Journal of Engineering Research and Reports

Volume 25, Issue 7, Page 82-93, 2023; Article no.JERR.102664
ISSN: 2582-2926

Fabric-structural Parameters Affecting the Mechanical Properties of Fabric-cement Composites

Eman Eltahan [a++*]

[a] *Textile Engineering Department, Faculty of Engineering, Alexandria University, Alexandria, Egypt.*

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/JERR/2023/v25i7941

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/102664

Original Research Article

Received: 10/05/2023
Accepted: 18/07/2023
Published: 03/08/2023

ABSTRACT

This research work studies the effects of fabric structure on the mechanical properties of fabric cement composites. Seven fabric structures from the same fabric material were used. In this work different sets of specimens were made with different fabric layers after that these specimens were tested on tensile, bending and compression testing machines. It was found that the mechanical properties of the composite materials were influenced by the properties of the reinforced fabric. Fabric tensile strength, which is determined by the fabric's structure, construction, and the number of reinforced fabric layers, is the key factor influencing both tensile and flexural strength of the cement composites. Additionally, when the number of fabric layers increases, some attributes of composites, such as tensile and bending strength, increase while compressive strength decreases.

Keywords: Cement composites; fabric layers; composite properties; fabric structure.

[++] *Professor of Textile Engineering;*
**Corresponding author: Email: eman_eltahan@yahoo.com;*

1. INTRODUCTION

In recent years, there have been an increase in interest in the use of textile materials as reinforcement for cement and concrete elements for a variety of applications, including thin elements, lightweight goods, repair, strengthening, and pre-stressed concrete components [1,2]. The potential of textile composites as a strengthening material for numerous issues linked with the deterioration of infrastructures is now being recognized by civil engineers and the construction industry.

Because of their excellent technical qualities, fibre reinforced polymer composites (FRPCs) have become more widely used in the construction sector during the past decades. According to Sandeep et al. [3], there are numerous aspects of FRPC materials, including guidelines for the selection of polymer adhesives for concrete, which have been highlighted by ACI Committee-503 [4] and Uomoto et al. [5]. Additionally, these are being considered as an alternative to conventional steel in reinforced concrete structures due to the continuing decline in the cost of FRPC materials. Karbhari [6] has also highlighted issues pertaining to material selection.

A description of FRPC material uses in civil engineering has been provided by Einde et al. [7] and Bank et al. [8], while general design recommendations for FRPC applications may be found in Bakht et al. [9], ACI Committee 440 [10], and Nanni [11].

Recently, a number of researchers revealed highly encouraging findings about materials made of cement that were reinforced with textile materials. The validity of employing untreated Bamboo with a natural fabric, as reinforcement for concrete beams and slabs was investigated by the [12 and 13]. It was discovered that while bamboo is not suitable for use in concrete beams in its natural, untreated state, it is a potential reinforcement material for concrete slabs. They also looked into the idea of reinforcing concrete slabs with High Tenacity Polyester (HTPET) net fabric, an industrial fabric [13]. In light of the capacity and crack propagation, the results indicate extremely good progress.

R.C. slabs can be successfully strengthened using the novel local composite fabric. Because woven frameworks were used, several weft kinds with diverse purposes may be used [14]. The purpose of this study is to investigate how the fabric structure and the amount of fabric layers affect the behavior of fabric-cement composite parts through an experimental design.

2. METHODS

The properties of the final product from fabric cemented composites depend mainly on fabric material and fabric structure, therefore in this work the same fabric material will be used and the final mechanical properties will be measured to show the effect of the fabric structure.

1. Cotton woven fabrics with different seven fabric structures will be used in the work:

a. Warp rib weave 2*2
b. Weft rib weave 2*2
c. Weft rib weave 4*4
d. Twill 2/2
e.8H-Satin
f. Honey comb
g. Crepe

The above mentioned fabrics have the following specifications:

$$62'',\ \frac{56*56}{24/2*24/2}$$

And total number of ends =3473 with reed number 14/4ends/dent

2. Ordinary Portland cement, CIM.I (42.5 N) Produced by Alex. Portland cement Company.

2.1 Tensile Strength of Fabrics

The tensile strength of the used fabrics in cement composites was measured. Tests were carried out on a fabric tensile testing machine according to ASTM [15] in textile testing laboratory of Faculty of Engineering.

2.2 Preparations of Fabric Cement Composites

Different types of composite specimens from cement and fabrics with different types of structure and materials were prepared with one, two and three layers of fabrics. These composite specimens were made by hand lay-up of the fabrics in 4:10 water to cement ratio paste matrix (water and cement). The fabric layers were placed in the molding box at equal distances from each other using a ruler to adjust the spaces between the layers. Another set of specimens were prepared without fabric (water and cement only) three specimens were made for each type of test according to ASTM [16] with different dimensions according to the stander test. These specimens were molded and cured under water at 20 °C for up to seven days, and the tensile, bending and compression properties were evaluated.

2.2.1 Dimensions of specimens for tensile test

All specimens for tensile test were 5 mm thickness, with lengths and widths of 150 and 25 mm, respectively.

2.2.2 Dimensions of specimens for bending test

All specimens for bending test were 40 mm thickness, with lengths and widths of 163 and 40 mm, respectively.

2.2.3 Dimensions of specimens for compression test

All specimens were a cubic shaped with 50 X 50 X 50 mm according to ASTM [17].

2.3 Instruments for Testing Specimens

2.3.1 Tensile test

The tensile properties of the fabric-cement composites were determined; test was carried out in a fabric tensile testing machine at rate of extension 1mm/sec.

2.3.2 Bending test

The flexural properties of the fabric-cement composites were determined; the test was carried out on a bending testing machine as shown in Fig. 1 at a span of 150 mm.

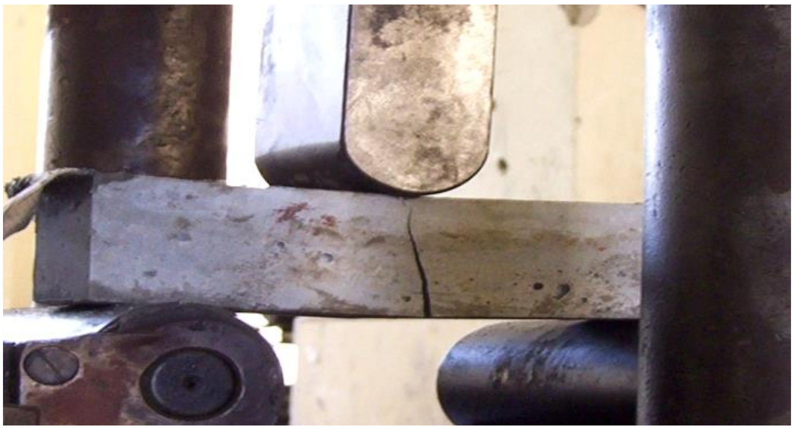

Fig. 1. Bending specimen after loading

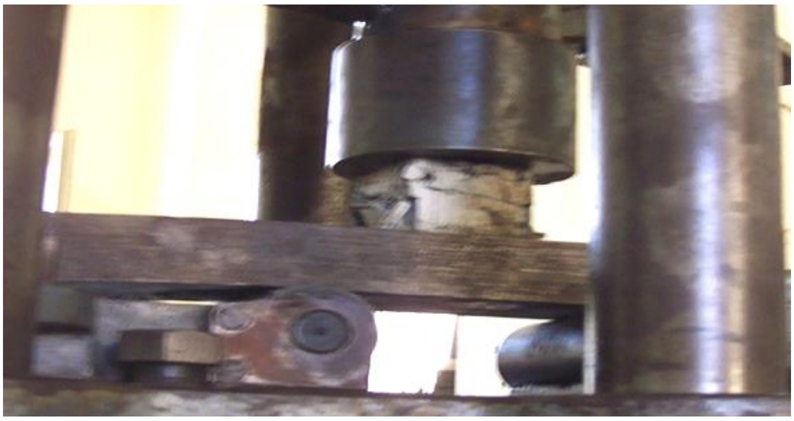

Fig. 2. Compression specimen after rapture

2.3.3 Compression test

The compressive strength of the fabric-cement composites were determined; the test was carried out in a compression testing machine as shown in Fig. 2.

3. RESULTS AND DISCUSSION

Fig. 3 and Fig. 4 show the influence of the different woven fabric structure on fabric tenacity in (gm/tex) and fabric breaking force in (N).

It is clear from the two above mentioned figures that, in all cases the greater the number of interlacing the lower is the breaking force of woven fabric. These results can be physically explained that, the mobility of yarns in the fabric depends on the number of intersections and weave float which can be gathered and support each other to share the tensile load applying on the fabric. Therefore because of 8-H satin has the highest float with fewer intersections so it bears higher tensile strength i.e. its yarns will be more in numbers to share the tensile load compare to other weaves, in those each yarn works individually to bear the load and hence it fails at low tensile strength. As well as the intersection points work as stress concentration and gripping points which increase the effect of loading and decrease the strength required for tensile failure.

3.1 Tensile Property of Fabric Cement Composites

Fig. 5 shows the effect of different fabric designs with one fabric layer on the tensile strength of fabric cemented composites. The amount of tensile strength depends on fabric properties and mainly its tensile strength which depends on its structure. As mentioned before that the greater the number of intersections per unit area the lower is the tensile strength or in other wards the longer the yarn float the greater is the tensile strength. These results confirm the physical explanation of the mobility of the yarn in the fabric, because 8H- satin gives higher tensile strength than other fabric designs.

Generally speaking is that, the higher the fabric strength, the higher is the composite tensile strength.

Figs. 6 to 12 show the effect of the number of fabric layers of different fabric structures on the tensile strength of the cemented composites. It is clear from these figures that the higher the number of the fabric layers the higher is the tensile strength.

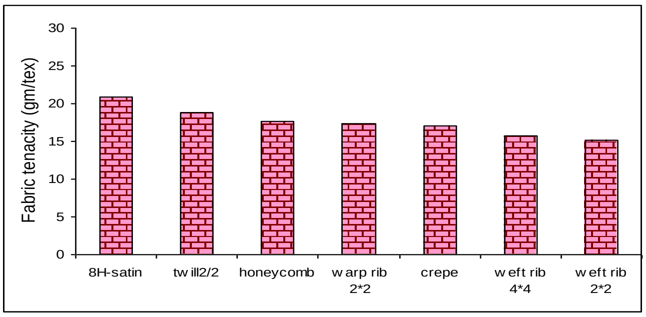

Fig. 3. Influence of fabric structure on fabric tenacity (gm/tex)

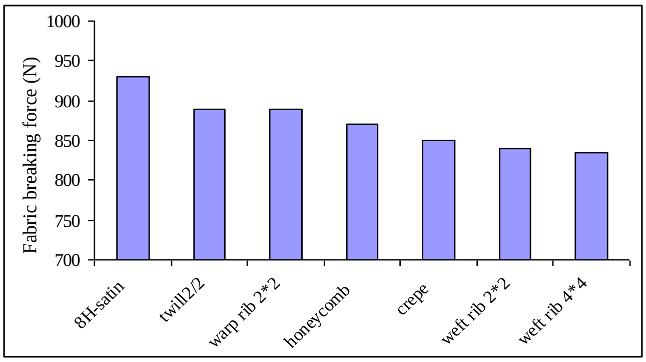

Fig. 4. Influence of fabric structure on fabric breaking force

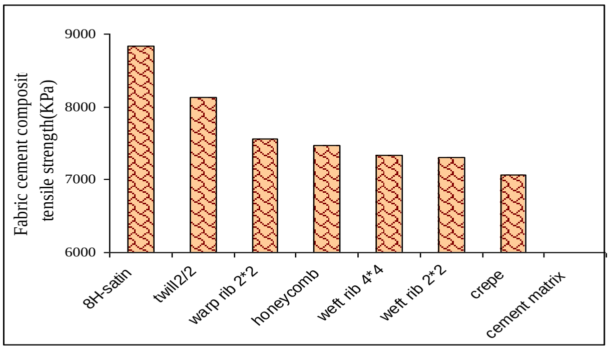

Fig. 5. Influence of fabric designs in fabric-cement composites on the tensile strength

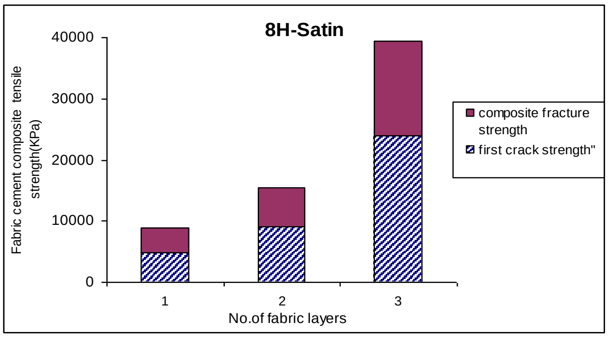

Fig. 6. Influence of number of fabric layers of 8-H satin cement composites on tensile strength

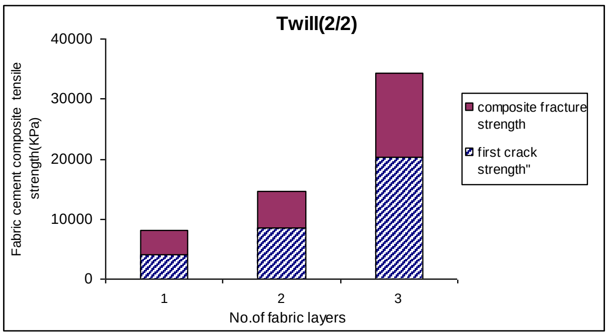

Fig. 7. Influence of number of fabric layers of twill (2/2) cement composites on tensile strength

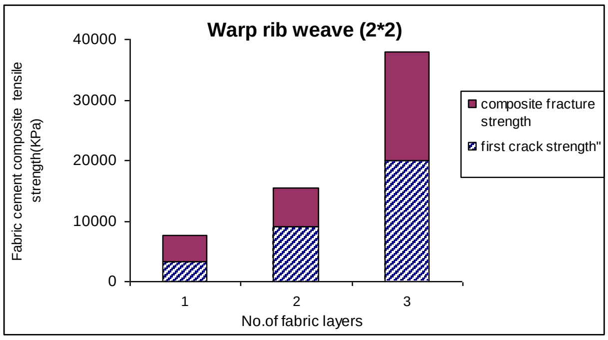

Fig. 8. Influence of number of fabric layers of warp rib weave (2*2) cement composites on tensile strength

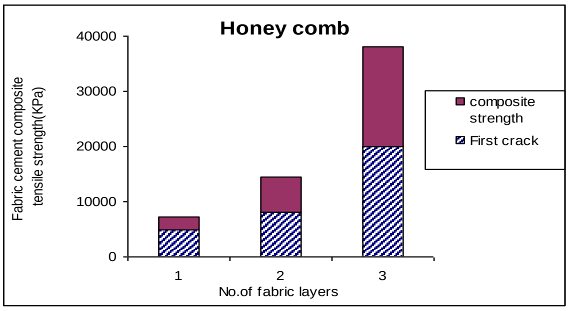

Fig. 9. Influence of number of fabric layers of honey comb cement composites on tensile strength

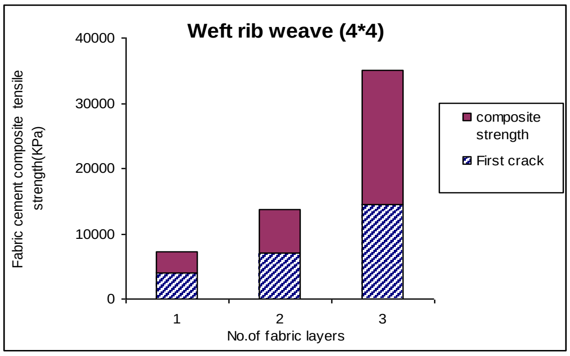

Fig. 10. Influence of number of fabric layers of weft rib weave (4x4) cement composites on tensile strength

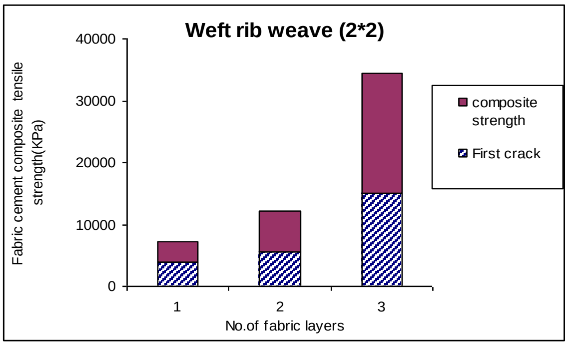

Fig. 11. Influence of number of fabric layers of weft rib weave (2x2) cement composites on tensile strength

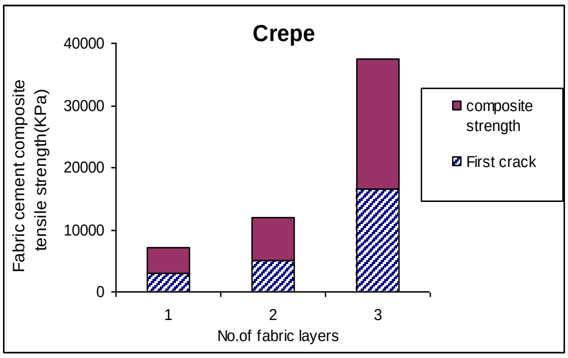

Fig. 12. Influence of number of fabric layers of crepe cement composites on tensile strength

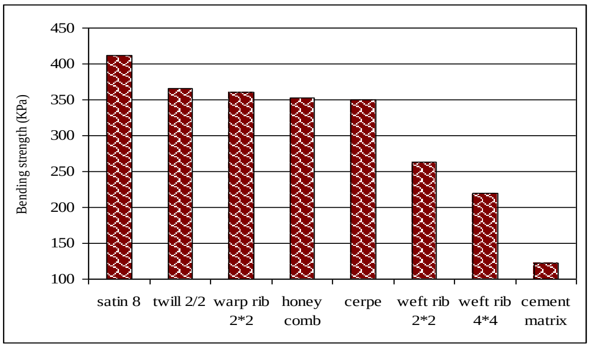

Fig. 13. Influence of fabric structure on the flexural strength of fabric-cement composites comparing with the flexural strength of the cement matrix

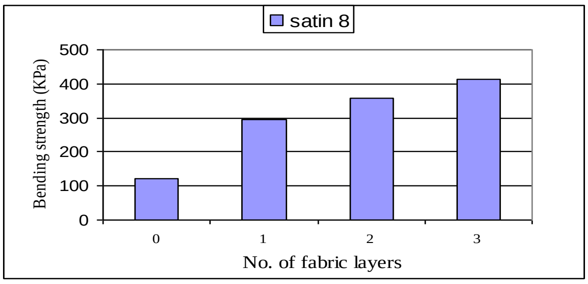

Fig. 14. Influence of number of fabric layers from 8-H satin on flexural strength of cement composites

Fig. 15. Influence of number of fabric layers from twill 2/2 on flexural strength of cement composites

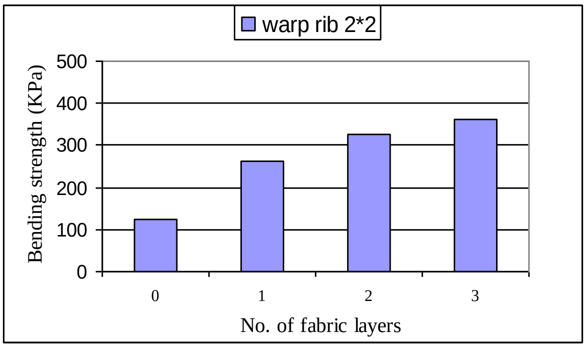

Fig. 16. Influence of number of fabric layers from warp rib weave 2*2 on bending strength of cement composites

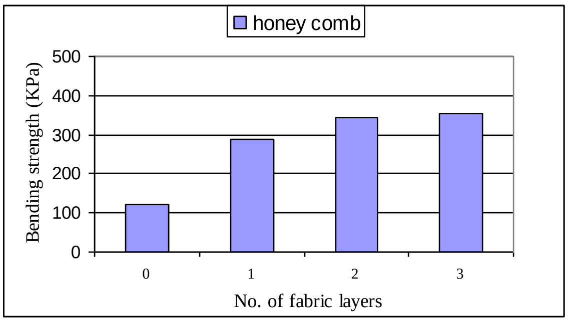

Fig. 17. Influence of number of fabric layers from honey comb on bending strength of cement composites

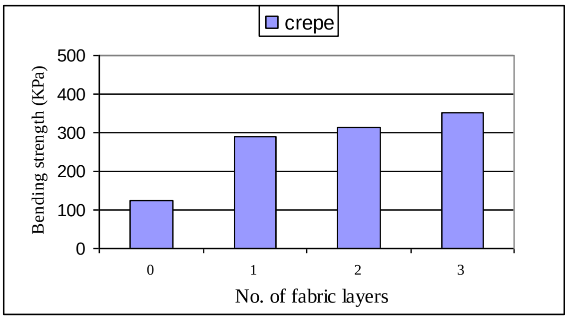

Fig. 18. Influence of number of fabric layers from crepe on bending strength of cement composites

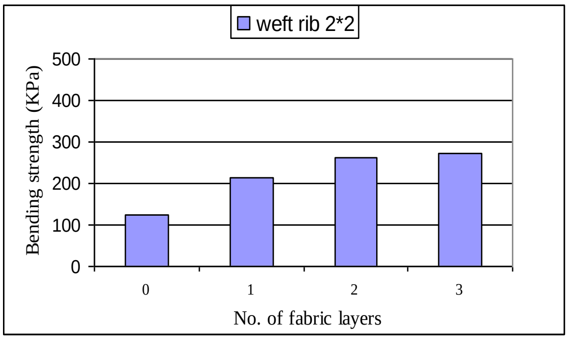

Fig. 19. Influence of number of fabric layers from weft rib weave (2x2) on bending strength of cement composites

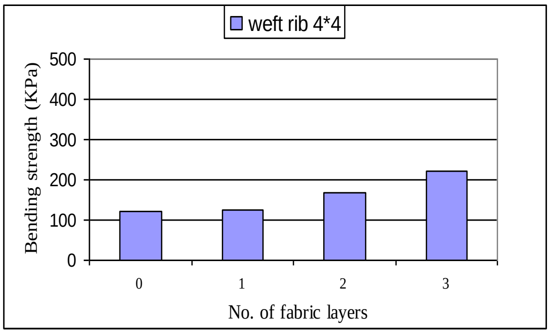

Fig. 20. Influence of number of fabric layers from weft rib weave (4x4) on bending strength of cement composites

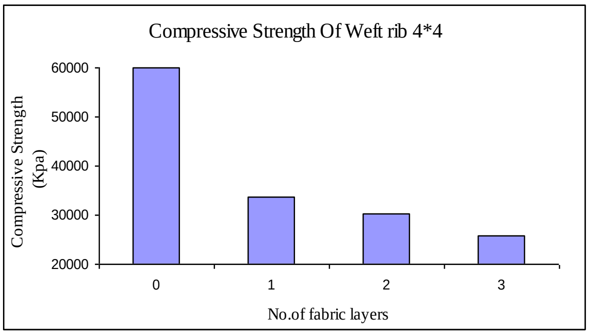

Fig. 21. Influence of number of fabric layers from weft rib weave (4x4) on compression strength

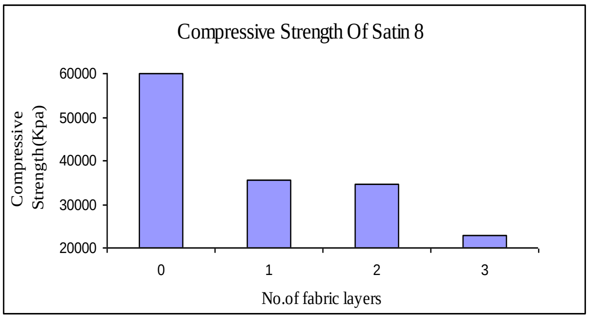

Fig. 22. Influence of number of fabric layers from 8-H Satin on compression strength

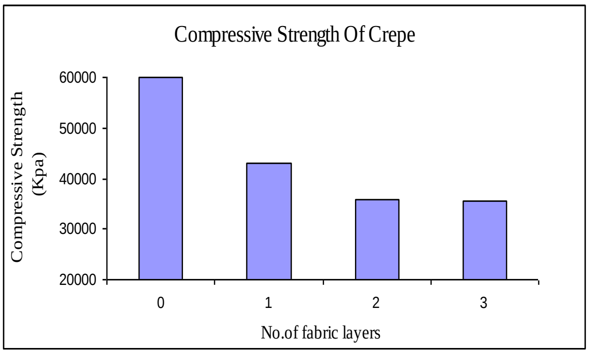

Fig. 23. Influence of number of fabric layers from crepe on compression strength

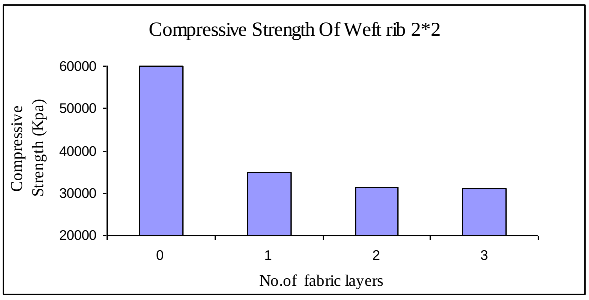

Fig. 24. Influence of number of fabric layers from weft rib weave (2x2) on compression strength

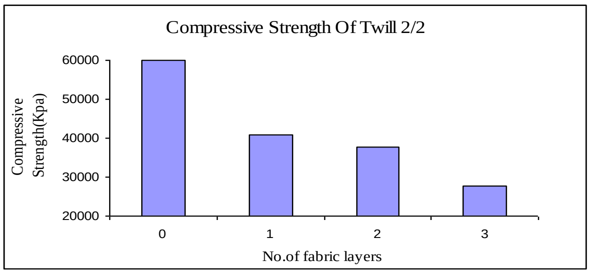

Fig. 25. Influence of number of fabric layers from Twill (2/2) on compression strength

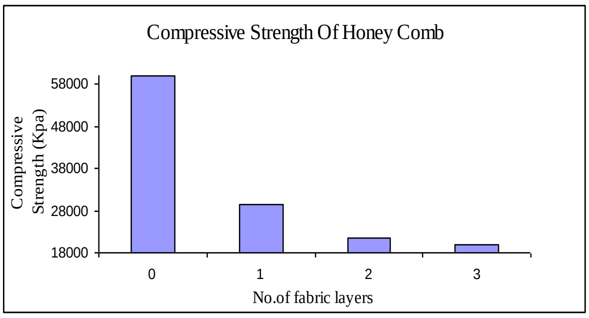

Fig. 26. Influence of number of fabric layers from honey comb on compression strength

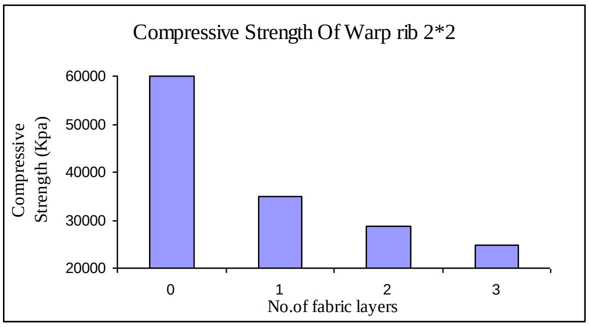

Fig. 27. Influence of number of fabric layers from warp rib weave (2x2) on compression strength

3.2 Bending Property of Fabric Cement Composites

Fig. 13 illustrates the effect of fabric structure on the flexural strength of fabric-cement composites at the same number of fabric layers (one layer) in comparing with the flexural strength of the cement matrix. From the figure the flexural performance of fabric–cement composites is influenced by fabric geometry. Fabrics with higher number of intersections per unit area have the lower flexural strength. This is because the higher number of intersections means that the yarns are more crimped and when the load is applied, the crimped yarns begin to be straight and the fabric becomes extensible and cannot bear a high load.

Also it was observed that a number of cracks appear when a small load applied on it. But if the fabric has a low number of intersections per unit area it will be less extensible and it can bear higher load because it is already tensioned. Therefore the lower the number of intersections per unit area the higher is the flexural strength of fabric-cement composites. Then it can be explained that the load is applied on two parts one of them is extensible (fabric) and the other is inextensible (cement), and the less fabric extensibility the higher is the bending strength of the fabric composite material. The flexural performance of fabric-cement composites is not only influenced by fabric structure but also by the number of fabric layers which reinforce the cement.

The Figs. 14 to 20 present the effect of the number of fabric layers on the flexural strength of fabric- cemented composites for each fabric structure. As shown the higher the number of the fabric layers the higher is the flexural strength.

3.3 Compression Property of Fabric Cement Composites

Un-reinforced cement has high compressive strength Figs. 21 to 27, because the bonds between cement grains are very strong. Fabrics have different structures and different numbers of layers are added to the cement. The results are compared with the results of the cement without fabrics to represent the effect of the fabric structures and fabric layers which added to the cement composite.

Figs. 21 to 27 illustrate the effect of number of fabric layers on the cement compressive strength for different fabric structures. It is clear that the higher the number of the fabric layers the lower the compressive strength.

These results are on the contrary in the case of tensile and bending strength as discussed before because the original compressive strength of the cement is very high and also the bonds between its grains are very strong, by adding one or more number of fabric layers the results were unsatisfactory, these results due to the isolation in cement grains and the presence of fabric make as insulator between the grains and so the bonds between it become weaker than without fabrics. By increasing the number of fabric layers, the compressive strength decreased also because the bonds become more and more weak. Therefore adding fabrics as reinforced material isn't useful with respect to compressive strength.

4. CONCLUSION

From the results and discussion fabric structures play a great role in the cement tensile and bending strength. From the technical point view of fabric structures and its effect on the mechanical properties of fabric cemented composites it was concluded that:

1. The fabric's characteristics, particularly its tensile strength, which depends on the fabric's structure, affect the tensile and bending strength values of cement-composites.
2. The higher the number of intersections per unit area of the fabrics; the lower is the tensile strength. In other words the longer the yarns float in the fabric weave, the greater is the composites tensile strength which is clear in satin weave than fabrics with yarns inclined to the fabric plane (plain).
3. It was also discovered that the more fabric layers there are, the lower the compressive strength is for all types of fabrics. In contrast, the tensile and bending strengths are higher because the fabric layers isolate the material. The compressive strength is also found to be lower than the tensile and bending strengths due to the weaker cohesive forces between the cement grains with and without fabrics. So adding fabrics with more than one layer is not recommended with respect to the compressive strength. But one fabric layer with lower cover factor can be used to decrease the loss in bonds of cement grains.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Peled A, Mobasher B. Pultruded fabric–cement composites. ACI Materials Journal. 2005;102(1):5–23,
2. Peled A, Mobasher B, Sueki S. Technology Methods In Textile Cement-Based Composites. Concrete Science and Engineering. A Tribute to Arnon Bentur, Edited By Kovelr k, Marchand J, Mindess S, Weiss J. RILEM Proceedings PRO. 2004;36:187-202.
3. Sandeep S, Pendhari, Tarun K, Yogesh M. Application of polymer composites in civil construction. Department of Civil Engineering. Indian Institute of Technology Bombay, Powai, Mumbai 400 076, India; 2008.
4. ACI Committee-503. Guide for the selection of polymer adhesive with concrete. ACI Mater J. 1992;89(1):90–105.
5. Uomoto T, Mutsuyoshi H, Katsuki F, Misra S. Use of fiber reinforced polymer composites as reinforcing material for concrete. ASCE J Mat Civil Eng. 2002; 14(3):191–209.

6. Karbhari M. Materials consideration in FRP rehabilitation of concrete structures. ASCE J Mat Civil Eng. 2001;13(2):90–97.
7. Einde L, Zhao L, Seible F. Use of FRP composites in civil structural application. Constr Build Mater. 2003;17:389–403.
8. Bank L, Gentry T, Thompson B, Russell J. A model specification of FRP composites for civil engineering structures. Constr Build Mater. 2003;17:405–437.
9. Bakht B, Al-Bazi G et al. Canadian bridge design code provisions for fiber-reinforced structures. ASCE J Compos Const. 2000; 4(1):3–15.
10. ACI Committee 440. Guide for the design and construction of externally bonded FRP system for strengthening concrete structures. American Concrete Institute, Farmington Hill, MI; 2002.
11. Nanni A. North American design guidelines for concrete reinforcement and strengthening using FRP: Principles, applications and unresolved issues. Constr Build Mater. 2003;17:439–446.
12. Mohie Eldin M, Eltahan E. Validity of using bamboo as reinforcement of concrete beams. Proc. of the International Conference on Advances in Civil, Structural and Construction Engineering – CSCE. Rome, Italy. 2016;5-10.
13. Mohie Eldin M, Eltahan E. Possibility of using bamboo and high tenacity polyester (HTPET) net fabric as reinforcement of concrete slabs. Proc. of the Ninth Alexandria International Conference on Structural and Geotechnical Engineering, (AICSGE9), RC28. Alexandria, Egypt. 2016;1-16.
14. Osama M, Mohamed A, Sayed H, Asmaa k. Designing composite fabric for strengthening concrete slabs. International Design Journal. 2018;8:207-216.
15. ASTM designation: D5035-95
16. ASTM designation: C348-80
17. ASTM designation: C349-82

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/102664