Reinforcement of white cement by adding fiberglass

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Abstract

This research studies the reinforcement of white cement mortar and reduse cracking by using the fresh and hardend state when addition glass fibers. The glass fiber was replacement rate of 1% , 2% , 3% of the white cement mortar weight . The flow table and setting time was fresh state. In addition, the overall strength of hardened concrete was investigated by using compressive and flexural strength tests as well as dry shrinkage and water absorption. Results showed that fiber addition generally reduces the fresh mortar of workability and no effect or very slight of setting time and reduce dry shrinkage in hardend state. while increases the the flexural strength ,water absorpation. The addition of fibers is one of the nominated methods to overcome the initiation of these cracks as well as the addition of glass fibers reduce the water bleeding of mortar The glass fiber has not a considerable impact on the compressive strength of mortar and increase the flexural strength

1. Introduction

White portland cement or white ordinary portland cement is similar to ordinary gray portland cement in all respects except for its high degree of whiteness. White portland cement is used in combination with white aggregates to produce white concrete for prestige construction projects and decorative work[1]. White cement is a Portland cement which conforms to the specifications of ASTM C150. The general understanding is that certain white cements are not quite as strong as ordinary Portland cement. White Portland cement provides excellent

thermal insulation in comparison to other cement types. The light is reflected well by white cement. It not just offers the building a charm and nice appearance, yet it also provides energy through enlightening the exterior and interior of building[2]. It offers excellent surface finishing. It could be adequate for crack filling and tile grouting [3].Because white cement has early age shrinkage cracking problems, some structural applications in building construction are applied.[4] Utilized for colored concrete with using inorganic pigments for producing brightly-colored concretes and mortars. Utilized in roads because of a high reflectiveness characteristic for adding visibility to highway medians[5].

The glass fibers reinforced mortar (GFRM) is considered an advanced and modern composite material in the field of construction. This composite consists of cementitious matrix includes (cement, sand and water) and reinforcement which is represented by glass fibers[6] .Cement mortar without any fibers addition will promote the generation of cracks as a result of dry and plastic shrinkage or other reasons related to volume changes. These cracks' development results in elastic deformation of cement mortar. The addition of fibers is one of the nominated methods to overcome the initiation of these cracks as well as the addition of glass fibers reduce the water bleeding of mortar[7][8].

GFRM is considered a new building material which has superior properties than ordinary mortar[9].The Addition of glass fibers (GF) to cement mortar is one of adopted methods to improve the properties,

performance and durability of mortar. This addition constructs a cohesive structure overcomes the property of dimensional instability related to the influence of external conditions due to the fragility of the mortar. Also GF addition producing structure with properties better than normal mortar, among these properties are reduced permeability, water proof [10].The glass fiber has not a considerable impact on the compressive strength of mortar. and increase the flexural strength[11]. There are many researchers who have presented studies on white cement and the additives was used in this study such as,

Temiz et al. had investigated the possibility of using WPC that contains pyro-phyllite in producing white concrete[12], Carbone et al., had investigated the impact of polymers on properties of white Portland cement pastes in the hardened state[13]. Cherop et al , had looked into the effects of non-ionic cellulose ethers on white Portland cement properties[14]. Torres-Carrasco et al. investigated the use of synthetic feldspars to improve thermal efficiency in cement mortars[15]. Knapen et al, had used two types of binder are used in these modified cement mortar and concrete: a hydraulic cement system and a polymer system. The aggregates are incorporated in a polymer and cement hydrate network that is interpenetrating. Hoque et al. had investigated for different strength properties of white cement like the setting times and strength for various curing periods and aggregate proportions[16]. Fawzye et al , had discussed the effect of white cement on concrete properties such as fresh properties (slump), mass transport properties

(Isat- sorptivity) and mechanical properties (compressive- splitting tensile). The thermal gravimetric analysis (TGA) of cement paste containing various blending of white cement with SRPC is also investigated[17]. Al-kamal et al. had studied the flexural strength (fr) and the compressive strength (fc) of mortar by the replacement of the white cement that is partial with Nano-Zr2O3 particles. Zr2O3 nanoparticles have been utilized besides the use of the average diameter of 35nm with 4 different contents by white cement wt. (0.25%, 0.75%, 1.25% & 1.75%)[18].

2.Important of the work

The aim of this study is to use three additives to reduce the possibility of cracks occur in white Portland cement within the White cement mortar, such as glass fiber.

3.Materials and Experimental work

3.1 Materials

3.1.1 White Portland cement

The white cement utilized in this investigation complies with Iraq Standard No.5 criteria (IQS5:1993). The white cement's chemical synthesis is shown in table 1 below.

Table (1) Chemical synthesis of the white cement

Constituents	% weight	Specification limits of IQS (5:1993) [19]
CaO	68.12	-

Al2O3	4.75	-
Fe2O3	0.50	-
SiO2	24.03	-
So3	2.57	<3
MgO	0.77	<5
Loss on ignition	3.37	<4
Insoluble residue	0.46	<1.5
Lime saturation factor	0.9	0.66 – 1.022
Total	100	-

3.1.2. Fine aggregate

Standard sand was used in this research depend on ASTM C778 [20]. Table 2 shows grading of fine aggregate

Table (2). Grading of fine aggregate

Sieve size	Passing percent %
1.18 mm	100
0.600 mm	98.6
0.425 mm	74.1
0.300 mm	24.3
0.150 mm	0.12

Composition &properties	S-glass (%)

3.1.3 Glass fiber :

we used glass fibre type S-glass (alumina silicate glass without the calcium oxide but with a high magnesium oxide contents with the high tensile strength) to enhancing flexural strength. From (Hastin,NE ,USA)

Table(3)TypicalGlass Composition and Characteristics

3.1.4. Water:

SiO_2	65
Al_2O_3	25
MgO	10
Modulus (GPa)	80
Strength (MPa)	2600
Density (Mg/m^3)	2.49
Absorption	0.49

Distilled water was used in this study.

3.2. Distinguish of Mixtures

In this work, the mixtures was prepared by The control mixtures were made of Fine Aggregate (Sand), cement and water only. with no addition, therefore the results of this group are considered zero for the improvement in cement. and with addition was prepared from (cement ,sand ,water. Glass fiber) we partial replacement of cement by ratio are (1% , 2% , 3%)by weight of white cement. Table 6 shows in details distinguish of all mortar mixtures that were used in this study.

Table (4) Mix proportion of white cement mortar

Mixtures	G.F. % wt
WC	-
GF1	1%
GF2	2%
GF3	3%

4. METHODSP:

1. Flow table tested Using an ASTM C-230 [21].the standard of the flow test utilizes a standard molding of the conical frustum (Height 50mm, base diameter 100mm, top diameter 70mm), flow table has been wiped dry and clean and the flow mold is placed at center.The mortar poured at two layers each layer approximately 25mm in mold thickness and after that tamped 20 times with tamper, the tamping pressure is going to be appropriate for obtaining uniform mass in mold. After that poured the second layer in the same procedure for the 1st layer. then mortar has been cut off for obtaining a plane surface flus with top of mold through drawing of straight edge or the trowel edge with sawing movement over the top of mold. After 1 minute from completing the pouring operation of mortar the mold is lifted from mortar. The table is immediately dropped 25 times in 15sec, the mortar diameter is recording every one of the diameters to the nearest millimeter. The flow table test determines by:

Flow = [(Davg – Do) / Do] *100 ….eq(1)

Where,

Davg= Average base diameter

Do= Original base dia.

2.setting time test is a standard Vicat apparatus is utilized to determine the setting time according to (ASTM: C191) [22].when cement is mixed with (GF),this test was carried out by prepare a paste of binder (cement with or without additive) and poured the paste in mold (70mm lower diameter , 60mm upper diameter and 40mm height) and resting on the non- porous plate (glass plate), Initial time of setting was determined by using needle (1mm diameter),needle to the point where

it becomes in a contact with the test block surface and released quickly, which allows it penetrating the block of the test, this process has been repeated to the point where the needle fails at penetrating the block to 5±0.50mm from the mold's bottom. The duration from time of the addition of water into cement and time where the needle has failed at the penetration of the block of the test to 5 ± 0.50mm from the mold's bottom is referred to as the initial time of the setting. While the Final setting time was determined by using needle (5mm diameter) in the case of the gentle application of the needle to the mold's surface, the needle makes an impression there on. the final set was reached when the attachment has failed at making an impression on the test block surface. The period from the time of adding the water into the time at which needle has failed at making impression on the test block surface is known as final setting time

3. The compressive strength test is determined according to ASTM: C150 [23] using the dimensions of 50 x 50 x 50 mm A digital compressive machine (Control) with a capacity of 250kN was used to test the compressive strength cubes. The tests were conducted at 28 days of age, with an average of three test results used for each test. This test is useful in determining the mechanical qualities of cement mortar (strength and durability). the compressive strength is determined by using the formula below:

$$\sigma = P / A \quad \ldots(2)$$

where:

σ= Compressive Strength, P= Load

A=Cross sectional area

4. Modulus of rupture was tested Using an ASTM C 192 [24] prism with dimensions of 40 x 40 x 160 mm. Flexural strength is usually stated in design codes as the Modulus of Rapture (MOR). Flexural

strength can be calculated using the ASTM C 293 three-point loading test, according to the standard. All prisms in this study are tested on a test machine with a capacity of 30 KN. This test demonstrates the significance of material bending and breakage. Modulus of rupture is determined by using the formula below:

$$MOR = \frac{3PL}{2bd^2} \ldots\ldots (3)$$

P = maximum load in N , L = specimen length between supports in mm

b= fracture cross section width in millimeter d= the height of the fracture cross section in millimeters

The prisms are cast and cured under the same conditions as the compressive strength test specimens.

5. Absorption Test, After the specimens have been demolded They're weighted and drenched in water, then quickly removed and dried with a piece of cloth to remove any remaining water. The specimens are weighed again after this test, which reveals the holes in the material. The water absorption is determined by applying the Eq. 3:

$$Water\ absorption\ \% = \frac{(Ws-Wd)}{Wd}\ x100\% \ldots (4)$$

Where;

Ws: weight of the soaked pieces in gm.

wd: weight of the dry pieces in gm

6. Dry shrinkage test, was determined based on ASTM: C 596-04 [25]. a flow table test must be performed before inserting the materials to be tested in the molds to establish how much water each sample requires to achieve a flow value of 110 percent. Test specimen molds must have dimensions of 25 x 25 x 285 mm .before and after

drying, the length of mortar bars differed. is measured using this method. This test demonstrates the likelihood of cracks in the mortar. determined by applying the Eq. (5)

$$\text{Dry shrinkage\%} = \frac{Li\ after\ 25\ day(mm) - L\ after\ 3\ day(mm)}{l\ eff\ (250mm)} \times 100 \quad \ldots(5)$$

Where: -

L_i - Length of specimens after 25 days. (mm)

L- Length of specimens after 3 days. (mm)

L_{eff} - The effective length of the test specimen. (250mm)

4.7 Preparation for compressive strength and flexural strength:

The procedure of prepared mortar has been divided into two main branches. initially, it was weighed and the amount of sand, cement and water were calculated.

1-Weighing the components by a sensitive digital balance of 0.01 gm digits.

2-Dry mixing of additives with cement mortar for glass fiber

3-Sand and cement mixed together for about two minutes, the water and additive was added to the mixture and mixed for four minutes according to ASTM C305 [26].

4-The mortar was withdrawn from the mixer and put into clean, oiled molds; the sample densification was done in two layers on a vibrating table, with each layer vibrating for 1 to 1.5 minutes until no air bubbles emerged on the casting surface.

5- A spatula was used to finish the samples' surfaces.

6- Molds were covered with plastic sheets after molding to preserve moisture, and samples were maintained at room temperature for 24 hours in the lab.

7- The samples were then demolded and cured in water before being tested.

5. Results and discussion :

5.1 Flow table test:

Table 1 shows the results of MOR test for each samples.

Table (5) the result of flow table

Mixtures	Flow table%
WC	46
G.F1	44
G.F2	42
G.F3	39

we notice a decrease in the operability values when adding fiber, that is, when we increase the amount of fiber replaced by cement, the operability values decrease, due to:

It is attributed to the fact that the fibers have a large surface area, and this large surface area negatively affects the rheological and fresh properties of the mortar. As it spreads over large areas, it hinders the movement of particles in fresh mortar[27] [28]

5.2 Setting time test:

Table (6) shows the results of initial and finale setting time test for each samples.

Table (6) for initial and final setting time

Mixtures	Setting time	
	initial	finale
GF1	1:40	2:40
GF2	1:45	1:45
Gf3	1:45	2:50

we note that the fiber glass does not have a significant effect on the setting time, as it increases by a rate of minutes when the content of the replaced glass fiber of cement is increased, and then it stops, which does not affect even if the content is increased. This is due to

the surfaces of fiber-class are free from smoothness and roughness, so we did not notice any agglomeration during mixing, and the fibers are distributed on the basis that they are not (floating on the surface or sinking to the bottom), which can be related to the use of chemical additives[29]

5.3 Compressive strength (fc):

Table (7) shows the results of compressive strength test for each samples.

Table (7) Results of compressive strength test

Mixtures	fc (MPa)
WC	26.1

G.F1	27.4
G.F2	26.8
G.F3	26.4

we note that the fiber class does not have a significant effect on the setting time, as it increases by a rate of minutes when the content of the replaced glass fiber of cement is increased, and then it stops, which does not affect even if the content is increased. This is due to the surfaces of fiber-class are free from smoothness and roughness, so we did not notice any agglomeration during mixing, and the fibers are distributed on the basis that they are not (floating on the surface or sinking to the bottom), which can be related to the use of chemical additives[29].

5.4 Modulus of rupture (MOR)

Table (8) Shows the results of MOR test for each samples.

Table (8) results of MOR test

Mixtures	MOR (MPa)
WC	6.2
G.F1	6.4
G.F2	6.7
G.F3	6.9

we notice that the more glass fiber content substituted in the cement increases, the greater the flexural strength increases, due to :

the fibers resist the spread of cracks, which leads to a reduction in the sudden failure of the mortar, which leads to an increase in the carrying capacity of the mortar. The fibers resist the spread of cracks, which leads to a reduction in the sudden failure of the mortar, which leads to an increase in the carrying capacity of the mortar[30].

5.5 Absorption of water

Table (9) shows the results of absorption test for each samples.

Table (9) results of absorption test

Mixtures	Absorption %
WC	3.88
G.F1	3.92
G.F2	3.95
G.F3	3.97

we note that the fiber class does not have a significant effect on the setting time, as it increases by a rate of minutes when the content of the replaced glass fiber of cement is increased, and then it stops, which does not affect even if the content is increased. This is due to the surfaces of fiber-class are free from smoothness and roughness, so we did not notice any agglomeration during mixing, and the fibers are distributed on the basis that they are not (floating on the surface or

sinking to the bottom), which can be related to the use of chemical additives[29].

5.6 Dry shrinkage

Table (10) shows the results of dry shrinkage test and flow table test for each samples.

Table (10) results of absorption test

Mixtures	W/C determined by flow table test %	Dry shrinkage %
WC	46	0.007
G.F1	44	0.006
G.F2	42	0.004
G.F3	39	0.003

we note that the fiber class does not have a significant effect on the setting time, as it increases by a rate of minutes when the content of the replaced glass fiber of cement is increased, and then it stops, which does not affect even if the content is increased. This is due to the surfaces of fiber-class are free from smoothness and roughness, so we did not notice any agglomeration during mixing, and the fibers are distributed on the basis that they are not (floating on the surface or sinking to the bottom), which can be related to the use of chemical additives[29].

6. Conclusions :

The following conclusions can be made from the above-mentioned test results:

1. The use glass fiber considerably reduce the possibility of cracks occur in white cement mortar.

7. References

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