Effect of Glass Wool Addition on Some Properties of Cement Mortar

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ABSTRACT

This work presents an investigation of possible incorporation of the glass wool (fiberglass insulation) in cement mortar as an insulating building material. Mortar of ordinary Portland cement of (1:3) cement to sand ratio was mixed with glass wool at different weight percentages ranged between (0 – 0.24) wt%. Density, water absorption, thermal conductivity, compressive strength and flexural strength experimentally were investigated for mortar specimens after curing for (28 days). The results showed that the incorporation of glass wool decreases the density, thermal conductivity and compressive strength, but the flexural strength of cement mortar enhances. Thermal conductivity of the cement mortar has decreased by about 44 % by increasing of glass wool content up to 0.24 wt%. Thus, utilization of glass wool as constituents in cement mortar appears to be a promising opportunity that enables applying as thermal insulation materials in constructions.

Keywords: Cement mortar, glass wool, flexural strength and thermal conductivity.

INTRODUCTION

Cement mortar is a workable paste consisting of cement, sand and water. It is widely used for joining the building blocks such as bricks, stones, concrete masonry units together, plastering and tile placing etc. [1,2]. Cement mortar exhibits a low to medium compression strength compared to other cement-based materials, like concrete, while its flexural strength is semi-brittle [3]. Mortar might undergo shrinkage, cracking and problems of low durability under the long term serves, depending on the environmental conditions. Incorporation of fibers in the cement mortar is considered a common method to improve the physical and mechanical properties of mortars [3-5].

Many experiments by several authors have been carried out of using various types of fibers in the cement-matrix composites. For example, Chung [6], reported that addition of short carbon fiber in a cement matrix composites exhibit attractive tensile and flexural properties, low thermal conductivity, high corrosion resistance and low drying shrinkage behavior. Shu et al [4], studied the effect of carbon fiber with different sizes on the mechanical properties of cement mortar. The results show that the hybrid fiber mix exhibited superior tensile performance of mortars. Mahdi [7], studied the effect of glass fiber on cement mortar. The results showed that the mortar mixed contents of 1 wt% glass fiber gave a higher flexural and compressive strength than the mortar mixed with 2 wt% glass fiber content.

Thermal insulating of mortars is an important means to face the problem of energy consumption issues in construction wrapping. The thermal insulating mortar represents one of the possible solutions for energy efficiency issues in building field [8,9]. In percent work, cement mortar incorporated with glass wool fibers is investigated for this purpose. Glass wool is considered one of the most effective insulation products, because of its thermal and acoustic properties, light weight, chemically inert and high tensile strength. The glass wool consists of fine, long, inorganic fibers of glass which is layered and arranged using a binder into a texture similar to wool. Typical the nominal glass wool fiber diameters approximate of 4 to15 microns [9-11].

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The aim of percent work is to study the possibility of incorporation of glass wool in cement mortars for enhancing the mortar insulating properties. Hence, this work focuses on the experimental study of mechanical properties and thermal conductivity of glass wool embedded in cement mortars.

Experimental Work

Materials:

Ordinary Portland cement was used in this work as the main components of the binder for preparing of cement mortar. This cement provided by Tasloga cement factory, and it is conformed according to the Iraqi specification No.5/1984. AL-Ukhaider natural sand was used as fine aggregate. This fine aggregate was sieved to obtain of <1.12 mm particle size. Glass wool is used as additive material in the cement mortar mixture. Glass wool used in this work having a density of 24 kg/m^3 and it is provided from NATINDCO Company-India, as a blanket roll form with a width of 1.2 m. Glass wool blanket has been chopped in small pieces of about (0.5–1) cm^3 size and then opened its tangles by hand in order to easily mix with cement mortar mixture.

Mortar Mix Proportion:

The cement mortar mix was prepared with a ratio of (1:3) cement to sand. The glass wool was added to the cement mortar mix at different percentages of (0, 0.06, 0.12, 0.18 and 0.24) wt% by total weight of mortar mix. Cement mortar mix with glass wool were mixed by hand in the dry condition firstly, and then ordinary tap water was added to produce a uniform cement mortar-glass wool mixture. The water to cement ratio was equal to 0.5 for all of mortars.

Casting and Curing:

The cement mortar specimens were casted using cubes of (50 mm), prisms of (25x25x120) mm from steel molds, and a disc of (35 mm in diameter and 15 mm in height) plastic mold. The molded specimens were stored in laboratory conditions and covered with wet burlap for the first 24 hours to prevent moisture loss. After removing from molds, the specimens were cured by submerged in a tap water tank at temperature of ~30°C for 28 days. The shapes of casted specimens are illustrated in figure (1).

Specimens Tests:

The physical, mechanical and thermal properties of the cement mortar samples were measured. Bulk density and water absorption of mortar specimens have been determined by using the procedure specified in accordance to the ASTM C-642. The compressive strength of cubic mortar specimens was calculated according to the ASTM C-109. Flexural strength of the prism specimens was performed using three-point bending method according to the ASTM C-348. Thermal conductivity of the disc specimens shape was measured by the hot disk method. Figure (2) shows the mortar specimens during compression and flexural test.

Figure (1): The casted specimens of cement mortar contents glass wool.

Figure (2): The mortar specimens during compression and flexural test.

Results and Discussion

Density:

The relationship between weight fractions of the glass wool on density of the cement mortar is shown in figure (3). It has been shown that the density of cement mortar specimens is slightly decreased with increasing of glass wool content. This decreasing seems reasonable because glass wool fibers are lighter than fresh cement mortar mix, and a larger content of glass wool will decrease the density. Moreover, the fact that incorporation of fibers into a composite makes to generate air in the matrix and increase in porosity and thus reduced the final density [12].

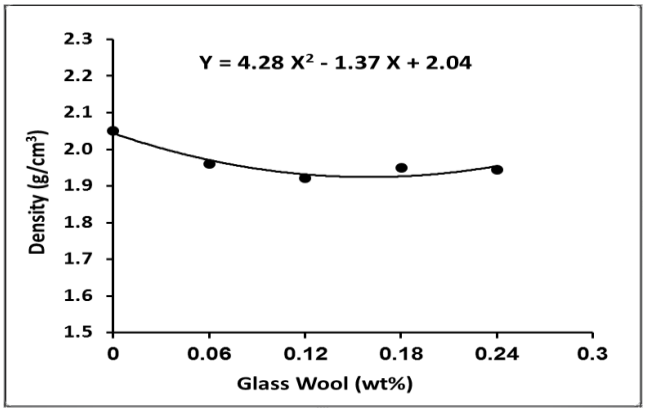

Figure (3): Effect of glass wool contents on the density of cement mortar specimens.

Water Absorption:

Water absorption property is a measure of the porosity and it provides useful information about the volume of permeable pores inside the samples and possible connectivity between these pores [3]. Reducing the water absorption of mortars as much as possible is necessary in most of mortar applications in order to enhance its durability [13, 14]. The influence of glass wool addition on the water absorption of cement mortar is shown in figure (4).

Figure (4) revealed that the percentages of water absorption of mortar specimen is decreased, to reach the minimum value of (3.53%) with addition of 0.12 wt% glass wool as compared to the absorption of fresh mortar specimens of (4.61%). The further increasing of glass wool content, more than 0.12 wt%, in cement mortar the absorption increases. When the glass wool content is less, the fibers of glass wool may be bonded with the cement and forms same as a network in the mortar structure, which makes to isolate the pores and hence reducing the permeability of pores. With increasing of glass wool fibers content more than 0.12 wt%, some of these fibers were appeared on the surface of mortar specimens. It is reported that the glass wool fiber has moisture absorption about 3 % of weight at a relative humidity of 90 % [11]. Therefore, the presence of glass wool fibers on the surface of specimens can be considered as

capillary tubes for water transport and thus assist the water to penetrate inside the specimens, thereby the water absorption percentages of cement mortar increases.

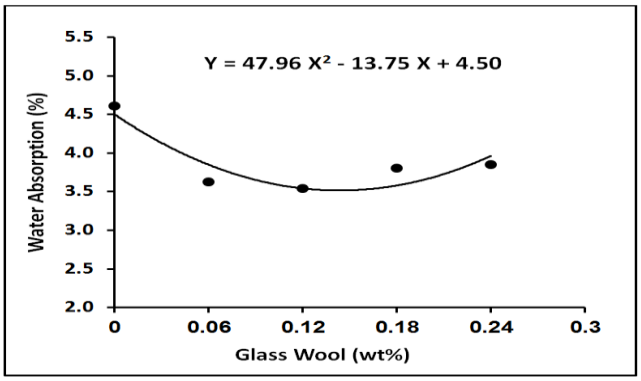

Figure (4): Effect of glass wool contents on the water absorption of cement mortar specimens.

Thermal Conductivity:

The objective of measuring this property is to obtain a mortar for plastering buildings has better thermal insulation, which helps to prevent the temperature leaking from inside the building to outside or vice versa. The relationship between thermal conductivity of cement mortar specimens that content different values of weight fractions of glass wool is presented in figure (5).

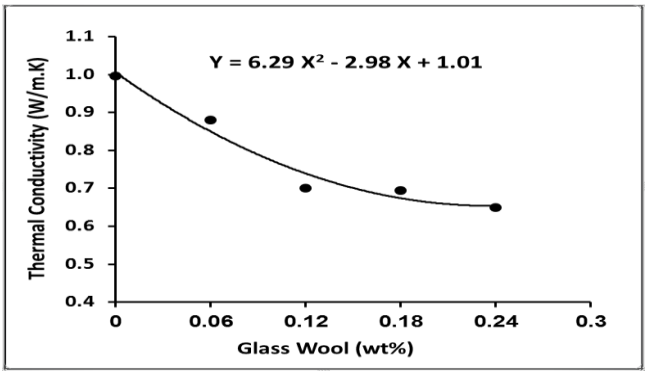

Figure (5): Effect of glass wool contents on the thermal conductivity of cement mortar specimens.

It is clear that the thermal conductivity of mortar specimens exhibited a continuous decrease in values with increase of glass wool percentages in the cement mortar. Thermal conductivity of cement mortar is decreased about 44 % with addition 0.24 wt% of glass wool. This is due to the glass wool fibers has a lower thermal conductivity of (0.035 W/m.K) [10], compared to that of cement mortar matrix. Consequently, the enhancement of thermal insulation of the mortar specimens is attributed to the inherent low thermal conductivity of the glass wool fibers. Besides, the fact that embedded of fibers in a composite makes to generate air in the matrix and lowers the density [12].

Compressive Strength:

Figure (6) shows the variations of compressive strength of the mortar specimens with addition of glass wool. It has been observed that the compressive strength decreases with increasing of glass wool content. The decreasing of compressive strength of cement mortar specimens is about 19 % with addition of 0.24 wt% of glass wool. This behavior is attributed to

the light weight of glass wool fibers that works as inclusion or same as voids within a cement mortar matrix, which leads to reduce the mortar strength. In fact, the packing and aligning of short fibers is more difficult than the larger one. Hence, the mortar filled with the short fibers result in an increase of the flaws numbers, and this generates reduce in the density and compressive strength [12]. Generally, the mortar mix incorporated with fibers was required more water amount than mortar without fibers. This fact leads to lack in the hydration action in cement mortar structure with increase of glass wool content [12,15].

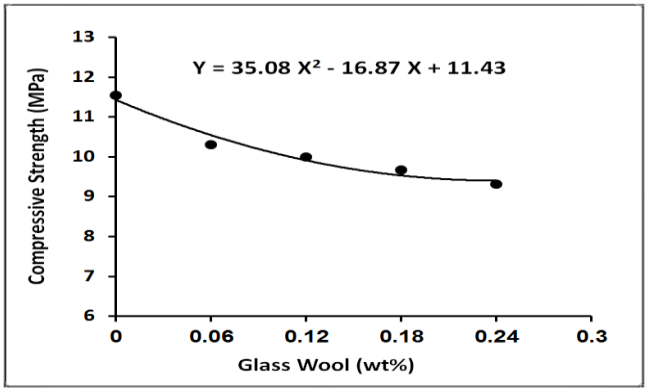

Figure (6): Effect of glass wool contents on the compressive strength of cement mortar specimens.

Flexural Strength:

Tensile strength is an important property of cementations materials because its structures are highly vulnerable to tensile cracking due to various kinds of effects and applied loading itself. However, the flexural test is one measure of the tensile strength of cement-based materials due to difficulty in applying uniaxial tension to its specimens because of its brittle nature and low tensile strength [5,7]. The effect of glass wool addition on the flexural strength of cement mortar is shown in figure (7). The flexural strength of mortar specimens is slightly enhancement with an increase in the weight fraction of glass wool. This behavior can be explained that the mortar specimens in the flexural test are subjected to the tension state more than compression. Thus, that the fibers of glass wool are able to resist the tensile strength higher than the cement mortar matrix, and that in turn lead to an increase in effective fracture energy [5]. The dispersed of glass wool in cement mortar enhanced the plastic deformation, absorb a portion of energy and make the crack propagation path longer. Thereby, the fracture energy increases and the flexural strength of cement mortar increase with increasing of the glass wool content.

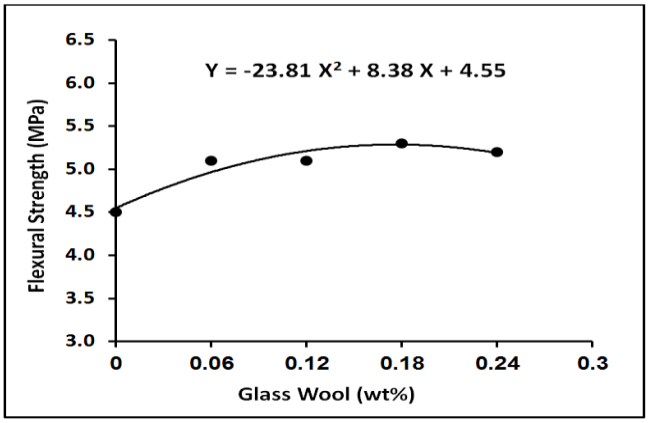

Figure (7): Effect of glass wool contents on the flexural strength of cement mortar specimens.

CONCLUSIONS

In this work, the effect of glass wool on the cement mortar properties was studied. The main conclusions obtained from this work can be summarized as follows:

1. Increasing of glass wool content in the cement mortar allows lightens the mortar by decreasing its density. Reducing the mortar density will make it a better material for building of light-weight structural components.
2. Thermal conductivity of the cement mortar is decreased of about 44 % with increasing of glass wool addition up to 0.24 wt%. Thermal conductivity has shown a promising opportunity for glass wool in mortars, because the new mortar attained good thermal insulation value compared to fresh mortars.
3. Incorporation of glass wool in the cement mortar mix generally improved the flexural strength, but resulted in reduction of compressive strength, thus related to the glass wool fibers properties in the mortar, which absorbed capacity of bearing load through tension state higher than compression.
4. It can be concluded that using of low glass wool contents up to 0.12 wt% in the cement mortar mix, enables obtaining a mortar with somewhat acceptable thermal and mechanical properties, which can be well used in the insulation constructions as a new mortar material for energy efficiency in the buildings.

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