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Effect of Short Fibre in Structural Mortar to Enhance Mechanical Properties

Salahaldein Alsadey
e-mail: salahalsadey@yahoo.com

Civil Department, Faculty of Engineering, Bani Waleed University

Abstract

Fiber- reinforced bond mortar is a term used when mortar is strengthened with haphazardly dispersed short fibres. The fundamental destinations of the paper were to examine the impacts of short-fiber on auxiliary concrete mortar of used polypropylene. The practices of plain bond mortar and fiber- reinforced cement mortar are thought about. Finally, information for the new and solidify properties if the cement mortar were gathered and investigated. The extent of this investigation depends on the use of polypropylene short-fibres. To assess the impacts of polypropylene short-fiber on the flow ability of reinforced mortar. An investigational consider was led on the cement mortar reinforced by the diverse rates of polypropylene short fiber (0, 0.5,1 and 1.5%). The fundamental goal of this work is to contemplate the mechanical properties of cement mortar containing diverse rates of polypropylene short fiber. Diverse tests have been done to decide a few perspectives in particular the droop test and compressive strength at period of curing 28 days was led on reference and polypropylene short-fiber strengthened mortar examples. The outcomes demonstrated that the use of polypropylene short-fiber gives a change in these properties. The outcomes demonstrate a noteworthy expanding in compressive strength with the augmentation of short-fiber content in cement mortar.

Keywords: *Mortar, Polypropylene, Short-Fibre, Cement, Compressive Strength.*

1. Introduction

Cement mortar blends are fragile materials that are more grounded as far as pressure, while weaker as far as flexure and strain. At the point when subjected to pressure, these unreinforced fragile grids at first twist flexibly. The flexible reaction is trailed by miniaturized scale splitting, at that point confined full scale breaking, lastly cracks. Break or splitting in solidified cementitious materials is normal and it occurs because of ductile anxieties surpassing the little elasticity of the framework because of load impacts, shrinkage, or other ecological elements. Fragile materials are considered to have no noteworthy post-breaking pliability. Along these lines, once a crack happens, unless there is either customary or fiber fortification to draw in and increase the framework with included elasticity, the framework encounters a sudden, weak disappointment.

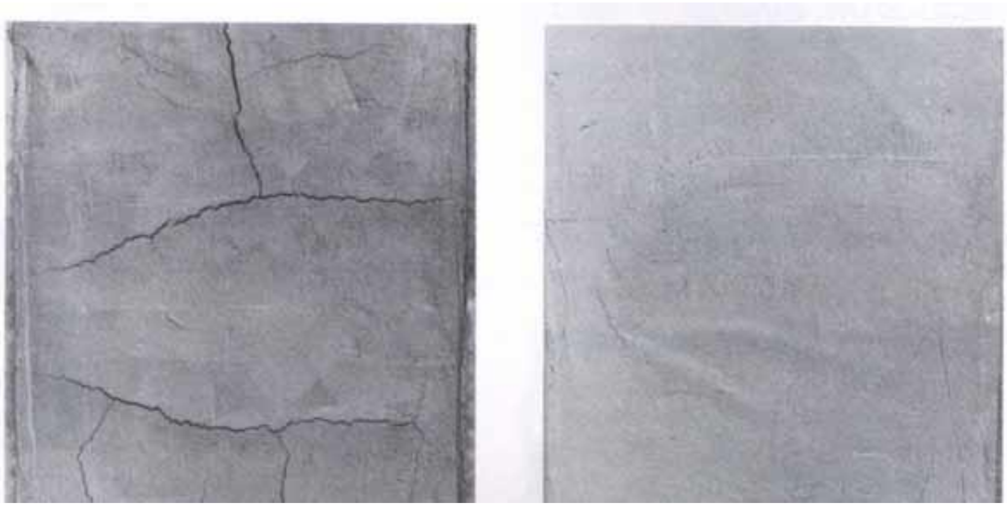
The load bearing capacity of the fibre reinforced mortar depends on the volume dosage rate applied into the mortar matrix. In this fibre cement composite, the failure strain of fibre is normally greater than the failure strain of the mortar. As to prevent the failure of fibre, the load bearing capacity of the fibre must be greater than the load applied on the mortar when the first crack appears. This was assume that the mortar does not contribute any further strength beyond the point of first crack, as the load was fully transfer to the fibre that contains in the mortar. Furthermore, the fibres are able to carry more load, result that the ultimate strength of the fibre cement composite is higher than the matrix strength itself. The fibre reinforced mortar consists of distribution of short fibres in the cement matrix. Such contribution of short, inclined fibres on the mechanical properties of fibre reinforced mortar is usually less than long fibres placed parallel to the load. This means that the efficiency of the short and inclined fibres is less. However, the efficiency of the fibres in the cement matrix to enhance the mechanical properties of mortar can be judged into two ways the property enhancement in the strength of mortar and the property enhancement in the flexural of mortar. These effects on the properties of mortar were depending on the fibre length, the orientation of fibres distributed in the mortar and the shear bond strength of the fibre/cement composite. All of these three factors were not independent as the effects on the fibre length and orientation are largely effect to the bond between the fibre and cement matrix.

Polypropylene fibres are one of the fundamental sorts of fiber used as a part of the market, aside from steel fibres. Be that as it may, the two kinds of fibres fluctuate fundamentally in their flexible and quality properties. For a long time, steel fibres have been generally used as a part of cement and mortar flatwork and splashed cement and mortar applications. The development of polypropylene fibres has acquainted with the world the likelihood of having an elite and more financially savvy item in the commercial center. Polypropylene fibre likewise have better strength as plastic does not rust. It likewise adds to the straightforwardness in taking care of as it weights around one-fifth of a comparable steel short-fiber. The generation of polypropylene began since 1954. By year 1960, polypropylene had started to be connected as concrete or mortar support. At to start with, plain and straight polypropylene fibres were used, however the outcomes are poor as the holding in a solid or mortar blend was deficient. This is because the mechanical interlocking was not good. As a result, twisted polypropylene fibres were developed and are still used today. The mechanical bonds of these new developed fibres increased considerably.

Fiber-reinforced is mortar containing fibrous material which increases its structural properties. It has short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers – each of which lend varying properties to the mortar. Polypropylene fibres are one of the fundamental sorts of fiber used as a part of the market, aside from steel fibres. Be that as it may, the two kinds of fibres fluctuate fundamentally in their flexible and quality properties. For a long time, steel fibres have been generally used as a part of cement and mortar flatwork and splashed cement and mortar applications. The development of polypropylene fibres has acquainted with the world the likelihood of having an elite and more financially savvy item in the commercial center. Fiber–reinforced cement is turning into an undeniably famous development material because of its enhanced mechanical properties over unreinforced cement and its capacity to improve the mechanical execution of customarily strengthened cement. Fiber fortification is a standout amongst the most essential adjustment techniques to change the weak idea of plain concrete. Fibres are for the most part used as opposition of breaking and fortifying of cement. Throughout the most recent three decades, fiber- reinforced cement (FRC) has been the subject of numerous examinations. Explores have been performed on the conduct of fiber- reinforced cement subjected to different kinds of stacking and consolidating distinctive fibres running from steel, glass, plastic, and common fibres in different sizes and shapes [1].

The use of fibers in cement-based materials may considerably enhance the toughness, impact resistance, durability and reduce the cracking in concrete [2]. The main weaknesses of incorporating the fibers are the loss of workability and the increased difficulty of casting. This status may lead to an insufficient workability and high volumes of entrapped air in mortar, which cause reduction in its strength and durability [3]. The modern concrete can be designed to have the high flow ability, whereby the term 'flow ability' suggests that the concrete is able to flow in the congested reinforcement areas and fill complicated formwork without segregation [3, 4]. Additionally, the repaired mortar connected to concrete is generally difficult to merge well; subsequently, the said mortar with high flowability may convey significant focal points to the thin form framework [5]. Fibres give a powerful auxiliary fortification to shrinkage and split width control. Full scale breaks and potential issues are counteracted and blocked when smaller scale splits meet fibres as concrete solidifies and therapist. Impacts of split control fortification by extra of fibres in concrete appeared in figure 1 underneath.

The cracks in cement composites are inevitable. There are two types of cracks. One is formed when the stress exceeds the strength of cement composites; the other is formed in the plastic stage and caused by external temperature, relative humidity, and loss of moisture due to wind [6]. Adding polypropylene fibers to the cement composites is an effective method of preventing crack formation [7]. The dispersion of the fibers in the wet mixture and their bonding with the mortar can reduce bleeding, prevent cracks, and increase the strength of the mortar [8]. Sanjuan et al. [9] suggested that polypropylene fibers can improve the properties of the mortar and also restrict plastic shrinkage cracks.



Without fibre-reinforced With fibre-reinforced

Figure 1. Comparison of cracks with and without Fibre reinforced.
(Source: Fibremesh, 1989)

Banthia and Gupta [9] demonstrated that the more the fiber content is, the more prominent the break opposition of the mortar is. Ward and Li [11] proposed that fiber frames impact the properties and workability of the mortar, while Singh et al. [12] demonstrated that polypropylene fibres have magnificent holding, and can enormously enhance the properties of the mortar. The impacts of utilization of Polypropylene fiber in the mechanical properties of concrete mortar directed that the utilization of polypropylene fiber gives an unambiguous change in these properties. The outcomes likewise demonstrate a critical expanding in compressive quality with the addition of fibres content in bond mortar [13]. Numerous scientists have led examinations to ponder fiber-strengthened cement previously. [14] directed elasticity, flexural quality and compressive quality tests on mortar examples reinforced with steel and glass fiber and found that the pliable or flexural quality of steel fiber-strengthened mortar was no less than a few times that of plain mortar examples. So also, [15] watched that the impact on the compressive quality of adding steel fibres to solid reaches from immaterial and here and there up to 25%, while the option of steel fibres fundamentally expands the strain limit and flexible twisting durability of the solid lattice by around 75%. Present day cement can be intended to have an awesome level of flowability, which enables the solid to stream in congested fortification territories and fill confused formwork isolating [16, 17]. Mortar fills in as the reason for the properties of streaming cement, and surveying the properties of flowable mortar is an essential piece of the outline of streaming cement, [18]. Then again, the repair mortar connected to concrete is normally difficult to smaller well; in this manner, repair mortar with a high level of flowability may convey extensive points of interest to a limited shape framework [19]. It has been known that fibre-reinforced mortar had been used in the early years of structural building. Many researches have been carried out and quite a number of investigations have been performed for fiber reinforced mortar. The use of randomly distributed fibre reinforcement can be considered to be a lucrative method of providing higher structural strengths to mortar structures. However, stresses caused by shrinkage to mortar itself historically been a problem to control because of their unpredictable and irregular occurrence. At present, in our local market, one can find only a limited range of fiber reinforced composite mortars, mainly used in many precast components, in horizontal floors, blankets or similar element, and less in plasters, where the research seems to be less developed. This present study aimed at investigating the effects of short fiber on structural cement mortar. The scopes involved in the study are as follows:

• Investigate the effects of different percentages polypropylene short-fibre on structural cement mortar.

• Compare and determine the characteristic of plain and fibre-reinforced mortar.

• Lastly, data for the fresh and harden properties of the cement mortar will also be collected and analysed.

2. Materials and Mix Proportions

a. Materials Used and Properties

The test examination was done in the Concrete Laboratory of the faculty of Engineering. The bond used as a part of mortar blends was the customary Portland concrete compose I fabricate in Zlitan. The fine total was sea sand, with a fineness modulus of 2.86 and most extreme size of under 5 mm, and water. Superior (8 mm) polypropylene short-fiber was used as a part of this examination. This short-fiber demonstrates a miniaturized scale support fabricated from (100%) polypropylene. It was brought from Sikca Company for Construction Chemicals. Polypropylene fiber followed necessities of ASTM C1116-1997, Type III [20]. It was put away under cover far from warm sources. Table (1) demonstrates the physical and specialized properties of polypropylene fiber.

Table 1. Physical and Technical Properties of Polypropylene Fibre

Composition	100% Virgin polypropylene fibre
Fiber length	8 mm
Specific gravity	0.91
Melting point	160◦C
Tensile strength	(137-689) MPa
Young’s modulus	(5500-7000) MPa
Fiber thickness	18-30 microns
Elongation	25-40 %
Alkali content	Nil
Sulfate content	Nil
Chloride content	Nil

b. Mix Proportions and Testing Method

Four mortar blends were readied using the water-bond proportion as 0.5. The blend outline of the control blend (M1) was completed by the total volume strategy given by the ACI 211.1 [21] to accomplish the criteria of streaming bond mortar. The polypropylene short-fiber of the volumetric portions 0.5, 1 and 1.5% were used to get ready blends: M2, M3 and M4, separately. Each bunch of mortar was delivered in a dish blender. At to begin with, bond, sand, water were added to the blender and blended for 3 minutes. At that point the polypropylene short fiber was dispersed to keep any agglomerates of fibres and the blend was additionally blended for other 3 minutes. The Flow test for the blends was performed by ASTM C230 [22] with a focused on stream of 150 ±10mm. The compressive strength test was done quickly as indicated by ASTM C109 [23] for each test blend. As per ASTM C192-88 [24], in the wake of blending process, the blend was promptly filled shape by methods for a scoop; three 3D square examples of 50 mm were used. Moreover, the prismatic wood molds (40 × 40 × 160 mm) were used for the flexural strength test as indicated by ASTM C348 [25] Casting of the examples was completed in two layers; each layer was compacted by using a little steel bar. The entire compaction was controlled by appearance of a film of concrete mortar on the best and the air void was never again showing up. After compaction, the best surfaces of examples were trowelled level for acquiring smooth surface. In the wake of throwing, all examples were kept under nylon sheets inside the research facility for (24±2) hours to guarantee a muggy air around the examples and to keep quick vanishing of water from the examples, and afterward they were demoulded and cured until the point when they were tried. All examples arranged for compressive was put away in tap water tanks until testing age of 28 days. It merits specifying that all the exploratory approaches embraced in this task comply with the standard test methods. The test set up was organized remembering in the research facility and to its asset restrictions. The majority of the tests were worked effectively and securely all through the task.

3. Results and Discussion

The exploratory outcomes acquired from each test and examination of the test outcomes. The test tests were completed to acquire the mechanical properties and conduct of short fiber reinforced mortar, while additionally contrasted with the regular plain mortar. The examinations of mechanical properties and conduct incorporate the flowability, compressive strength, and the flexural strength of short fiber strengthened mortar. With the dialogs and results got from the exploratory tests, it is plainly to know the impact of short fiber polypropylene used as a part of the auxiliary mortar.

a. Effect of Polypropylene Short Fiber on flowability

The impact of polypropylene short-fiber on the stream of the four bond mortar blends is featured in Table (2). It is anything but difficult to take note of that the incorporation of polypropylene short-fiber in cement mortar diminishes the streaming capacity. Then again; a higher measure of polypropylene short-fiber influences misfortune to stream capacity. Taking everything into account, droop test couldn't be considered as a reasonable test to survey the flowability of cement mortar. This is because of the hardening impacts of the strands which inevitably impact the consequences of the droop test.

Table 2 The Flowability Results for All Mortar Mixes

Mix Designation	Fiber Volume Fraction %	Flow (mm)
M 1	0	255
M 2	0.5	240
M 3	1.0	215
M 4	1.5	210

b. Effect of Polypropylene Short Fiber on Compressive Strength

The consequences of compressive strength test exhibited in Table (3) and figure 2 underneath demonstrates the outcomes for the pressure strength test led on polypropylene short-fibres of various bit of short-fibres. The expansion in the compressive strength of the bond mortar strengthened with polypropylene short-fiber was up to 23.22 % contrasted and that of the reference mortar without polypropylene short-fiber. This outcome was gotten from the low volume division of polypropylene short-fiber 0.5 % used as a part of the blend (M2). The use of 1.0 % of polypropylene short-fiber used as a part of the blend (M3) builds the compressive strength up to 40.94 % contrasted and that of the reference mortar without polypropylene short-fiber.

On the other hand, the compressive strength of the bond mortar with polypropylene short-fiber volume part expanded altogether contrasted with the reference mortar. It is perceptible that the expansion of the compressive strength by using 1.5 % volume division of polypropylene short-fiber (M4) would build the compressive strength up to 54.81 %, instead of the reference mortar. This condition can be established from the change in the mechanical bond strength when the fibres enable the capacity to postpone the small scale break arrangement and capture their proliferation a short time later up to a specific degree [26-27]. The correlation between control mortar blend with the diverse volume division of polypropylene short-fiber used as a part of this investigation demonstrates that there is noteworthy upgrade of compressive strength. This is again because of the expansion of mechanical bond strength. For the most part, a lower flowability mortar blend has a tendency to give a higher strength mortar. Notwithstanding, after assessed the compressive test, it shows there is no connection between the augmentations of polypropylene short fibres for the compressive strength to the flowability of each mortar blend. Consequently, a definitive compressive strength for all fiber reinforced mortar does not rely upon their flowability.

Table 3. The Compressive Strength Results of Mortar Mixes

Mix Designation	Short-Fiber Volume Fraction %	Compressive Strength (MPa)
M 1	0	25.45
M 2	0.5	31.36
M 3	1.0	35.87
M 4	1.5	39.40

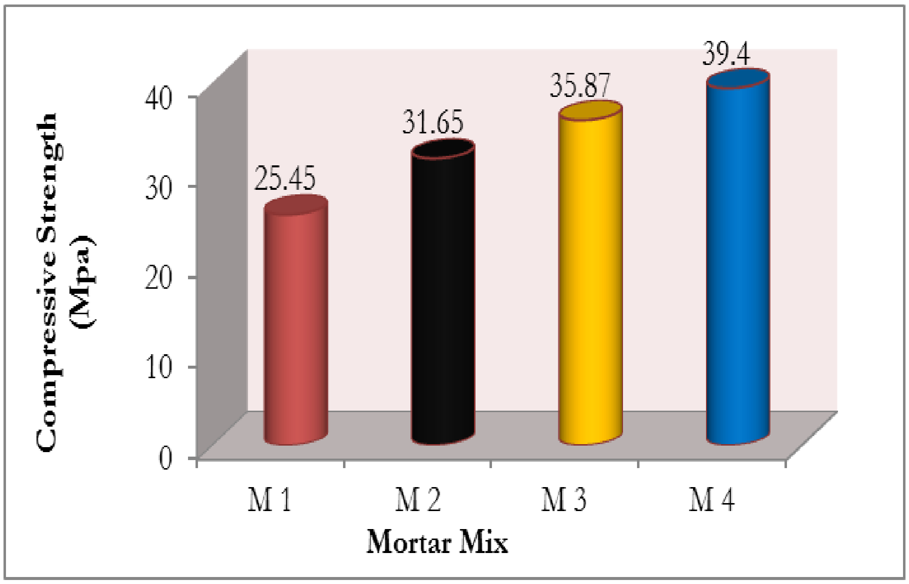


Figure 2. Compressive strength of Polypropylene Fibre Mortar

c. Effect of Polypropylene Short Fiber on Flexural Strength

The flexural strength pattern on all mortar blends when the level of short fiber expanded. Nonetheless, the flexural strength of the mortar blends is appeared in Table 4 and Figure 3 recorded amid the test and the flexural strength distinction in rate for all blend clusters contrasted with control bunch. An examination of Figure 3 demonstrates that a straight relationship exists between the flexural strength and the polypropylene short fibres volume division. The expansion in the flexural strength of the blend containing a 1.5 % volumetric portion of polypropylene short fiber is 53.73 % higher than the control blend, which might be because of the better compaction and homogeneity of the short fiber circulation in mortar blend. It can likewise be noticed that the use of different rates of polypropylene short fiber fundamentally increment the change in flexural strength. An outline can be drawn from the test outcomes that the flowability of mortar marginally lessened as the polypropylene short fiber measurement rate increments. Consequences of compressive strength test demonstrated that the use of polypropylene short fiber in mortar may not effectively increment in strength. In flexural test indicated examples with polypropylene short fibers that extreme increment in strength from examples without polypropylene short fibers. The use of short fibers was completely used with regards to post-breaking stage.

Table 4. The Flexural Strength Results of Mortar Mixes

Mix Designation	**Short-Fiber Volume Fraction %**	**Flexural Strength (MPa)**
M 1	0	3.61
M 2	0.5	4.22
M 3	1.0	4.91
M 4	1.5	5.55

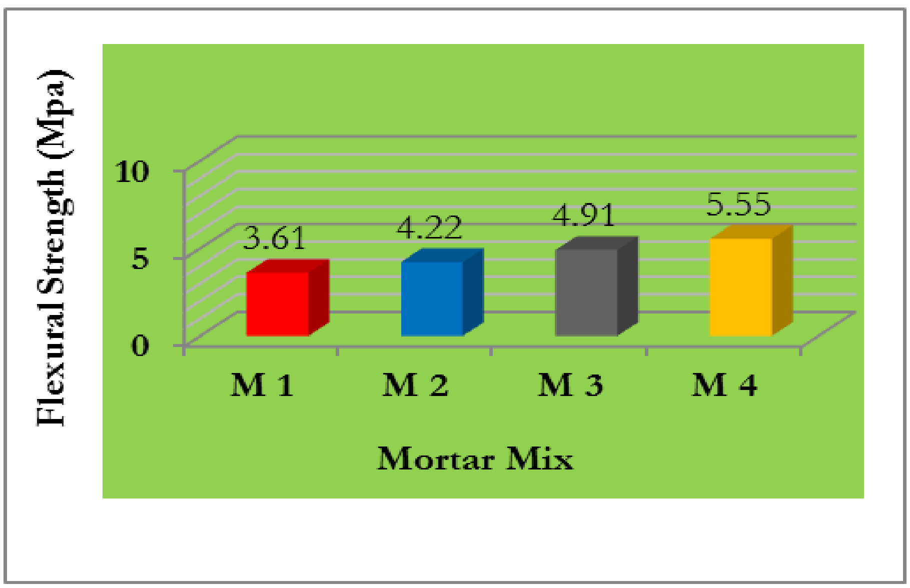


Figure 3. Flexural Strength of Polypropylene Fibre Mortar

4. Conclusion

The main point of this examination was met as it had effectively explored and broke down the impacts of polypropylene short-fiber on basic bond mortar. Additionally, the accomplishment of the investigation destinations (scopes) set in start of the examination was likewise accomplished. This subsequent new material would be used for the most part for the rebuilding or restoration of old building, landmarks and that's only the tip of the iceberg. The cost of fabricate of this item would be practically identical to other comparable composites available, and a substantial scale creation would offer a considerable measure of economies. Polypropylene short fibres are suggested for straightforward mortar support and for in this manner creating composite mortars, on the grounds that other than enhancing flexural and pressure capacities or microcrack engendering constraint, other physical and mechanical properties can likewise be considered. At the point when more established building should be restored, the mortar being referred to is helpful on the grounds that the rabbits net or the metal wire can be expelled for the promptly reinforced putting that can infiltrate much more profound and unpredictable voids that can show up in the wake of evacuating previous mortar. Ultimately, proposals for additionally thinks about were recommended with the use of the polypropylene short fibres in mortar to examine more on its mechanical properties. Based on the aftereffects of this examination, the accompanying conclusions might be deducted:

1. The use of polypropylene short-fiber influences the workability of fiber strengthened bond mortars; Polypropylene short-strands deliver unforgiving blends altogether.

2. The use of polypropylene short-fiber increment the compressive strength when fiber volume portion surpasses (0.5%) by around (31.65 Mpa), (35.65 Mpa) for (1%) and (39.40 Mpa) for (1.5%) volume division of polypropylene short-fiber.

3. The flexural strength outcomes demonstrate that the use of 1.5% of the polypropylene short-fiber as volumetric part expands the flexural strength by around 5.55 Mpa using 1.5% of fiber volumetric division.

5. Recommendation For Further Studies

The exploration displayed here for give more valuable data that could bolster additionally look into in the field of polypropylene reinforced composite materials, both to fill in the needs in the field and to empower the wide use of such materials. Assist examinations were exceptionally prescribed and ought to be completed to see more mechanical properties of polypropylene short fiber reinforced mortar. A few suggestions for additionally examines are specified beneath:

• The issue on the flowability of the crisp polypropylene short fiber reinforced mortart can be lessening by including synthetic admixture, for example, superplasticiser, silica fume or blast furnace slag. Consequently, with high flowability new mortar can downgrade the speedy hardening impacts from the short fibres.

• More examinations and lab tests ought to be done to think about on the mechanical properties of polypropylene short fiber reinforced mortar.

• The blend of short fibres may have a tendency to give more proficient mechanical properties of structure. Assist examination can be done by blend of various kinds of short fibres into the mortar blend.

• To extend the use of fiber reinforced mortar, unique or more confused geometry of fiber can be used to explore the impacts of short fibres in the mortar through new and solidified properties.

• The mechanical properties of fiber reinforced mortar might be diverse in different temperatures. Test on solidify defrosting conditions were prescribed.

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