Studying the effect of adding different lengths of glass fibers on some properties of mortar

Nada Hamad Khalaf [1]
1)Materials Engineering Department, Faculty of Engineering, Mustansiriyah University, Baghdad, Iraq,
ebma012@uomustansiriyah.edu.iq

Yasir Khalil Ibrahim[1]
alaniyasir15@gmail.com
1)Materials Engineering Department, Faculty of Engineering, Mustansiriyah University, Baghdad, Iraq,

Sahib Mohammed Mahdi [1]
sahebmahdi58@gmail.com
1)Materials Engineering Department, Faculty of Engineering, Mustansiriyah University, Baghdad, Iraq,

ABSTRACT

Mortar is a brittle material that breaks throughout the drying process because of its hygroscopic nature (it expands when wet and contracts when dry). Fibers embedded in the cementitious matrix improve the flexural, tensile, and fracture toughness of mortar, all while reducing the cracking breadth. In an effort to enhance these features, an attempt was made to investigate the influence of different lengths of glass fibers in cement mortar. In this study glass fibers with length 20 and 30 mm were added to improve the properties of cement mortar. The fiber volume fraction that used 0.25%, 0.5% and 0.75% with water to cement ratio of 0.33 and super plasticizer equivalent to 2.5 % of the cement weight .The samples were casted into cube molds (50×50×50) mm for compressive strength test and prismic molds (40×40×160) mm for flexural strength test. The density of the specimens was also calculated as a physical test. Total members cured for 3,14 and 28 days in water curing tank before test .Comparing of FRM with plain mixture ,the outcomes have revealed that adding glass fibers makes the material stronger and lasts longer.

Keywords: Cement mortar, glass fiber, compressive strength ,volume fraction

1.Introduction

Cement mortar is the one of the most widely used building materials. It is made by mixing the right amounts of cement, fine aggregate, and water. When the mixture was put into molds and left to dry, becomes hard like stone. Cement mortar gets stronger over time because of the chemical reaction between both the water and the cement. [1] Without fibers, mortar will produce fractures owing to drying and plastic shrinkage, and other causes of volume changes in mortar. The production of these microscopic fissures results in the elastic deformation of mortar. Plain mortar is a weak substance with low modulus of rupture and strain capacity values[2]. Utilizing fibers in mortar improves the tensile,impact flexural,wear resistant, fatigue, deformation capability, toughness qualities greatly and load-bearing capacity after cracking . [3,4]. In recent years, glass fibers have also become accessible, which do not suffer from the corrosion issue that plagues steel fibers. [5]. The use of glass fibers in mortar is increasing nowadays. Normal mortar gives low strength, less resistant to crack. If glass fibers are added to mortar, it imparts high tensile strength, reduces bleeding of water and controls

cracking . Also the use of glass fibers yields higher flexural strength and enhance the ductility properties [6]. GFRM is widely and dependably use for architecture (e.g., cladding, mouldings, gardening), building (e.g., roofs, windows and walls rehabilitation, foundations and floors), engineering, and other fields (i.e. permanent formwork, utilities, acoustics, bridges and tunnels, roads, water and drainage) [7]. Yogesh Iyer Murthy et al. [8] found that the mechanical strength of normal M30 grade concrete went up when 25m and 5cm long glass fibers were used to replace fine aggregate. Kavita S Kene et al[9] investigated the impact of glass and steel fibers in concrete and observed that by adding steel fibers at 0.5% y volume of mortar, improved brittleness of mortar. Avinash Gornale, et al [10] examined the durability of concrete reinforced with glass fibers. The investigation discovered that the inclusion of glass fibers improve the flexural strength ,compressive strength, split tensile strength of M20, M30, and M40 grade concrete at 3, 7, and 28 days by 25% to 30%, 20% to 30% and 25%, respectively, when compared to plain mix.

2. Experimental procedure

2.1 materials

2.1.1 Cement

The cement utilized in this project is ordinary Portland cement. All cement qualities are validated by reference to IQ.S.5:2019[11]. To prevent any discrepancies between batches, the total quantity was bought and kept in a dry place. The physical parameters of cement are shown in table (1).

Table (1): physical properties of cement

Test	Results	IQ.S. 5:2019 limits
Fitness (cm^2/g)	4678	>2800
Time of setting		
initial(minute)	120	>45
final(hour)	3:50	>10
Compressive strength(N/mm2)		
2 days	25	>20
28 days	43	>42.5

2.1.2 Sand

The sand employed in this experimental program was Al -Ekhaider natural sand that met to Iraqi specificatiom limits No.45/1984 [12]. The sand had been sieved with a 1.18mm sieve. Table (2)shows sand grading and physical qualities.

Table(2): grading of sand

Mesh Size(mm)	%Passing By Weight	IQ.S. 45/1984 limits
1.18	59.7	55-90
0.60	39.3	53-59
0.30	12.4	8-30
0.15	2.28	0-1
% passing sieve 75µm	3.6	≤ 5
Percentage Of Salt%	0.114	≤0.5

2.1.3 Glass fiber

The glass fibers employed in mortar prevented the localization of micro cracks into macro fissures, resulting in an increase in tensile strength. It increases the strength of mortar, which improves its durability. The glass fibers are roving glass fiber (E-glass) with an elasticity modulus of 72 GPa. The physical parameters of glass fiber are displayed in table 3.

Table (3): physical properties of glass fiber

Properties	E-glass fiber

Density(g/cm^3)	2.56
Tensile strength(Mpa)	3443
Tensile elongation %	2.75
Modulus of elasticity(Gpa)	76

Figure(1):the glass fiber used

2.1.4 Super plasticizer

Glenium 54 is utilized to preserve the water-to-cement ratio and enhance the workability of mortar mixtures.

2.1.5 Water

Water is an essential component of mortar since it begins the chemical reaction between cement and water, and the mix water was devoid of chlorides and sulphates. Normal potable water was utilized throughout the experiment and for curing mortar samples.

2.2 Experimental work

Mixtures of 1:2.75 cement/sand ratio and water / cement ratio of of 0.33 and super plasticizer of 2.5% of cement weight were prepared for making mortar with different glass fibers percentage (0.25, 0.5 and 0.75) % by volume fraction .The glass fiber reinforced mortar were prepared by cutting a glass fibers into 20 and 30 mm by length and add to the mix. The fibers were weighed before mixing . After the mixing process the specimen was poured in oily cast iron molds of (5×5×5)cm for compressive strength test, and 160×40×40 mm prisms steel mould for flexural strength test. When the specimens were solidified they de-molded and cured for 3,14 and 28 days before test as shown in table (4)

Table(4):designation of cast

Mix plan	Cement	Sand	Water	Admixture %	Glass fiber
Glass fiber reinforced mortar	1	2.75	0.33	2.5	0
	1	2.75	0.33	2.5	0.25
	1	2.75	0.33	2.5	0.5
	1	2.75	0.33	2.5	0.75

3 .Testing

Different tests were conducted on the specimens to determine and compare the properties mortar reinforced glass fibers:

3.1 Density

The density was evaluated by drying the samples for 24 hours to confirm that they were dry, and then weighing the dry samples. The density was determined using dividing each sample's dry weight by the sample size.

3.2 compressive strength

A 50mm x 50mm x 50mm steel mold made of cast iron is utilized to make mortar cubes. Before casting, the sides of the mold and the base plates were oiled so that the mortar wouldn't bind to the mold. The compressive strength test is displayed in figure (2).

Figure(2): compressive strength test

3.2 flexural strength

The 160 x 40 x 40 mm steel mold is tightened and lubricated carefully. They were allowed to cure in a curing tank for 3, 14, and 28 days before being tested with a universal testing equipment. Figure (3) depicts the flexural strength evaluation

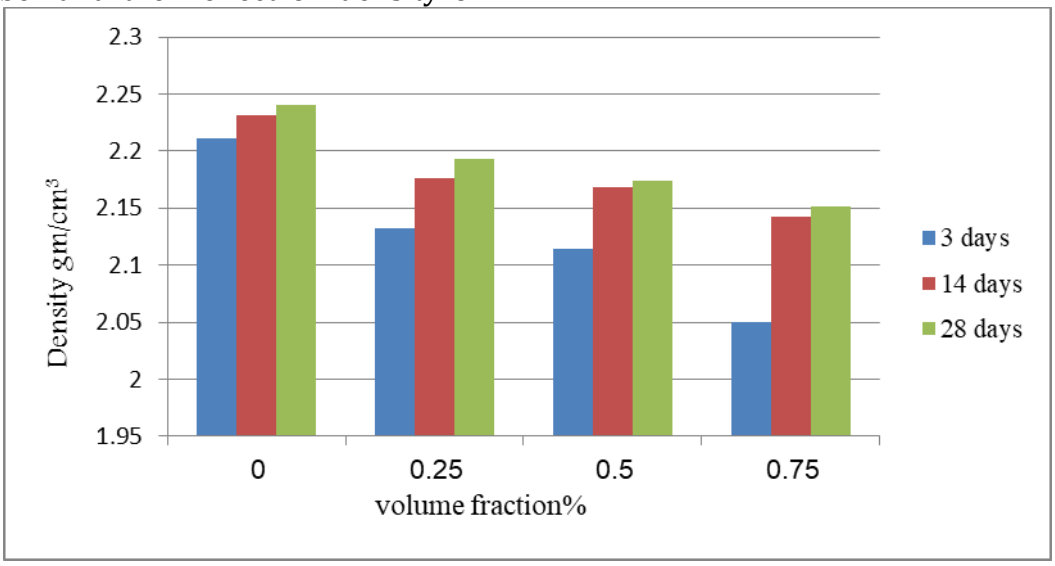
Figure(3): flexural strength test

4.Results And Discussions

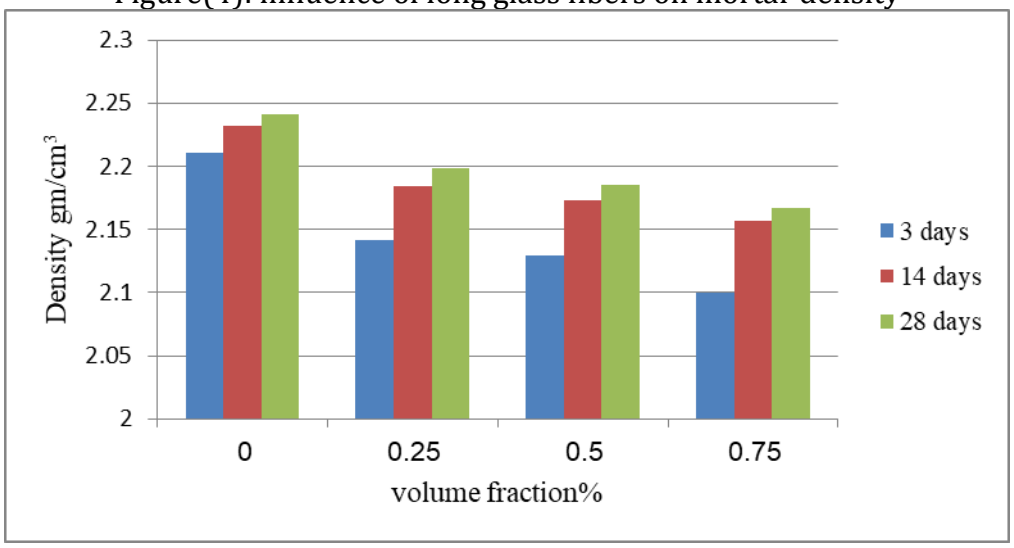
4.1 density

The specimens with the addition of GF with (0.25 , 0.5 , 0.75) volume fraction percentages

shown in Figures 4,5 shows decreasing in density of GFRM with increasing in percentage of glass fiber when compared with the plain mixture. This decreasing resulted from the vacancies that are formed in the mortar structure due to the addition of GF as well as the light weight of GF makes the specimens lighter than control specimens , consequently results in decreasing of density due to the direct proportionality between the weight and density[13] . A comparison between long fiber and short fiber and their effect on density of mortar specimens is shown in Figures 4,5 after 3,14 and 28 days of curing . The comparison of reinforced mortar specimens with respect to control specimens which have the higher density. The lower density was achieved by long fiber . This is because the addition of long fibers to the composite lowered the packing, causing the disruption of fiber distribution and the formation of large voids. Clearly, composites with larger void content have a lower density [14].



Figure(4): influence of long glass fibers on mortar density

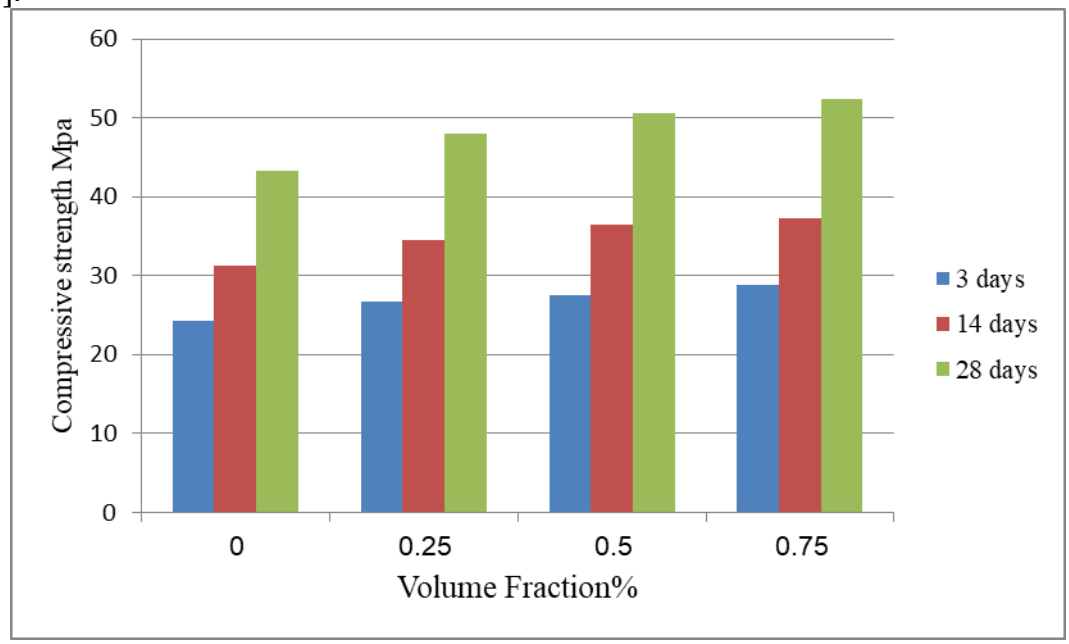


Figure(5): influence of short glass fibers on mortar density

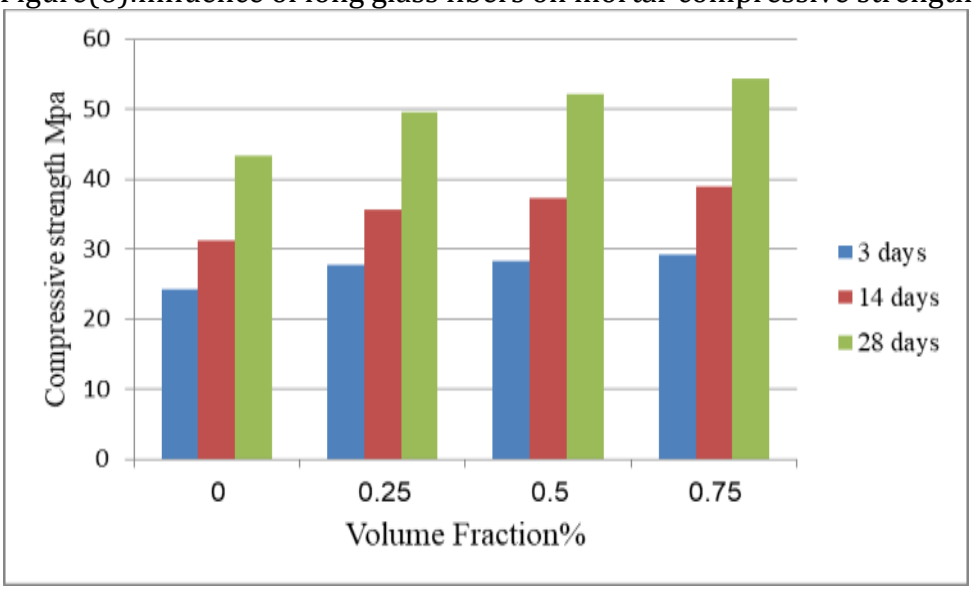
4.2 Compressive Strength Test

The compressive strength gradually improves with the rise in the percentage of fibers as shown in figures 6,7. The reason for the increase is that the glass fibres enhance the bond strength and This is the explanation of increasing in compressive strength by the addition glass fibers [15]. The compressive strength is inversely proportional to the fiber length. Similar findings have been reported by Khedari et al [16]. This is related to the fiber spacing in the specimen. It is suggested that

shorter fibers are aligned to be distant from each other which yield high density and strength. In contrast, longer fibers result in fiber cluster which then creates voids, low density and reduces strength[14].



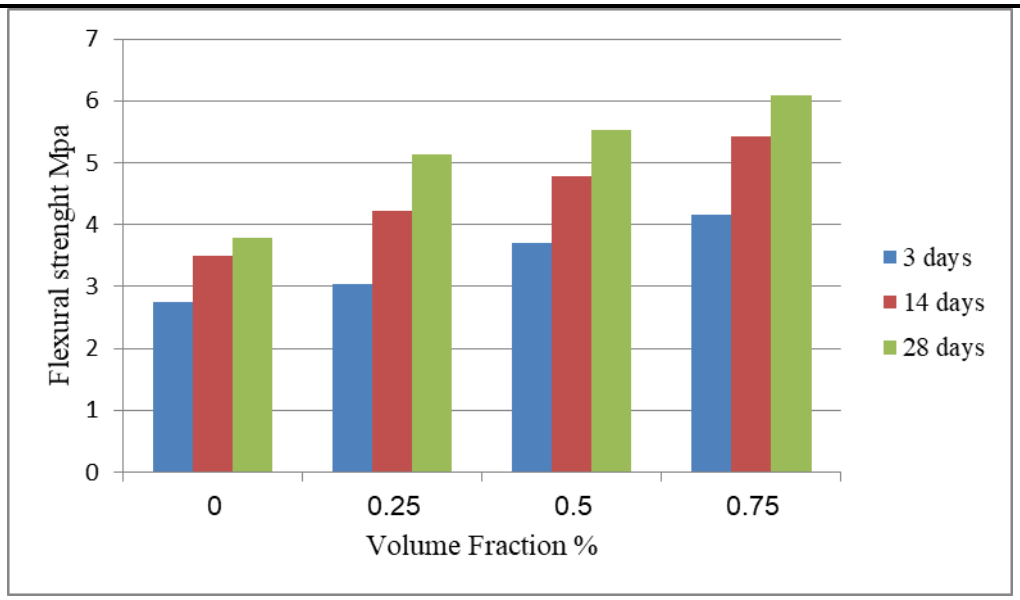
Figure(6):influence of long glass fibers on mortar compressive strength



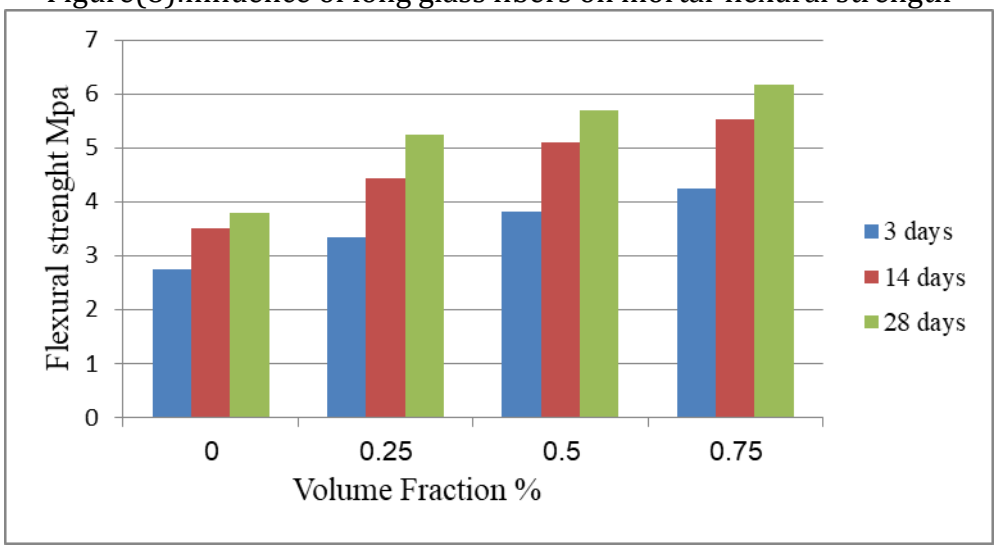
Figure(7):influence of short glass fibers on mortar compressive strength

4.3 flexural strength test

The effects of glass fiber length on flexural strength curves of mortar with is displayed in Figure 8,9. It can be seen that the flexural strength enhanced with the rise in the amount of the glass fiber because the fibers prevent the crack propagation and tend to delay the rapid failure of mortar's structure, hence increasing the mortar's load-bearing capability [17]. In terms of flexural strength, the 20 mm length of fiber also was better than the 30 mm long of glass fiber This may be attributed to the fact that short glass fibers were easier to fill the space and compact the cement mortar than lengthy fibers [18].



Figure(8):influence of long glass fibers on mortar flexural strength



Figure(9):influence of short glass fibers on mortar flexural strength

5.Conclusion

This paper shows test results cement mortar having different lengths of glass fibres and different volume fractions. Some conclusions can be drawn as follows:

1. Shorter fibers length are able to improves mechanical strength more than longer fibers length for same amount of fiber in mortar.
2. The optimal amount of fiberglass used to the cement mortar was 0.75 percent by volume because the increase in the fiber content reduces the average distance between the fibers and produces more fibers to bear the loads and delay the spread of cracks and this results in an increase in strength.
3. The addition of fiberglass increases the mechanical property of the mortar.
4. The cement mortar with the fiberglass is less dense overall than the same mixture without the fibers.
5. The inclusion of fiberglass might minimize cracks propagation that caused by several loads.

References

1. Mohamed, M. A., Moh, M. A., Akasha, N. M., & Elgady, I. Y. I. (2016). Experimental study on effects of fiberglass and fiber waste in mortar mixes. International Journal of Engineering Sciences & Research Technology, 5(10), 485e93.

2. Deshmukh, S. H., Bhusari, J. P., & Zende, A. M. (2012). Effect of glass fibers on ordinary Portland cement mortar. IOSR journal of engineering, 2(6), 1308-1312.
3. Qian, C. X., & Stroeven, P. (2000). Development of hybrid polypropylene-steel fibre-reinforced mortar. Cement and mortar research, 30(1), 63-69.
4. Gao, J., Sun, W., & Morino, K. (1997). Mechanical properties of steel fiber-reinforced, high-strength, lightweight mortar. Cement and Mortar Composites, 19(4), 307-313.
5. Chawla, K., & Tekwani, B. (2013). Studies of glass fiber reinforced mortar composites. International journal of structural and civil engineering research, 2(3), 176-182.
6. Vishal, E.,Prof. Jai Shankar, P.(2014).Influence of Glass Fibres on High Performance Mortar.International Journal of Engineering Research & Technology (IJERT).Vol. 3 Issue 5.
7. Iskender, M., & Karasu, B. (2018). Glass fibre reinforced concrete (GFRC). El-Cezerî Fen ve Mühendislik Dergisi, 5(1), 136-162.
8. Murthy, Y. I., Sharda, A., & Jain, G. (2012). Performance of glass fiber reinforced mortar. International journal of engineering and innovative technology, 1(6).
9. Murthy, Y. I., Sharda, A., & Jain, G. (2012). Performance of glass fiber reinforced mortar. International journal of engineering and innovative technology, 1(6).
10. Gornale, A., Quadri, S. I., Quadri, S. M., Ali, S. M. A., & Hussaini, S. S. (2012). Strength aspects of glass fibre reinforced mortar. International Journal of Scientific & Engineering Research, 3(7), 1-5.
11. I. S. Specification, "No. 5/2019, Portland Cement," Cent. Organ. Stand. Qual. Control (COSQC), Baghdad, Iraq, 2019.
12. Iraqi standards specification, No. 45/1984.Aggregate from natural source for concrete and construction
13. Halliday, D., Resnick, R., & Walker, J. (2013). Fundamentals of physics. John Wiley & Sons.
14. Zuraida, N., Sopyan, I., & Zahurin, H. (2011). Effect of fiber length variations on mechanical and physical properties of coir fiber Reinforced Cement-Albumen Composite (CFRCC). IIUM Engineering Journal, 12(1), 65-77.
15. Ghedan, R. H. (2013). Effect of Addition Carbon and Glass Fibers on Bond Strength of Steel Reinforcement and Normal Mortar. Eng. & Tech. Journal, 31(1).
16. Khedari, J., Suttisonk, B., Pratinthong, N., & Hirunlabh, J. (2001). New lightweight composite construction materials with low thermal conductivity. Cement and Mortar Composites, 23(1), 65-70.
17. Shakor, P. N., & Pimplikar, S. S. (2011). Glass fibre reinforced mortar use in construction. Int. J. Technol. Eng. Syst, 2(2).
18. Shahidan, S., Abdul Rahim, M., Nik Zol, N. S., Azizan, M. A., & Ismail, I. (2015). Properties Of Steel Fiber Reinforcement Mortar With Different Characteristic Of Steel Fiber. In Applied Mechanics and Materials (Vol. 773, pp. 28-32). Trans Tech Publications Ltd.