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Reinforcement of building plaster by waste plastic and glass

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Abstract

Plaster is a building material widely used in finishing buildings work, known for its qualities, which allow it a growing demand in the construction market; it is a favorable material to protection of the environment, very malleable, low density, also its thermal and sound insulation, regulator of the hygrometry of the enclosures and decorative, but the fragility of plaster poses a problem in design of decorative pieces with a langue size dimension, which causes problems for the users; in this study the plaster will be reinforced by fiber from waste plastic and powder glass, by introducing ratio (1 and 2 % for plastic fiber and 5 and 10 % of glass powder) of the introducing volume of reference specimens plaster studied. The results shows the positive effect of the introducing the waste plastic fiber and glass, that the results shows increasing the values of stress in flexion testing of reinforcing plaster beams, and also improving of the fragile behavior, in the other hand including waste glass has improving too the density of various comparing in to reference plaster beam.

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1. Introduction

Plaster has been used as finishing material in construction for walls and ceilings for It excellent performance favorable to the protection of the environment, easy application, and low density, with notable functional properties as firebreak, thermal insulation, hygrometry regulator speakers, decorative Fabio Iucolano et al. (2015).
In addition, the large availability, relative low cost, easy handling and mechanical characteristics suitable for different uses, makes the gypsum a widely used construction material M. Arikan et al. (2002). However the fragility of plaster material is the subject of much research works. In order to overcome these limitations, the mechanical

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properties of all the binders can be enhanced with the addition of fibers to produce fiber-reinforced composites Hamzaoui R et al (2014).
Recently, eco-friendly materials are playing an important role in the building materials market, most of all natural fibers used to reinforce several typologies of composites materials like plastics Sullins T et al (2017), but the use of natural fibers as reinforcement in building materials is the weak interaction between fiber and binder matrix. Accordingly, a large number of studies focused on chemical (such as silane alkalization or mercerization and acetylation treatments) or physical treatments of the fibers to enhance their surface roughness improve the fiber-matrix adhesion and reduce the moisture absorption Van de Weyenberg et al (2006).
Concerning the reuse of recycled plastic in mortars and concrete, extensive studies have been conducted on used tyre modified concrete and mortars A Turatsinze (2007).
The use of PET waste in cement-based composites will provide benefit in the disposal of wastes and, in addition, will reduce the environmental damages due to the use of natural mineral aggregates resources. The use of waste plastic as lightweight aggregate in the production of concrete provides both the recycling of the plastic waste and the production of a lightweight concrete in an economical way M Frigione (2010).
Glass waste is representing urgent environmental problems all over the world. H Du et all (2013), and the usability of fine glass powder as a value-added product as it could replace a proportion of an expensive concrete constituent such as Portland cement was possible. H Du et all (2014), these materials occupy huge parts of the landfills spaces. due to the non biodegradable nature of glass, and causing serious environmental pollutions (air, water and soil pollutions). Also, the lack of spaces for new landfills is a problem facing the dense population cities in different countries. The reuse of glass wastes can be an interesting to reduce the environmental impact. Recycling of these wastes will help to conserve the earth's natural resources, minimizes the landfills spaces and saves energy and money Hogland W (2002). Different studies have been done to investigate the optimum percentage of waste glass that can be used as a partial replacement to cement to produce concrete, investigated the use of (5. 10 and 20%) of waste glass as a partial replacement to cement. The glass waste powder used was slightly higher in particle size distribution than that of Portland cement. Schwarz et al (2008), but the introducing of waste glass in plaster is not cited in studied, in the work we proposed the effect of similar introducing of plastic fiber and powder glass in plaster beam, in physical and mechanical properties of the composite plaster materiel.

2. Material and Methods

The materials used in this work are: Plaster: KNAUF [FLEURIS], glass powder from glass waste, having undergone a fine grinding, and plastic waste type PET polyester high resistant, recover as waste, that is used as packaging cord in industry, as shown in Figure 1.

Fig 1-a: Glass powder.

Fig 1-b: Plastic fiber (20 mm).

Fig 1-c: Plastic fiber (2 mm).

2.2. Composite formulation

The absence of a universal method for the formulation of plaster-based compositions the compositions are formulated as according to the following steps:

At the beginning the normal consistency is determined and the ratio E / P = 0.60 is fixed.

We will cut the plastic with a thickness of 3 mm and length of 14 to 15 cm. The percentages (water. glass powder. plastic waste) are related to the amount of plaster of the composition concerned.

The elaborate compositions are synthesized in this table:

Table 1: Summary of the compositions studied.

Compositions	Powder glass	Plastic fiber	ρ (g/cm^3)
Composition 1	0 %	0 %	1.24
Composition 2	0 %	1 %	1.33
	0 %	2 %	1.37
Composition 3	5 %	0 %	1.35
	10 %	0 %	1.37
Composition 4	5 %	1 %	1.33
Composition 5	5 %	2 %	1.31
Composition 6	10 %	1 %	1.28
Composition 7	10 %	2 %	1.36

2.3. Tensile strength of fibers

The tensile tests of the plastic strapping (PET), are doing in tensile machine test as shown in figure 2.

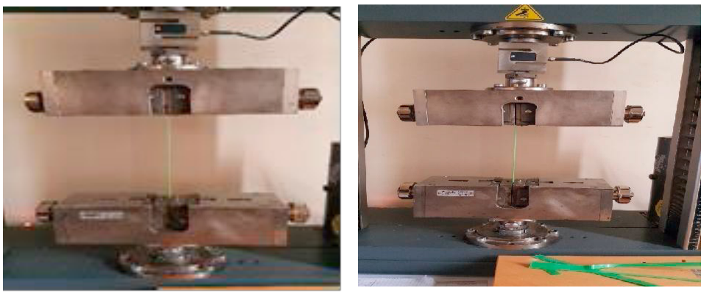


Fig 2: Tensile test of plastic fiber

The figure 3 shows the strain-strain curves of tensile tests on plastic fibers.

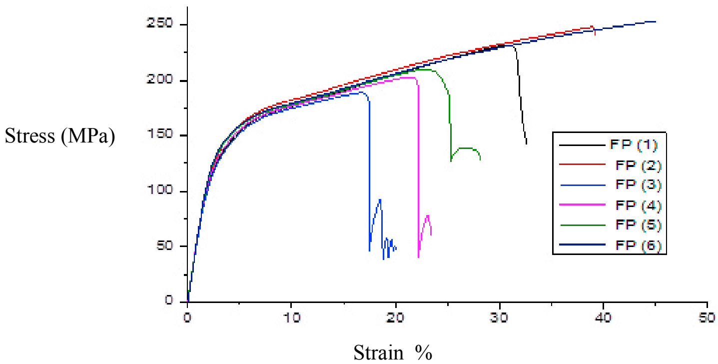


Fig 3: Tensile curve test result of plastic fiber

2.4. Mechanical characterization

2.4.1. Mechanical resistances

The mechanic tests are realized in a hydraulic press. The beams dimension is (4x4x16) cm^3 with constant (W / P) ratio W / P = 0.6, the bending tests are carried out, with a loading speed of 50 N / s ± 10 N / s. The failing of each specimen in flexion is carried out according to the device shown in Figure 4 below.

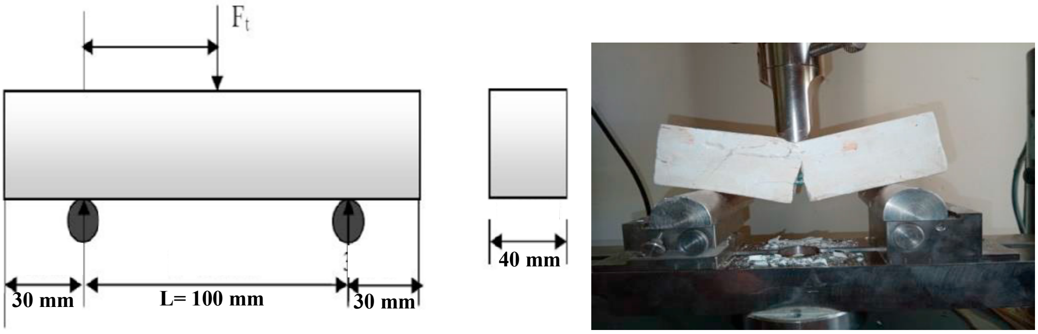


Fig 4: Flexural strength test of plaster specimen.

Flexural breaking strength is given by the following formula:

$$R_f = \frac{x1.5 \times Ff \times L}{b^3}$$

L: Distance between the test rolls of the beam (40x40x160) mm^3 (L = 100 mm);
Rf: Flexural strength in MPa;
Ff: Load at break in N.
b: Width of the square section of the prism in mm (b = 40 mm). Results and discussion

Table 2: Summarize the composition of the variant specimens studied.

Compositions	Powder glass	Plastic fiber	ρ (g/cm^3)	Fmax (N)	σ bending stress (MPa)
Composition 1	0 %	0 %	1.24	936.94	2.20
Composition 2	0 %	1 %	1.33	1965.73	4.61
	0 %	2 %	1.37	1854.10	4.35
Composition 3	5 %	0 %	1.35	892.38	2.09
	10 %	0 %	1.37	843.16	1.98
Composition 4	5 %	1 %	1.33	1282.09	3.00
Composition 5	5 %	2 %	1.31	1852.05	4.34
Composition 6	10 %	1 %	1.28	1921.53	4.39
Composition 7	10 %	2 %	1.36	1958.79	4.43

The following figures (5-11), represent the variation of the force as a function of the displacement of all the specimens studied in this work.

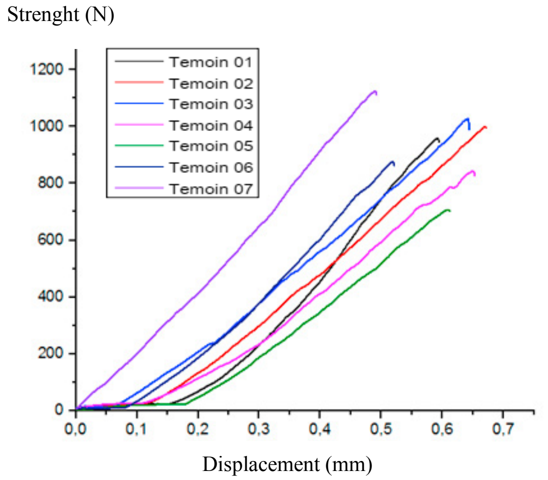


Fig 5: Three point flexural curve test results (Composition 1).

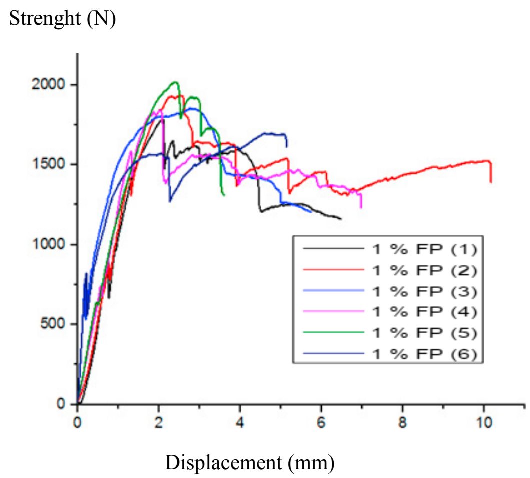


Fig 6: Three point flexural curve test results (Composition 2).

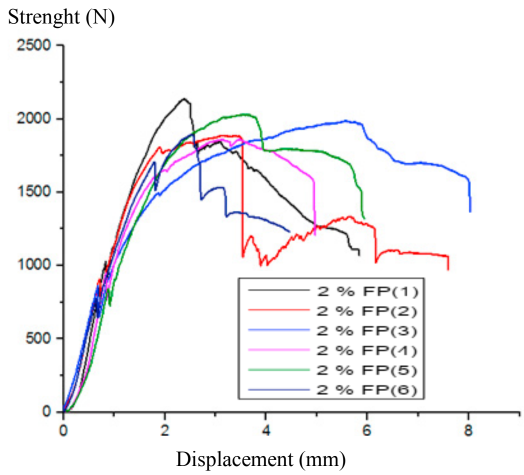


Fig 7 Three point flexural curve test results (Composition 3).

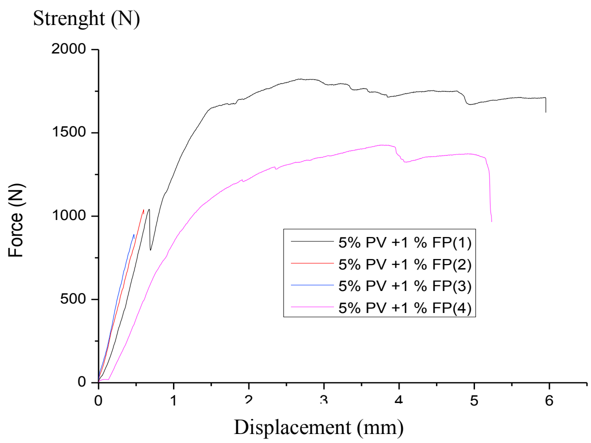


Fig 8: Three point flexural curve test results (Composition 4).

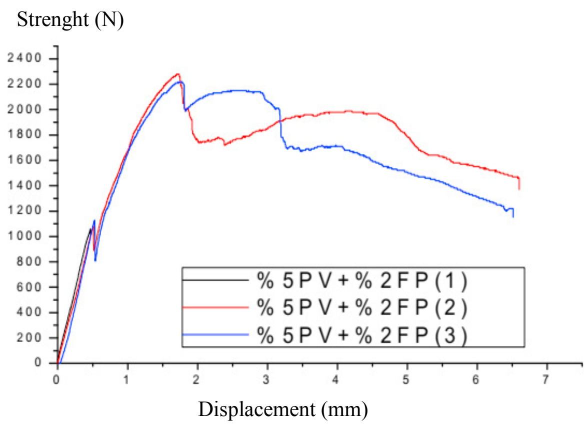


Fig 9: Three point flexural curve test results (Composition 5).

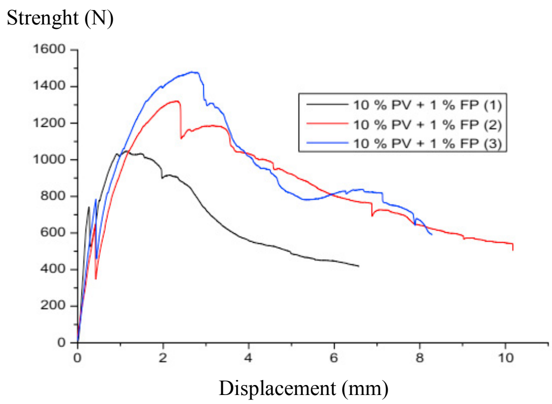
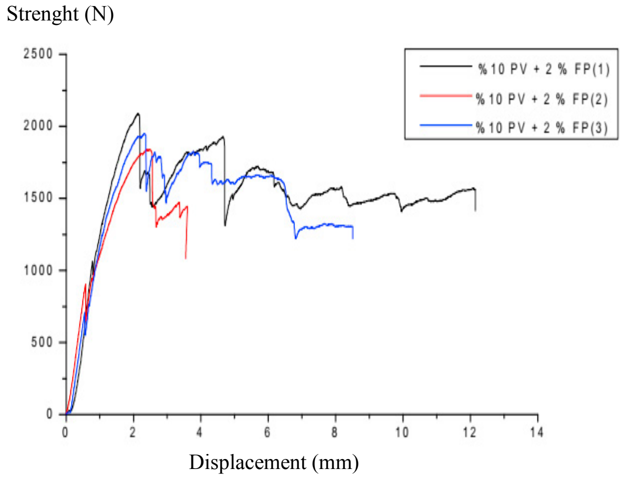


Fig 10: Three point flexural curve test results (Composition 6).



F. 0% PV).

Fig 11: Three point flexural curve test results (Composition 7).

3. Discussion and interpretation of the results

According to the results that the figures (6-11) represent the curves of the flexural tests, we observe the amelioration of mechanical resistance to flexural test for all the compositions with addition of plastic fiber as shows the figures (2-4-6-8 and 10) with 1% and 2% of plastic fiber), and (05% and 10% of glass powder) which represented in figures 7-8-9-10 and 11, compared to the witness plaster beam, this is explained the reinforcement of plaster with plastic fiber, also the observation of changing of the behavior, with is a fragile for the beam without fiber, and elastic behavior in the case of the introduction of fiber.

The flexural curve show the increasing of flexural strength for the beams content of (2% of plastic fiber as shows in figures 9 and 11) compared to (1% of plastic fiber) this growth perhaps because of the increase in percentage of fiber introducing in the plaster that explained the tinsel resistance of plastic fiber.

The figures (8 and 9) represent a growth in flexural strength for the beams content of (2% of plastic fiber + 5% glass powder-figures 9) relative to (1% of plastic fiber + 5% glass powder-figure 8) this growth perhaps due to the integration of plastic fibers.

The curves also show a growth of the flexural strength for the beams content of (2% of plastic fiber + 10% glass powder) relative to (1% of plastic fiber + 10% glass powder-figure.11) this increase can be caused by the integration of plastic fibers.

From the figures, a decrease in flexural strength is observed for the beams content of (2% of plastic fiber + 10% glass powder-figure.11) and (1% of plastic fiber + 10% glass powder-figure.10) relative to (2% of plastic fiber + 5% glass powder-figure.9) and (1% of plastic fiber + 05% glass powder-figure.8) this decrease can be a result of the percentage increase of glass powder from 5% to 10%.

According to the figures, a decrease in the flexural strength is also observed for the content of (1% of plastic fiber + 10% glass powder-figure.10) relative to (1% of plastic fiber + 5% glass powder) this decrease can be the result of the increase in percentage of glass powder from 05% to 10%.

4. Conclusion

The effect of plastic waste fibers and glass powder on the mechanical properties of plaster based composite was investigated in this paper. Furthermore, the effect of different rate additions of fibers and the consequent in flexural resistance was too improving.

Too, we investigated the possible uses of glass and plastic waste in the plaster material, as reinforcement, the results of flexural testing of all beams with plastic fiber, confirms the amelioration of mechanical behavior after reinforcement by the waste fiber that we have improving the tensile resistance, the fiber with high tensile strength, which contributed to the improvement of the mechanical flexural strength of the plaster.

In the light of the results, this work can offer a new construction material with an improvement of the mechanical properties in bending of the plaster material.

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