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The Properties of Fiber Reinforced Gypsum Plaster

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Authors' contributions

This work was carried out in collaboration between both authors. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims: Investigations were conducted on the development of gypsum plaster used naturally by adding 1% of admixture (Superplasticizer) and reinforcing it with Barchip fibers.
Methodology: Different percentages of Barchip as 0, 0.5, 0.75, 1, 1.25 and 1.5% were used. The compressive and flexural strength of such gypsum plaster are discussed
Results: The results show that the use of 1% superplasticizer with 1% of Barchip fiber increased the compressive and flexural strength by about 44 and 62%, respectively.
Conclusion: The use of superplasticizer with Barchip fibers would significantly enhance the mechanical properties of gypsum plaster.

Keywords: Barchip fiber; Gypsum plaster; Properties; Superplasticizer.

1. INTRODUCTION

Gypsum-based materials that are used in residential, commercial, and industrial buildings as wall panels, partitions, and boards has emerged as a unique construction materials due to lightness, cheap price, wide source, and easy application. They have favorable formability

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and excellent appearance which gains remarkable mechanical properties whilst strengthen with suitable additives or reinforcing fibers [1].

Various research works have been carried out to increase the mechanical strength of the plaster. Researchers stated that deflocculating agents such as gum arabic in conjunction with lime (gum arabic 85 parts, quicklime 15 parts by weight) reduced the cohesive forces and thereby the water requirement. The addition of only 1% of this additive enables casts to be made at water–solid ratio as low as 35% using calcium sulphate hemihydrates, with consequent increase in compressive strengths [2].

Bijen and Van der Plas [3] have formed a new composite material that has a high mechanical strength and durable to external effects by adding acrylic polymers in dispersion state together with glass fiber into the plaster. Although the mixture contains high level of glass fiber (13% by weight), it is fluid in Consistency.

Gypsum plaster is a material of excellent properties to be used in the construction of buildings. it has a good acoustic performance; it is a fireproof material, which in response to fire emits water vapour only; it helps to regulate the humidity of the walls and it is a natural, organic and environmentally friendly construction material [4].

Therefore, this research was conducted to investigate the use of superplasticizer with different percentages of Barchip fibers to study the mechanical properties of gypsum plaster reinforced with fibers.

2. MATERIAL AND MIX PRPORTIONS

2.1 Materials

Commercial gypsum that is mainly used for interior building compartments was used in this work to produce the studied composites. The main mechanical parameters evaluated for the neat plaster are a Young's modulus E = 1.4 GPa, and a compressive strength = 6.2 MPa.

The superplasticizer (SP.) is Conplast SP1000 obtained from FosrocSdn. Bhd. The synthetic fiber (Barchip) was obtained from elasto plastic concrete and its characteristics are presented in Table 1 and Fig. 1.

Table 1. Physical properties of Synthetic fiber (Barchip)

Fiber Properties	Quantity
Average fiber length,(mm)	30
Average fiber width ,(mm)	0.52
Tensile strength (MPa)	550
Young's modulus (GPa)	8.2
Specific gravity	0.92
Melting point (C˚)	150- 165

Fig. 1. Barchip fiber used in the study.

2.2 Mix Proportions

An approximated gypsum plaster composition is given in Table 2. The five mixtures (R0-R4) were prepared using the mix proportion 1:0.5 and 1:0.44 (Gypsum: water), respectively. The addition of fibers would affect the workability and consistency of gypsum, therefore the use of 1% of superplasticizer was used to maintain the same consistency of gypsum plaster. The use of 0.5, 0.75,1, 1.25 and 1.5% of barchip fibers was used for the preparing the mixes: R2-R6.

Table 2. Mix proportions of gypsum plaster mixes

Mix type	**Gypsum** (Kg/m^3)	**w/gypsum**	**Superplasticizer (%)**	**Barchip fibers (%)**
R0	1562	0.5	-----	-----
R1	1562	0.44	1	-----
R2	1562	0.44	1	0.5
R3	1562	0.44	1	0.75
R4	1562	0.44	1	1
R5	1562	0.44	1	1.25
R6	1562	0.44	1	1.5

3. TEST METHODS

Three 50mm cube samples were used for each mix for the compressive strength tests according to ASTM C473 [5] as shown in Fig. 2. The cube specimens were left in the molds for 24 hours at 20°C. After demolding, the specimens were kept in air curing until the age of 28 days. In addition, prismatic steel molds (40 × 40 × 160 mm) were used for the flexural strength test according to ASTM C348 [6] as shown in Fig. 3. The air curing of the prismatic molds was used also in same way used for cubes used for compressive strength till the age of 28 days.

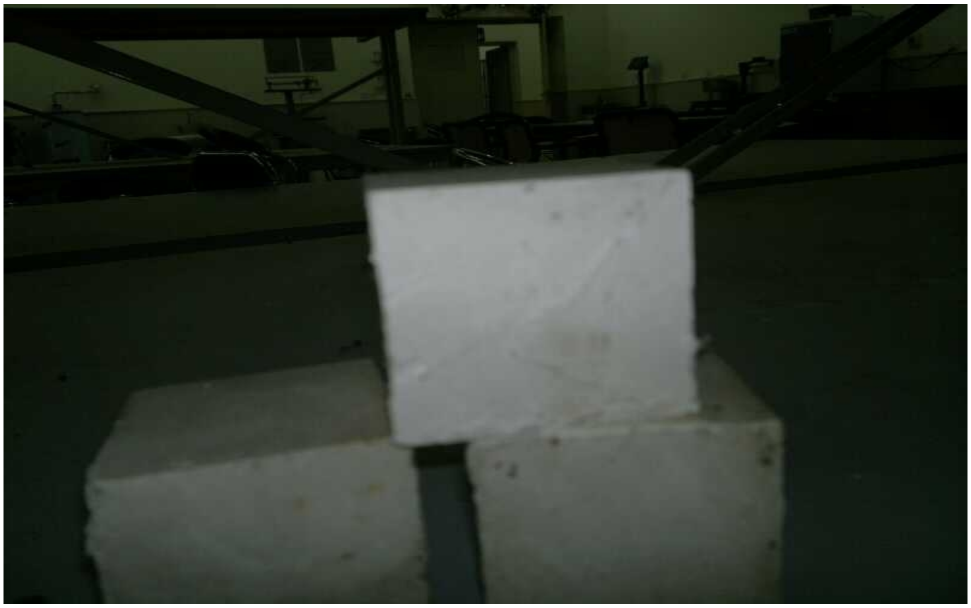

Fig. 2. Cubes 50 mm used for compressive strength tests.

Fig. 3. Prisms 40 ×40×160 mm used for flexural strength test.

4. RESULTS AND DISCUSSION

The results of compressive strength for gypsum plaster are shown in Table 3. It can be noticed that the use of superplasticizer increases the compressive strength from 6.2 MPa to 8.45 MPa. This is due to the ability of superplasticizer to decrease the water/gypsum ratio and thus the porosity of the gypsum plaster will be minimized resulting in a higher compressive strength [6-9].

Besides, the use of 1% of superplasticizer with different percentages of Barchip fibers increases the compressive strength. However, the best increment was obtained using 1% of Barchip fibers. The compressive strength of gypsum plaster using this percentage of fibers with 1% of superplasticizer increases the compressive strength by about 44%. The relationship between Barchip fibers and compressive strength is shown in Fig. 4. The polynomial regression analysis for such relation is shown in the equation below:

$$y = -0.3905x^2 + 0.8286\,x + 8.4423 \qquad \text{----------- (1)}$$

$R^2 = 0.9491$
Y= Compressive strength of gypsum plaster
X= Barchip percentage in the mix

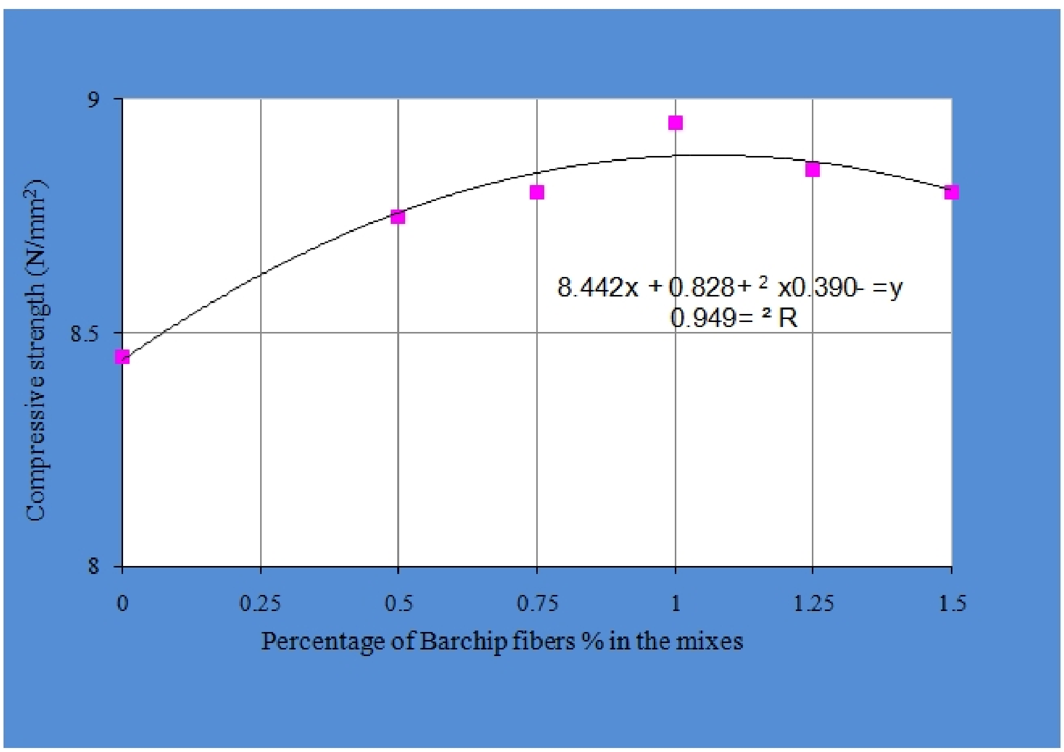

Fig. 4. Relationship between Barchip fibers and compressive strength of gypsum plaster.

Table 3. Mechanical Properties of gypsum plaster mixes

Mix type	Compressive strength, MPa	Flexural strength, MPa
R0	6.20	2.25
R1	8.45	3.05
R2	8.75	3.35
R3	8.80	3.50
R4	8.95	3.65
R5	8.85	3.6
R6	8.80	3.55

On the other hand, the results of flexural strength for gypsum plaster are shown in Table 3. It can be noticed that the use of superplasticizer increases the compressive strength from 2.25 MPa to 3.05 MPa. This is due to the ability of superplasticizer to decrease the water/gypsum ratio and thus the flexural strength of the gypsum plaster would increase in similar way of compressive strength [7-10].

Besides, the use of 1% of superplasticizer with different percentages of Barchip fibers increases the flexural strength. However, the best increment was obtained using 1% of Barchip fibers. The flexural strength of gypsum plaster using this percentage of fibers with 1% of superplasticizer increases the flexural strength by about 62%. The relationship between Barchip fibers and flexural strength is shown in Fig. 5. The polynomial regression analysis for such relationship is shown in the equation below:

$$y = -0.381x^2 + 0.9314x + 3.031 \qquad \text{-----------} \ (2)$$

$R^2 = 0.9658$
Y= Flexural strength of gypsum plaster
X= Barchip percentage in the mix

Whereas the relationship between compressive strength and flexural strength of gypsum plaster is shown in Fig. 6. The Polynomial regression analysis for this relationship is shown in the formula below:

$$y = -0.129x^2 + 3.5122x - 17.425 \qquad \text{-----------} \ (3)$$

$R^2 = 0.9487$
Y= Flexural strength of gypsum plaster
X= Compressive strength of gypsum plaster

It can be seen that the increment in compressive strength accompanied with the increment in flexural strength of gypsum plaster reinforced with fiber.

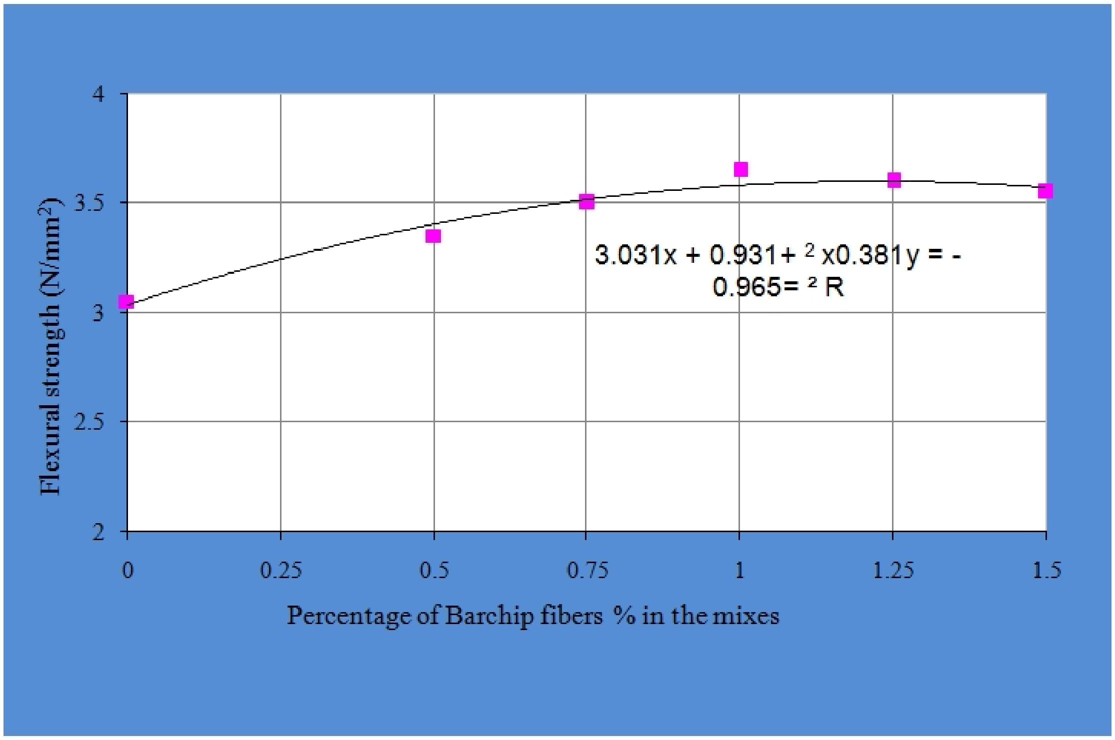

Fig. 5. Relationship between Barchip fibers and flexural strength of gypsum plaster

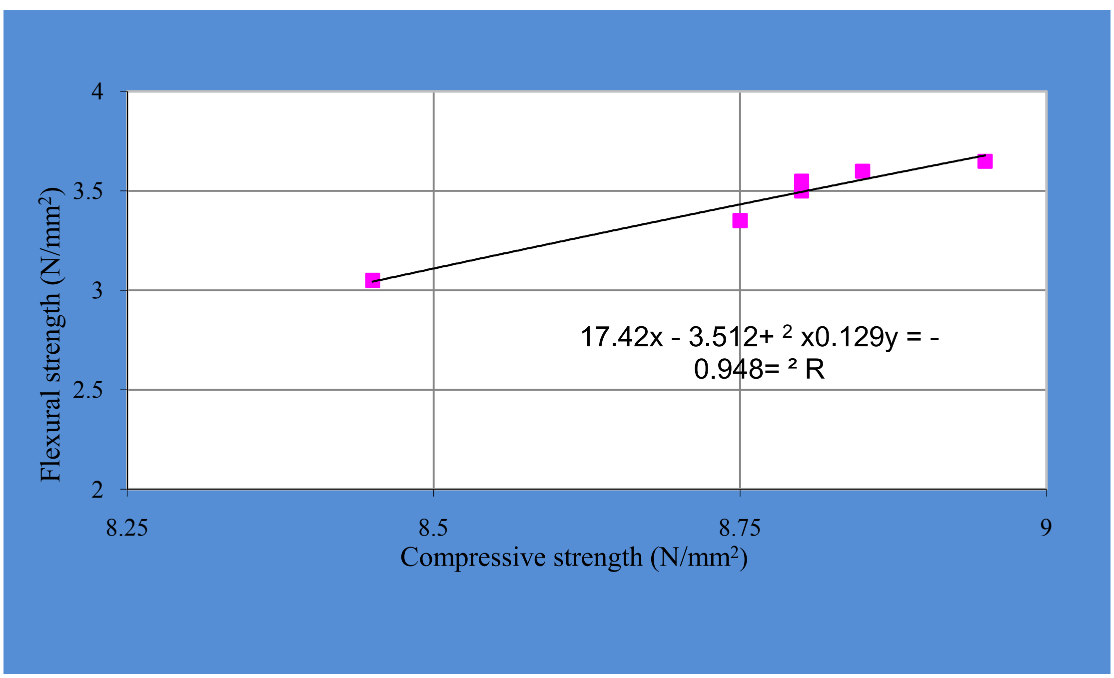

Fig. 6. Relationship between compressive strength and flexural strength of gypsum plaster

5. CONCLUSIONS

This study was conducted to investigate the compressive strength and flexural strength of gypsum plaster. The uses of superplasticizer and different percentage of Barchip fibers were studied. Some conclusions can be drawn as follows:

1- The use of 1% of superplasticizer would reduce the amount of water required for the optimum consistency.
2- The use of 1% of superplasticizer increases the compressive strength and flexural strength from 6.2 MPa and 2.25 MPa to 8.45 MPa and 3.05 MPa, respectively.
3- The incorporation of 1% of Barchip fibers in the gypsum plaster mix besides the use of 1% of superplasticizer was found to give the best value in term of compressive strength. Therefore, the compressive strength of gypsum plaster increased from 6.2 MPa to 8.95 MPa (44% increase) resulting from this use.
4- The use of 1% of superplasticizer and 1% of Barchip fibers in the mix was found to give the highest value of flexural strength of the gypsum plaster. Thus, the flexural strength increased from 2.25 to 3.65 MPa (62% increase).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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