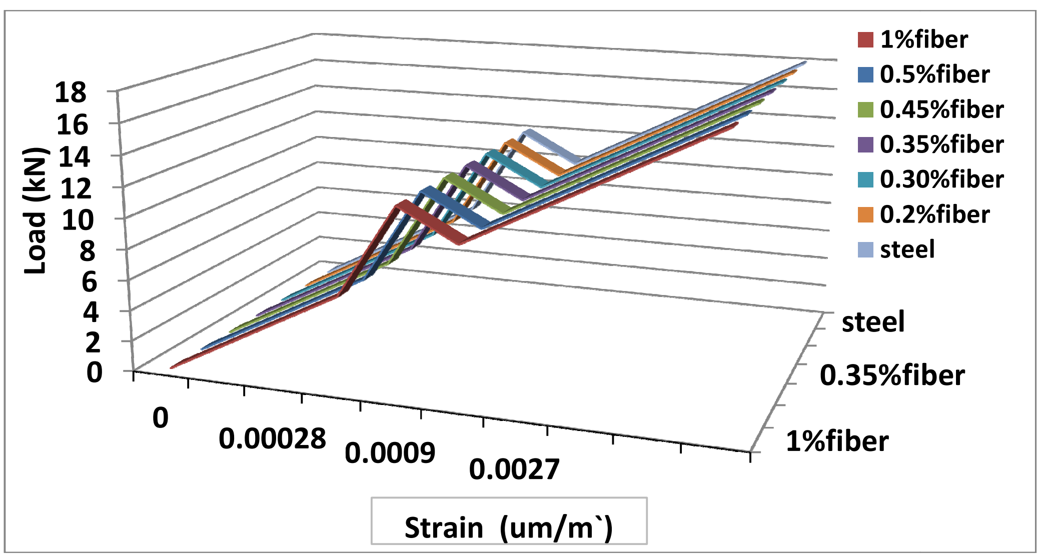

Fig. 11.b. Square footing

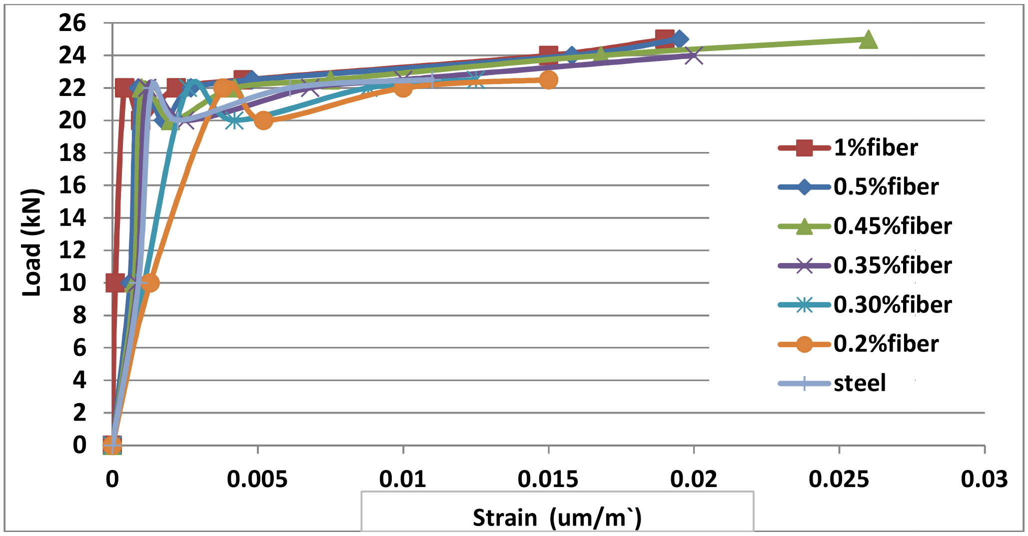

Fig. 12.a. Rectangular footing

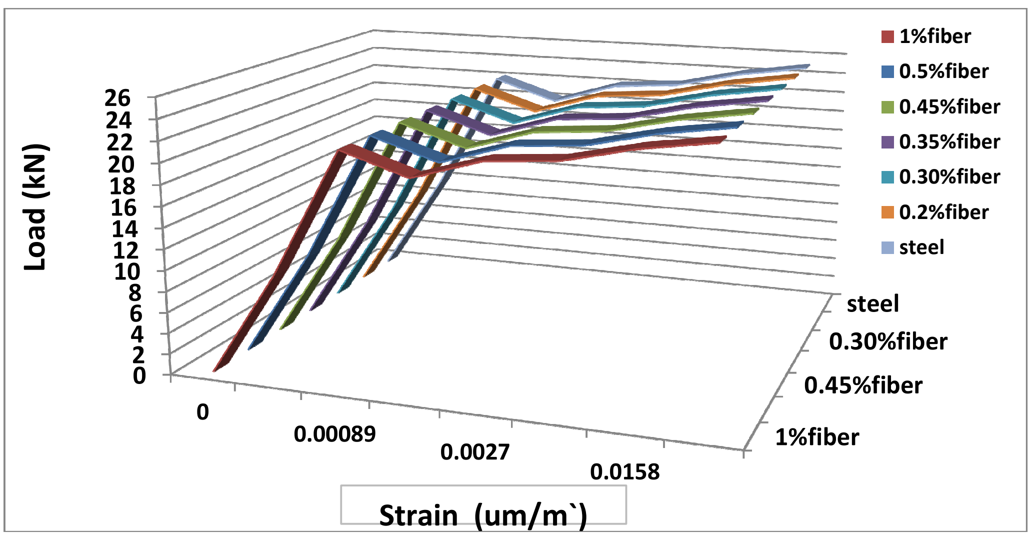

Fig. 12.b Rectangular footing

3.2 Starting of Failure

Appearance of first crack was considered the starting of failure of footings. The results of first crack appearance for reinforced footing models are plotted in Fig. 13.

First cracks or starting of failure for square and rectangular footing models appeared at a ratio of 0.2% fiber glass with AE of 2.3%. For square and rectangular footings, the steel reinforcement produced higher values of strength than the fiber glass with percentage up to 0.30% with AE of 3.1%. Whilst, the steel reinforced results were close to the fiber glass with a ratio of 0.35% of concrete volume with AE of 3.6%.

3.3Correlation 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), limitation (0.20 -1) % of wt.
x = fiber ratio limitation (0.20 -1) % of wt.

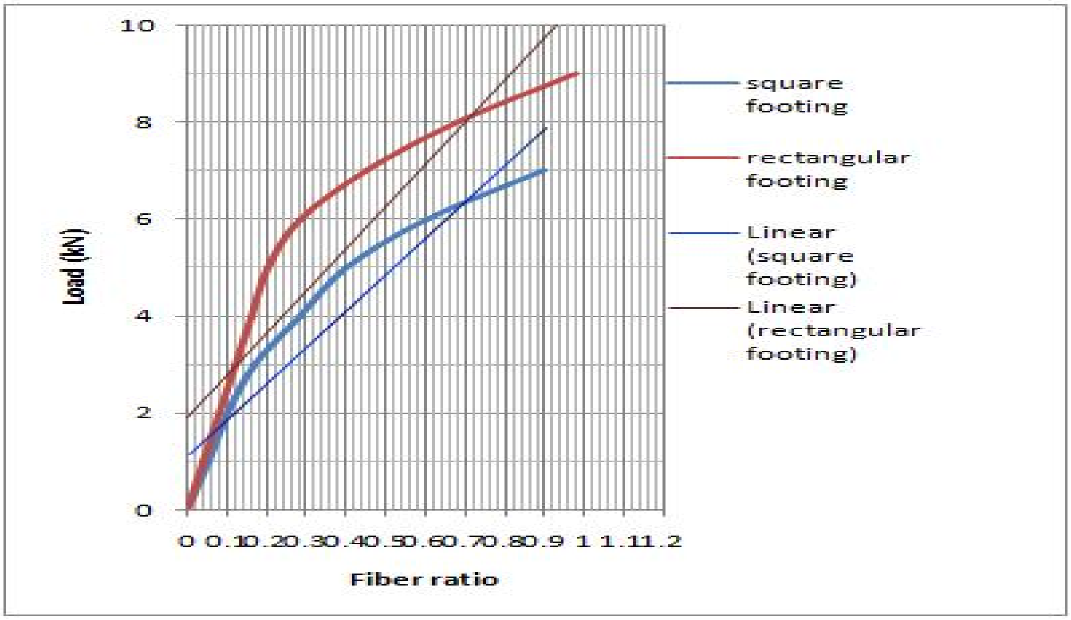

Fig. 13. First Crack (start of failure) linear between load of first crack and fiber ratio

4. CONCLUSIONS

In this study isolated footings randomly reinforced by different percentage of glass fibers had been evaluated. Based on the experimental results, it was concluded that, using of certain percentage glass fibers as reinforcement instead of a 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% with absolute error of 2.8. Whilst, the steel reinforced results were close to the fiber glass with a ratio of 0.35% with absolute error of 3.3%. The increasing in compressive and flexural strengths obtained with a ratio of fiber more than 0.50% with absolute error of 4.3%. of concrete volume. Empirical formulae were developed to correlate the relationship between the carrying load and fiber ratios for both square and rectangular footings.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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