International Journal of Engineering & Technology, 10 (2) (2021) 215-219

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Effect of textile fabric fiber on mechanical properties of cement-sand mortar

N. M. Musa [1], M. M. Lawan [1]*

[1] *Department of Civil Engineering, Kano University of Science and Technology, Wudil, Kano,*
**Corresponding author E-mail: mmlawan76@kustwudil.edu.ng*

Abstract

Cement-sand mortar is widely adaptable material used in construction as a binder for masonry walls or aesthetically for rendering and plastering. Fibre-reinforced mortar has been used for many years to increases the mortar's structural properties. This paper discusses the the influence of textile fabric fibre on the properties of cement-sand mortars. Flexural strength test, compressive strength test and drying shrinkage tests were carried out on mortars made with 0%, 0.5%, 1.0%, and 2.0% textile fabric fibre additive. The tests were conducted at 7, 14 and 28 days and the results obtained showed that addition of textile fabric fibre in cement-sand mortar increases the mortar flexural strength and the mortar compressive strength. While, addition of textile fabric fibre reduces the drying shrinkage it can be concluded that textile fabric fibre can be utilized in cement-sand mortar using 1% optimum content.

Keywords: *Textile Fabric; Cement-Sand Mortar; Flexural Strength; Compressive Strength; Drying Shrinkage.*

1. Introduction

Cement-sand mortar is a mixture of cement, sand and water widely used in construction as a structural binder of masonry walls (to hold together blocks, bricks, stones etc.) or aesthetically for rendering and plastering [1]. When water is mixed with cement and sand, the cement binder is activated, producing a strong bond between the mortars and the connecting block units. the mortars' chemical resistant makes it long lasting and suitable as a building material [2]. About half of the amount of Portland cement used in building construction is in masonry and plastering [3]. Cement-based mortars has the advantage of reaching maximum strength in 28 days compared with 90 days for lime-based mortars [4].

Mortars are characterized into four Types: M, S, N and O by ASTM C270 [5]. Type M mortar mix has the highest amount of Portland cement and it is recommended primarily for walls bearing heavy loads. It is a High compressive-quality mortar, however not exceptionally workable with compressive strength of 17.2MPa. Type S mortar is the ideal product to be used in masonry at or below grade. It is a mortar with higher flexural bond quality, it has compressive strength of 12.4MPa. Type N mortar is usually recommended on exterior and above-grade walls that are exposed to severe weather and high heat. It has compressive strength of 5.2MPa. Type O mortar is a Low-strength mortar, utilized generally for inside applications and reclamation with compressive strength of 2.4MPa [6]. While, BS 5628 [7] designated cement mortar into 4 groups as shown in Table 1.

Table 1: Different Designations of Cement-Based Mortars

	Mortar designation	Compressive strength class	Mix Ratio	Compressive strength at 28 days (N/mm^2)
Increasing ability to accommodate movement, e.g. due to settlement and moisture changes ↓	(i)	M12	-	12
	(ii)	M6	1: 3 to 4	6
	(iii)	M4	1: 5 to 6	4
	(iv)	M2	1: 7 to 8	2

(Source: [7]).

Fiber-reinforced mortars are improved mortars containing fibrous material which increases its structural properties [8]. The improvement of mortar strength by addition of fibre has been done for many years [9], in fact the composition of mortars was improved since ancient times using natural fibres, or natural polymers [10]. Fibres provide binding forces across cracks and thus prevent the cracks from growing. [11]. The fibres seems to stitch the matrix together and enhance the mechanical properties of the cement matrix [12]. There are different fibres whose use where ascertained in concrete such as steel fibres [13], textile fibre [14], polypropylene fibres [15] and other synthetic and natural fibres. Textile fabrics in municipal solid waste are found mainly in discarded clothing, although other sources include furniture, carpets, tires, footwear, and nondurable goods such as sheets and towels. Textile waste has been rated as the third in comparison to plastics and cardboards [16] and therefore their utilization will be an opportunity to mitigate today's waste management problems [17]. Therefore, this paper studies the influence of textile fabric fibre on the properties of cement-sand mortars.

2. Materials and methods

2.1. Materials

2.1.1. Cement

Cement: Dangote Portland limestone cement having grade 42.5 was used in this study. The cement has tested specific gravity of 3.15 and has complied with CEM II of NIS-444 Part 1[18].

2.1.2. Fine aggregates

Naturally occurring clean river sand obtained locally was used. The fine aggregate has specific gravity of 2.13 and particle size distribution shown in Figure 1, and the aggregate is within the stipulated limits of BS882 [19].

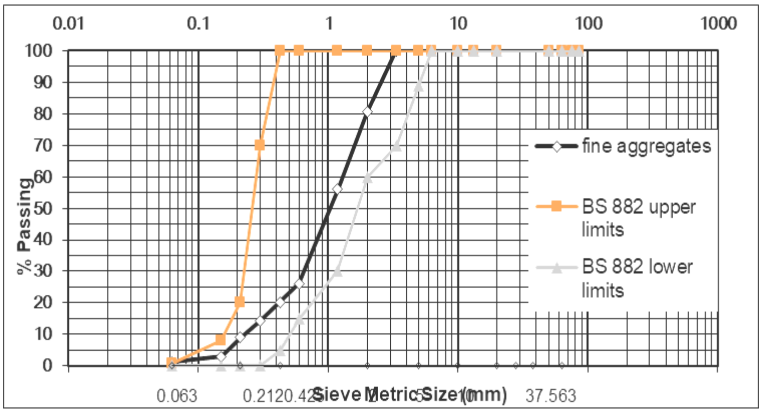

Fig. 1: Particle Size Distribution of the Fine Aggregates.

2.1.3. Fabric (textile) fibre

The fabric (textile) fibre used in this research was mainly cotton material obtained from waste product of tailoring shops. The average length and diameter of the shredded fibre is 1.8 cm and 0.53cm respectively. The fiber has average density of 52.4kg/m3.

Fig. 2: Textile Fabric Fiber Used.

2.1.4. Water

Water used for both mixing and curing was ordinary tap water.

2.2. Methods

2.2.1. Mortar production

Mortar is a mixture of a cement and sand. The mortar used in this study has a mix ratio of 1:3 as specified in BS EN 196-1 [20]. The dry mortar was initially prepared by mixing one part of cement with three parts of sand and thoroughly mixed, after that textile fabric fibres were added in the ratio of 0%, 0.5%, 1.0%, and 2.0% of the cement weight. After thoroughly mixing the constituent, water was then added and mixed to produce cement mortar. Each batch of three test specimen were mixed separately and consisted of 450 ± 2g of cement, 1350 ± 5g of sand and 225 ± 1g of water and appropriate textile fabric fibre content. The mortar was used for flexural strength test, compressive strength test and Drying Shrinkage Test.

2.2.2. Mortar flexural strength test

The centre-point loading method was used to determine the flexural strength as specified in BS EN 196-1 [20]. Forty five (45) prismatic test specimens measuring 40 millimeter × 40 millimeter cross-section and 160 millimeter length were produced and tested for flexural strength in accordance with BS EN 196-1 [20] recommendations. These specimens were casted, de-molded the next day, and then cured in accordance with the standard procedure in water until tested at 7, 14 and 28 days.

2.2.3. Mortar compressive strength test

From the prism prepared for flexural test (40x40x160mm), a cube of 40mm x 40mm x 40mm was cut from the broken half of each of the prism after flexural test as specified in BS EN 196-1 [20]. Compressive test was then conducted on each cube at 7, 14 and 28 days.

2.2.4. Drying shrinkage test

The test was conducted on the flexural test specimens before the flexural test by measuring its length to determine any shrinkage after thoroughly drying them, in accordance with BS EN 196-1:2005. The test was done at 7, 14 and 28 days.

3. Results and discussions

3.1. Mortar flexural strength

The flexural test measures the force required to bend a beam under three-point loading conditions, it is used as an indication of a material's stiffness and its ability to resist deformation under load. The values obtained are often used to select materials for parts that will support loads without flexing [12].

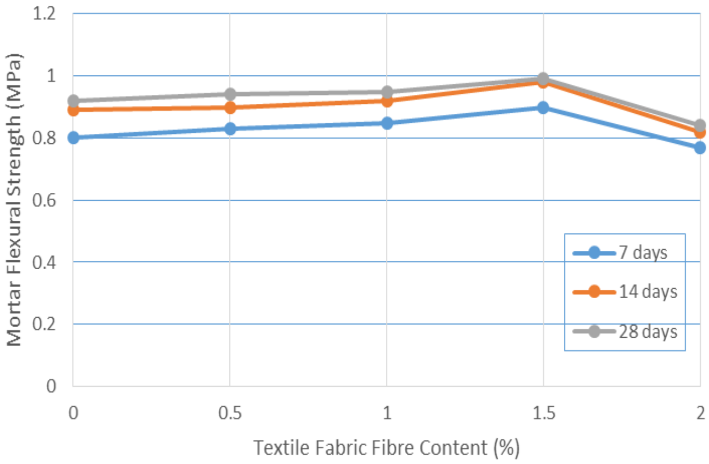

Fig. 3: Effect of Textile Fabric Fibre on Mortar Flexural Strength.

From the results of the mortar flexural strength test presented in Figure 3, the mortar flexural strength increases linearly with increase in fibre contents from 0% to 1.5%, after that the strength reduces. At 28 days, the strength of specimens with 0.5%, 1% and 1.5% textile fabric fibre content increases by 2%, 3%, and 8% respectively over the 0% (control) textile fabric fibre content. While at 2% fabric content the strength reduces by 9%. The trend is similar at 7 and 14 days. Also, curing has increased the flexural strength for all the fibre contents.

3.2. Mortar compressive strength

The compression test determines behavior of materials under crushing loads. Results of the mortar compressive strength test presented in Figure 4 shows that there is an increase in compressive strength as the textile fabric fibre content increases from 0% to 1% at 7 and 28 days. While at 14 days the maximum compressive strength is at 1.5% fibre content. Improvement in the compressive strengths of concrete and mortars due to fibre reinforcement has been usually attributed to crack closing due to the fibre influence [21]. The mortar compressive strength also increases with curing period due to continuation of hydration of anhydrate cement with time as shown in the Figure 4.

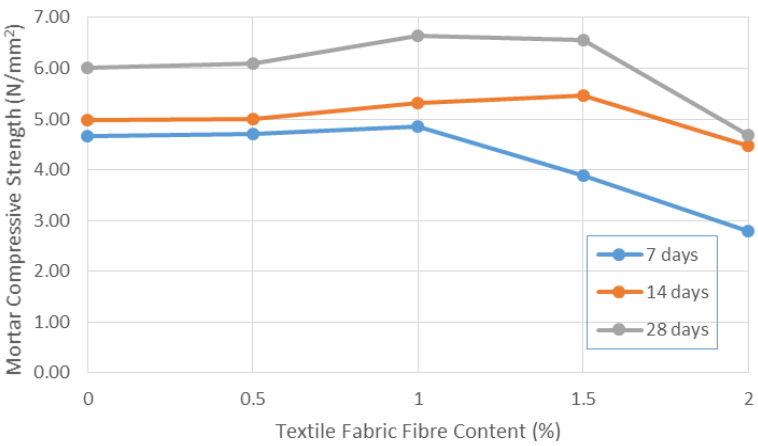

Fig. 4: Effect of Textile Fabric Fibre on Mortar Compressive Strength.

Considering 28 days compressive strength result, 0%, 0.5%, 1% and 1.5% fibre content having compressive strength of 6 N/mm^2, 6.08 N/mm^2, 6.63 N/mm^2, and 6.56 N/mm^2 respectively are within mortar designation type (ii), class M6 of BS5628 [7] or Type N of ASTM C 270, 2006. However, 2% fibre content with compressive strength of 4.69 N/mm^2 is within mortar designation type (iii), class M4 and is more suitable for use as masonry mortar. This is because Mortars that are stronger than the units they are bonding can result in cracking of the units [22]. The relationship between mortar compressive strength and mortar flexural strength is shown in Figure 5 to have linear relationship with good positive correlation.

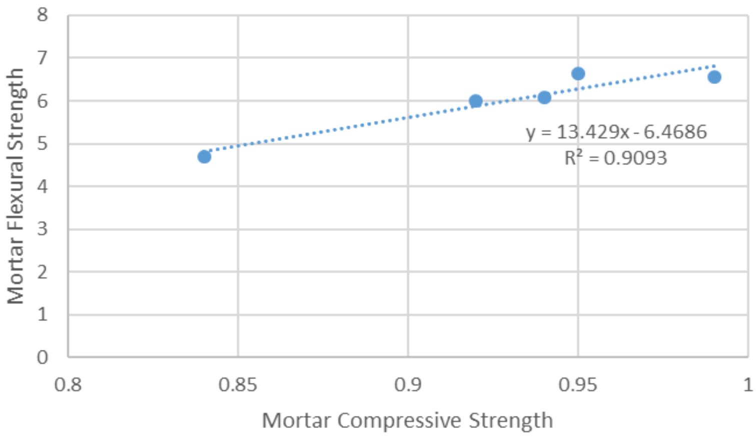

Fig. 5: Relationship Between Mortar Compressive Strength and Mortar Flexural Strength.

3.3. Mortar drying shrinkage

The results of the mortar drying shrinkage as presented in Figure 6, shows that addition of textile fabric fibre reduces the drying shrinkage. At 28 days, when compared with 0% fabric fibre content the drying shrinkage reduces by 9%, 64%, 70% and 72% for 0.5%, 1%, 1.5% and 2% fabric fibre content respectively. The trend is similar at 7 and 14 days. Shrinkage causes cracking in mortar and the lower the better. Since the formation of shrinkage cracking is closely correlated with the water evaporation rate, it was suggested that fibres tend to reduce the quantity of bleeding water by reducing segregation, which succeeds at lower water evaporation rates [23].

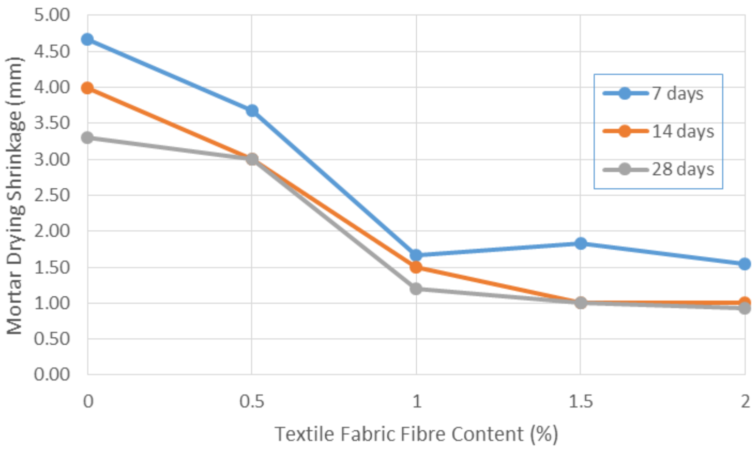

Fig. 6: Effect of Textile Fabric Fibre on Mortar Drying Shrinkage.

4. Conclusion

From the test results presented the addition of textile fabric fibre in cement-sand mortar increases the mortar flexural strength from 0% to 1.5% fabric fibre content, after that the strength reduces. The 1.5% fabric fibre content has the maximum strength. Similarly, the mortar compressive strength increases as the textile fabric fibre content increases from 0% to 1% fabric fibre content at 28 days with 1% having the maximum strength. While, addition of textile fabric fibre reduces the drying shrinkage, as the shrinkage reduces with increase in fibre content. Based on the result, textile fabric fibre can be utilized in cement-sand mortar using optimum content of 1%.

Acknowledgement

The authors acknowledge the support and finance provided by TETfund Nigeria through IBR Funding (TET-FUND/DESS/UNI/KANO/IBR/2018).

References

[1] Ramakrishna, G. and Sundararajan, T. (2019). A novel approach to rheological and impact strength of fibre-reinforced cement/cementitious composites for durability evaluation. Durability and Life Prediction in Biocomposites. Fibre-Reinforced Composites and Hybrid Composites. Elsevier. p. 389-406. https://doi.org/10.1016/B978-0-08-102290-0.00017-9.

[2] Hanif, I. (2017). Effect of nylon fiber on mechanical properties of cement based mortar. Materials Science and Engineering Conference Series. 2017. https://doi.org/10.1088/1757-899X/271/1/012080.

[3] Domone, P. and Illston, J. Construction materials: their nature and behaviour. CRC Press (2014).

[4] Ahmed, A. Properties of conventional cement and thin layer mortars. Construction Materials and Structures. IOS Press. (2014). p. 655-661.

[5] ASTM, C., 270 standard specification for mortar for unit masonry, annual book of standards. 2006, West Conshohocken: ASTM International.

[6] Alsalami, ZHA. (2017). Study the effect of partially replacement sand by waste pistachio shells in cement mortar. Applied Adhesion Science. 5(1): p. 19. https://doi.org/10.1186/s40563-017-0099-3.

[7] BS5628-1:, Code of practice for the use of masonry: Part 1. Structural use of unreinforced masonry. British Standards Institute, 389 Chiswick High Road, London, W4 4AL, http://www.bsi-global.com/, 2005.

[8] Alsadey, S. (2016). Effect of polypropylene fiber on properties of mortar. Int. J. Energy Sci. Eng. 2: p. 8-12.

[9] Broda, J., Application of Polypropylene Fibrillated Fibres for Reinforcement of Concrete and Cement Mortars. High Performance Concrete Technology and Applications (2016). p. 189. https://doi.org/10.5772/64386.

[10] Orban, YA. (2018). Virtual manufacturing and mechanical properties of synthetic fiber-reinforced mortars. Procedia Manufacturing. 22: p. 262-267. https://doi.org/10.1016/j.promfg.2018.03.040.

[11] Al-Tulaian, B., Al-Shannag, M., and Al-Hozaimy, A. (2014). Recycled Plastic Fibers for Minimizing Plastic Shrinkage Cracking of Cement Based Mortar. Int J Civil Environ Struct Construct Architect Eng. 8: p. 10-16

[12] Khan, MI. (2020). Impact of waste fibers on the mechanical performance of concrete composites. The Journal of The Textile Institute. p. 1-9. https://doi.org/10.1080/00405000.2020.1736423.

[13] Yuan, C. (2018). Bond behavior between basalt fibres reinforced polymer sheets and steel fibres reinforced concrete. 176: p. 812-824. https://doi.org/10.1016/j.engstruct.2018.09.052.

[14] Musa, NM, Lawan, MM, Baba, ZB, and Mukhtar. U. (2020). Performance evaluation of textile fabric fibre reinforced concrete. International Journal of Scientific & Technology Research.Volume 9, Issue 08.

[15] Gencel, O. (2011). Mechanical properties of self-compacting concrete reinforced with polypropylene fibres. 15(3): p. 216-225. https://doi.org/10.1179/143307511X13018917925900.

[16] Aghaee, K. and Foroughi, M. (2013). Mechanical properties of lightweight concrete partition with a core of textile waste. Advances in Civil Engineering. https://doi.org/10.1155/2013/482310.

[17] Alengaram, UJ., Al Muhit, BA and Bin Jumaat, MZ. (2013). Utilization of oil palm kernel shell as lightweight aggregate in concrete–a review. Construction and Building Materials. 38: p. 161-172. https://doi.org/10.1016/j.conbuildmat.2012.08.026.

[18] NIS-444, Quality standard for ordinary Portland cement. Standards Organisation of Nigeria, (2003). Lagos.

[19] BSI-882, Specification for aggregates from natural sources for concrete. 1983.

[20] EN, B., 196-1: 1995, Methods of Testing Cement, Part 1: Determination of Strength. British Standards Institute/The European Committee for Standardisation, Chiswick, London, UK, 1995.

[21] Abbas, AA. (2013). The effect of steel fiber on some mechanical properties of self compacting concrete. American Journal of civil engineering. 1(3): p. 102-110. https://doi.org/10.11648/j.ajce.20130103.14.

[22] MIA, M.I.A., Data sheet 23 : The Specification of an Appropriate Mortar. Mineral Products Association Ltd, London, www.mortar.org.uk, 2013.

[23] Bertelsen, I. Influence of fibre characteristics on plastic shrinkage cracking in cement-based materials: A review. 2020. 230: p. 116769. https://doi.org/10.1016/j.conbuildmat.2019.116769.