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Research Paper

Effect of Adding Porcelain and Glass Powder Mixture on Epoxy Properties

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Abstract

In this research, porcelain powder and glass was added by 0.25% (0.15% porcelain powder and 0.1% glass powder) to the epoxy used in the concrete strengthening. The addition improved epoxy properties and reduced the cost. The results showed that the addition of porcelain and glass powder decrease the interaction temperature by 11.37%, epoxy flow by 10.41%, and increase the compressive strength by 7.61%. Upon testing the improved epoxy cubes under the effect of temperatures up to 200° C compression resistance decreased by 6.36%, while both modulus of rupture and modulus of elasticity improved by (1.03% and 4.11%) respectively. The epoxy was tested and used to strengthen reinforced concrete beams and tests showed good improvement in flexural properties.

Keywords: *Carbon fiber, concrete beams, epoxy, glass, porcelain.*

1. Introduction

Recently, epoxy has been used in several fields, including strengthening and treating concrete parts, especially with polymers. But one of the main disadvantages of this type of treatment is the high cost, This cost is not only due to the high price of epoxy, but due to the working conditions imposed by the properties of the epoxy itself, which cannot be mixed in large quantities because of the heat resulting from the mixing of the two parts composed of A and B, which lead to the speed of hardness in addition to the nature of its texture, which is characterized by high flow, Hence the idea of this study which involves the addition of a mixture of porcelain and glass powder by 0.25% (0.15% porcelain powder and 0.1% glass powder) to the epoxy to improve its properties in addition to what this means to reduce the cost.

Literature Review: There are many studies conducted in this field, the most important of which are:

Al-Janabi (Al-Janabi, 1994) studied the mechanical properties of epoxy-supported by fibers palm with different percentages (16% and 18%). Which use in this study natural palm fibers, representing the internal part of the palm (the heart of the palm), She work several models and subjected to different temperatures and found that the strength of epoxy increases by increasing fiber strengthening and raise the temperature to a specific temperature and the best rate of addition of palm fiber is 18%.

Hisham and others (Hisham et al., 1999) calculated the coefficient of elasticity and the fracture coefficient of the strengthened epoxy material in three cases, where the copper wire was once strengthened once again with the steel wires separately and the hybrid strengthening of both types (copper wires and low carbon steel wires equally), The addition rate was constant 8% for all these materials, The properties of this strengthening for epoxy were studied at different temperatures (0, 28, 40 and 50° C) and compared with the standard epoxy material, It was concluded that for all types of epoxy- strengthened wire, the coefficient of elasticity increases with wire strengthening and decreases with increasing temperature. The fracture coefficient increases with wire strengthening and with increasing temperature except when approaching the glass transition rate (Tg) where the fracture coefficient is lower.

Kereem (2002) studied the mechanical properties of epoxy strengthening with powder of nickel. The powder was used in different sizes and ratios.It was found that the coefficient of elasticity and compression resistance increased with increasing percentage and size of the nickel powder added.

Osman (2008) studied the effect of adding alumina powder by 10% of the weight of the bonding material to the mechanical properties of the fiber- strengthening the epoxy material. The researcher concluded that both flexure resistance and elasticity coefficient increased by (33)% and (78)% respectively when adding alumina powder compared to glass fiber strengthening epoxy and is not supported by alumina powder.

Balqees and others (2009) studied the effect of ultraviolet radiation on some mechanical properties of epoxy supported in four different cases at the rate of 30% ,First in glass fiber, aluminum powder, Second with glass fiber, silica powder, third with aluminum powder only and finally with silica powder only, The samples were subjected to radiation for periods of (15, 50 and 100) hours, It was concluded that the best case for epoxy strengthening was the first and second, which increased compressive resistance, elasticity coefficient, shock resistance and all conditions of subjected to ultraviolet radiation.

Mohammed (2011) studied the mechanical properties of the bonded epoxy material with copper powder at different rates. He concluded that increasing the ratio of copper powder to epoxy increased the elasticity, strength, and resistance of shock and reduced the resistance of fracture and friction of epoxy, The best ratio added was used (15) % which improved the mechanical properties of epoxy.

Abdulaziz (2013) added iron and silicon carbides with different percentages of these materials (10%, 20%, 30%) to epoxy bonding material in addition to the use of metal mesh, polymer mesh and glass fiber, Where the metal models are glued with galvanized steel, copper, and aluminum, This process increased the bonding strength of epoxy after the use of these strengthening materials, This study included a statement of the effect of the addition of different strengthening materials on the shear stresses. It also included changing the addition of strengthening materials in different ratios and the effect of this change on the shear resistance of the glue layer, Shear resistance was measured for pasted models with factory gluey where a significant improvement in shear resistance was observed with variation in the rate of improvement of shear resistance with the difference of additives and the type of metal used, The highest improvement in shear resistance was for copper clad with epoxy plus 10% iron bond as a percentage of bond weight.

Khalid and others (2014) studied the strengthening of epoxy bonding with magnesium oxide powder (MgO) and in different percentages of epoxy weight (5%, 10%, 15%, 20%, 25%). They tested the elasticity and hardness coefficient of this strengthening. The results showed that the elasticity coefficient increases with the addition of the magnesium oxide powder added. The hardness is increased by a nonlinear relationship with the increase of magnesium oxide powder.

Wadad (2016) studied the shock resistance and water absorption ratio of the epoxy material supported and strengthening with eggshell powders for chicken and different percentages (1%, 2%, 3%, 4%). It was found that adding 1% egg peel powder gives high resistance to shock and water absorption.

Abdullah and others (2016) studied to improve the properties of Epoxy. Their study included the study of the mechanical properties resulting from the addition of fine sand to the bonding material at different rates (0.25, 0.5, 1, 1.25, 1.5) of the weight of this material, The results of the tests showed that this addition increased the compressive resistance, fracture coefficient, fire resistance, toughness and hardness of this material. This also decreases the heat of the reaction resulting from the partial response of the bonding material and also improved the workability of this material well. It has also significantly increased its toughness, stiffness, and ductility for beams strengthening with carbon fiber (CFRP). The best addition of sand was (1) thus contributing to reducing the cost of bonding material.

Abdullah (Qutaiba N. Abdullah 2018) studied the effect of adding three powders, the powder of porcelain, glass powder and brick powder on the bonding material separately and at different rates are (0, 0.25, 0.5, 0.75, 1 and 1.25) It was found that the best types of the three powders are the porcelain powder by adding 0.25, which added to the decrease of the reaction temperature by (15.56)% and improved the flow by (7.89)%. The compressive strength and the elastic coefficient increased by (13.33)% and (11)% respectively, while the fracture coefficient of (7.04)%. Either glass powder was added to increase the fracture coefficient by (10.54) % and decreased Both compression resistance, elasticity coefficient in the rate of (6.67) % and (6.5) %, respectively. While the addition of the powder bricks to the deterioration of the values of the factors of flexibility and refraction and low compressive strength also proved that all types of additives lead to a decrease in the temperature of the interaction and reduce the flow of epoxy while varying rates increase or decrease the values of both compressive strength and fracture, the flexibility coefficient .Therefore, the idea of this research was based on mixing the powders of porcelain and glass and then adding the mixture to the epoxy. The purpose of this study is to reduce the cost of epoxy by adding the mix of porcelain and glass together, in addition to the result of this addition of the improvement of the properties of epoxy represented by the resistance of compression, the coefficient of fracture & flexibility, the flow of material and temperature of the interaction.

3. Materials and Methods

The following articles were used in this study:

Epoxy: In this study was used epoxy-type Sikadur®-30, It consists of medium viscosity materials with a density of 1.65 kg / L, and the mixing ratio for its constituents A and B is 1: 3.

Powders Additive: A mixture of porcelain and glass powder was added by 0.25 (0.15 porcelain powder and 0.1 glass powder). Each material was crush separately after washing them well and then drying them. Each powder is passing separately from a 300 µm to 75 µm sieve. The remaining powder is then taken to a 75µm sieve, ensuring a homogeneous distribution of each powder. The powder is then washed well and then dried before adding.

Carbon Fiber: The carbon fiber used to strengthen concrete beams in this study is SikaWrap- 300C, Its weight is (225) gm/cm٢, and its tensile strength is (3900) N/mm^2.

Concrete Mix: The concrete mix is designed according to the requirements of (ACI-Code) Its compressive strength is (30) Mpa, and the ratio of water to cement (w/c) 0.54 and its slump (85) mm was used for casting the beams in this study.

Cubes and Prisms: For the new epoxy test, all tests performed by the original epoxy manufacturers should be carried out. Therefore casting the cubes and prisms containing the epoxy to be examined for testing and comparison purposes, Where the cubes measured (40x40x40)mm while the prisms were measuring (40x40x160)mm, The models were testing at 3, 7 and 28 days for both tests compression resistance for epoxy cubes according to ASTM C109 (ASTMC109, 2004) and the fracture coefficient for epoxy prisms according to ASTM C 348 (ASTM-C348, 2004), During the testing the epoxy prisms were placed under one point load, The distance between the supports (100)mm, as shown in Figure (1). For knowing the effect of high temperatures on the compressive strength of epoxy cubes, it is placed in an oven for three hours and at different temperatures starting from 25°C to 200°C. The temperature increase is gradual increase by 10° C every minute, and at the end, the temperature is left to set for 60 minutes to ensure equal and uniform temperature distribution.

Fig. 1: Represent both the compression resistance of the cubes and the fracture coefficient of the prisms.

Reinforced Beams: Nine concrete beams were cast with a length of (1000) mm and dimensions of (150 x 150)mm, It was reinforced with an iron fy = 672Mpa and (6)mm diameter with two bars at the top and three bars at the bottom and reinforced for the shear strength with the same diameter of the reinforcing steel every (60)mm, All reinforcing details were within ACI-Code limits. The nine different beams represent the first of which is a normal model without any treatment symbolized as (A) and the second model is strengthening by CFRP using the usual bonding material (E) while the third model after strengthening it with CFRP using the new bonding material (PG) , With three beams for each model, all models were tested under the One Point Load to know the type of failure and endurance.

4. Results and Discussions

Interaction temperature: The addition of the mixture of porcelain and glass to epoxy resulted in a decrease in the reaction temperature during the mixing by 11.37% compared to the temperature of the reaction of the first epoxy without adding. This decrease is beneficial in the possibility of processing more massive quantities in the case of vast strengthening, which requires the use of large amounts of epoxy at work without the scare of loss due to high temperature.

Epoxy Flow: The addition of the mixture of porcelain and glass led to reducing the flow of the mix by 10.41% compared to the flow of the first epoxy before the addition process. This new flow contributes significantly to giving more flexibility during work.

Compression Resistance: The addition of the mixture of porcelain and glass led to increased compressive resistance when the cubes were testing in the normal condition by (7.61)% for the first epoxy while their value decreased by (6.36)%. When exposing the models to high temperatures of 200°C, Figures (2) and (3) Compression resistance in both cases.

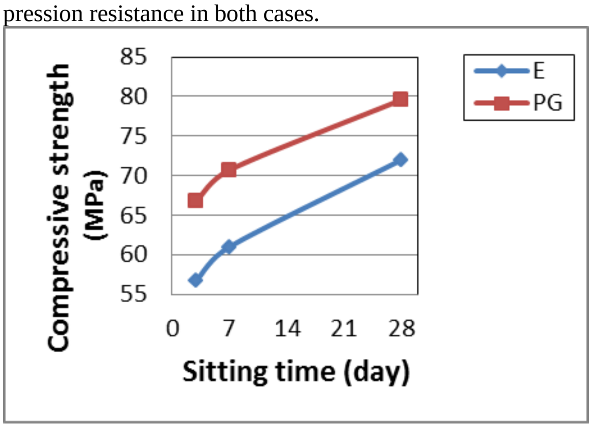

Fig.2: Compression strength of normal epoxy cubes and treatment

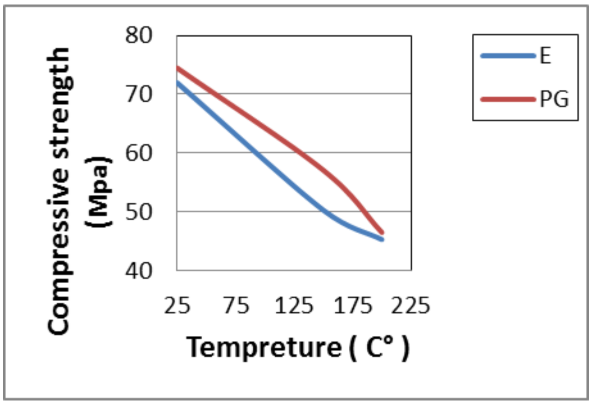

Fig. 3: Effect of temperature on the compressive strength of normal epoxy cubes and treatment

Coefficient of Fracture: It was found that when testing the prisms of the bonding material the addition of the mixture of porcelain powder and glass to epoxy has increased the value of the fracture coefficient by a small percentage not exceeding (1.03)% only. Figure (4) shows the effect of adding the powder to the value of the fracture coefficient.

Coefficient of Elasticity: In this test, the relationship between load and deflection is found for both the first epoxy and the new epoxy, and then the results are compared with each other. Figure (5) shows the relationship between the load and the deflection of the two cubes as the elasticity coefficient increased by (4.11)%.

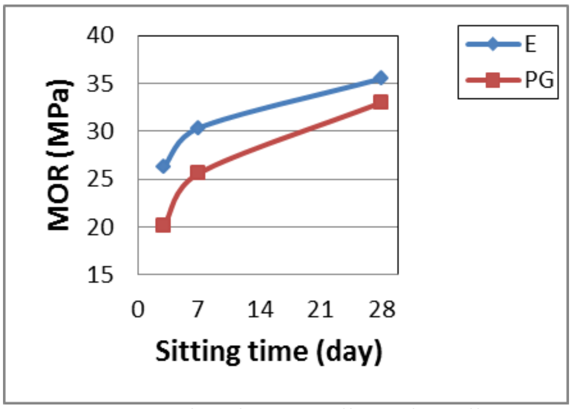

Fig. 4: The values of the fracture coefficient for different ages for both normal epoxy cubes and treatment

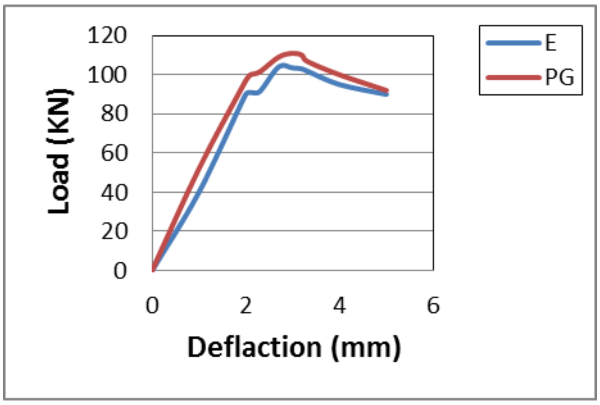

Fig.5: The load-deflection relationship after adding the mixture of porcelain and glass to the bonding material.

From the above it is clear that the addition of the mixture of porcelain and glass by (0.25)% to epoxy has improved all its properties and improved epoxy has been developed with better specifications and at a lower cost, to ensure the effectiveness of the improved epoxy this will be tested in CFRP paste used to strengthening concrete beams and ensure the efficiency of improved epoxy.

Strengthening of Concrete Beams: The improved epoxy was used in CFRP paste for use in strengthening concrete beams, Figure (6) shows the testing process. The results showed that the endurance and toughness of these beams increased by (81.07)% and (67.14)% respectively compared to the normal non-Strengthening beams endurance also increased by (1.96)%, as shown in Figure (7) which shows the relationship between the load and the deflection.

Fig. 6: Testing of concrete beams

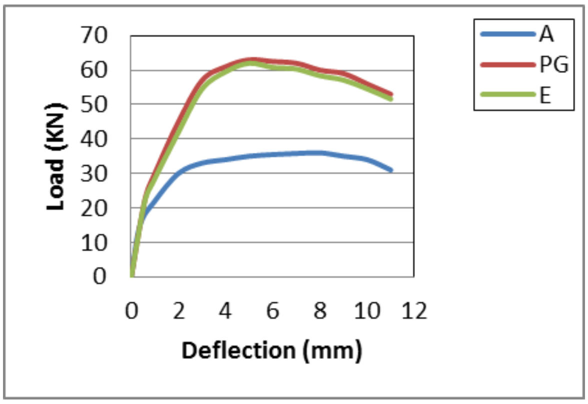

Fig. 7: The load-deflection relationship for ordinary concert beams and Strengthening

5. Conclusions

Through this study, it was found that the addition of powder from the mixture of porcelain and glass to epoxy resulted in the improvement of all its properties. Resulting in an improved epoxy with low cost and its strengthening reinforced concrete beams have increased the endurance and toughness of these beams compared to the non- Strengthening beams.

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