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Mechanical performance comparison of glass and mono fibers added gypsum composites

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ABSTRACT

Gypsum and gypsum based composite are widely preferred in construction industry for various purposes. Mechanical performances of gypsum composite have been enhanced by researchers in order to increase its area of usage. In this research, gypsum composites containing expanded glass were reinforced by glass fibers (GF) and mono polypropylene fibers (MPF). GF and MPF were used up to 1.5%. The flexural strength, compressive strength, and shrinkage behavior of the composites were examined within the scope of this study. 50 x 50 x 50 mm and 40 x 40 x 160 sized specimens were prepared for the mechanical performance tests. It was obtained that flexural and shrinkage behavior of the composite were enhanced with the addition of MPF compared to GF added mixes; however, compressive strength values were not as high as GF reinforced composites.

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1. Introduction

Gypsum composites are widely used in the construction industry depending on their good sound insulation, thermal and fire resistance properties (Gazineu et al., 2011; Heim et al., 2004; Li et al., 2011; Vimmrova et al., 2011). Different types of materials can be added for enhancing mechanical properties of the gypsum based composites (Eve et al., 2002). Among various types and sizes, fibers are effectively used for the improvement of the mechanical properties (Yu et al., 2012; Wu, 2004; Colak, 2006).

Reinforcement fibers can be classified into two groups: natural fibers and manufactured fibers. Flax and wool can be counted as natural fibers. And basalt, carbon, glass fibers are in the group of man-made fibers. Man-made fibers were used in this research. Glass fibers are widely preferred by the academics for producing gypsum composites (Medina and Barbero-Barrera, 2017). While producing GF reinforced composite panels, the use of GF cannot be counted as conventional. Traditional design criteria are not always applicable due to the usage of this type of fiber. Many researches have been conducted for better understanding of its structural behavior (Liu et al., 2008; Janardhana et al.,2007; Wu and Dare, 2006). Especially, shrinkage behavior of the gypsum composites is one of the main research topics (Zhao et al., 2008).

MPF were also added to the gypsum composites for improving mechanical properties (Tazawa, 1998). MPF are widely used for their high specific performances and low costs. They can also be added into the matrix as forming layers or frames (Eve, 2002; Medina and Barbero-Barrera, 2017). Numerous researches have been conducted to emphasize the importance of adding MPF into the gypsum based composites in the construction industry (Deng and Furuno, 2001; Martias, 2014).

2. Material and Experimental Method

Gypsum mixes were prepared as per the requirements of the Turkish standard TS EN 13279-1. The characteristic properties of the gypsum can be seen in Table 1. Expanded glass was used as aggregate. Properties of the expanded glass can be found in Table 2. Alkali resistant GF and MPF with the length of 10 mm were used for the experimental studies. The fiber properties are presented in Table 3.

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Table 1. Characteristic properties of the gypsum

Characteristic properties	
Compressive strength (MPa)	2.7
Flexural strength (MPa)	1.3
Dry density (kg/m^3)	800 – 1000
Workability time (min)	70 -95
Final setting time (min)	130

Table 2. Expanded glass properties

Expanded glass	
Specific weight (g/cm^3)	0.19 – 0.4
Compressive strength (MPa)	1.4 – 2.6
Water absorption by volume	7-19
pH	9-12
Color	white

Table 3. GF and MPF properties

GF		MPF	
Ultimate strength, bending (MOR, MPa)	20-28	Specific gravity	0.91
Elastic limit (LOP, MPa)	7-11	Tensile strength (MPa)	590
Compressive strength (MPa)	50-80	N/A	N/A
Modulus of elasticity (GPa)	10-20	N/A	N/A
Density (kg / m^3)	1870 - 2100	Density (kg / m^3)	910
Alkali resistant	excellent	Alkali resistant	excellent

Mix proportions and the experimental sets were given in Table 4. The gypsum was replaced with the expanded glass by 7.5% by weight of gypsum. The materials were mixed in a mixer for 3 minutes to for a better homogenous dry mixture. GF and MPF were added with water after this process and mixed for 5 minutes. The fibers were used at the ratios of 1%, 1.25% and 1.5% in the mix design. Polycarboxylate based plasticizer was selected as the chemical agent. Water/ binder ratio was kept constant at the value of 0.45 in order to obtain the stable mix..

Table 4. Mixture designs

Mixture Code	Gypsum (kg)	Expanded glass (kg)	GF (%)	MPF (%)	Water / binder ratio
GF-1	46.25	3.75	1	-	0.45
GF-2	46.25	3.75	1.25	-	0.45
GF-3	46.25	3.75	1.5	-	0.45
MPF-1	46.25	3.75	-	1	0.45
MPF-2	46.25	3.75	-	1.25	0.45
MPF-3	46.25	3.75	-	1.5	0.45

All prepared specimens were kept at the molds for 24 hours at the room temperature, and potable water was used for the mixes. Compressive and flexural strength of the samples were measured for 1, 7 and 28 days according to the TS EN 13279-2 standards. Shrinkage test was conducted with the help of laser based shrinkage test tool. The dimensional changes were recorded for 24 hours.

3. Results and Discussions

Mechanical properties of the composites were presented in this section. The compressive and flexural test results of the specimens are given in Figs. 1 and 2, respectively.

Compressive strength results showed that compressive strength values increase with the increase of each fiber ratios. However, GF reinforced gypsum composites results are higher compared to the MPF reinforced specimens. As seen in Fig 1, test results were complied with the similar literature researches (Medina and Barbero-Barrera, 2017; Martias, 2014). However, the results of other relevant studies are also confusing for the compressive strength values, this situation can be the effect of the size and the direction of the fibers.

As expected, the flexural strength values are increased with the increasing fiber ratio. Moreover, MPF added gypsum composites showed a better performance compared to GF reinforced mixes.

The shrinkage behavior of the gypsum composites can be found in Fig. 3. It was observed that dimensional stability of the MPF added composites are better against the GF added ones.

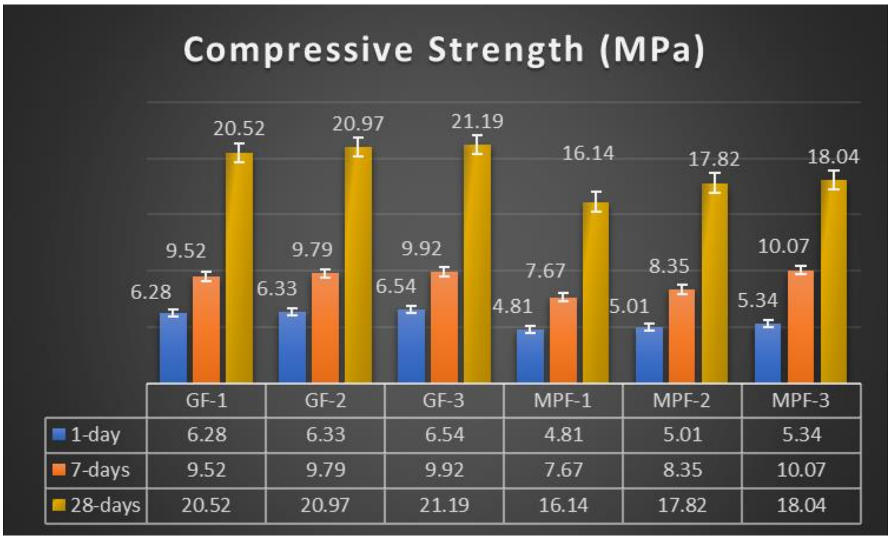

Fig. 1. Compressive strength test results.

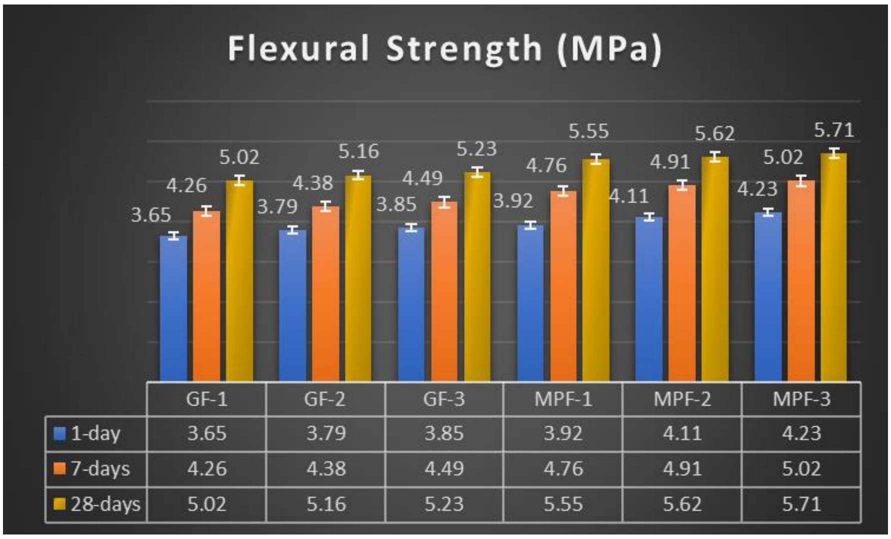

Fig. 2. Flexural test results.

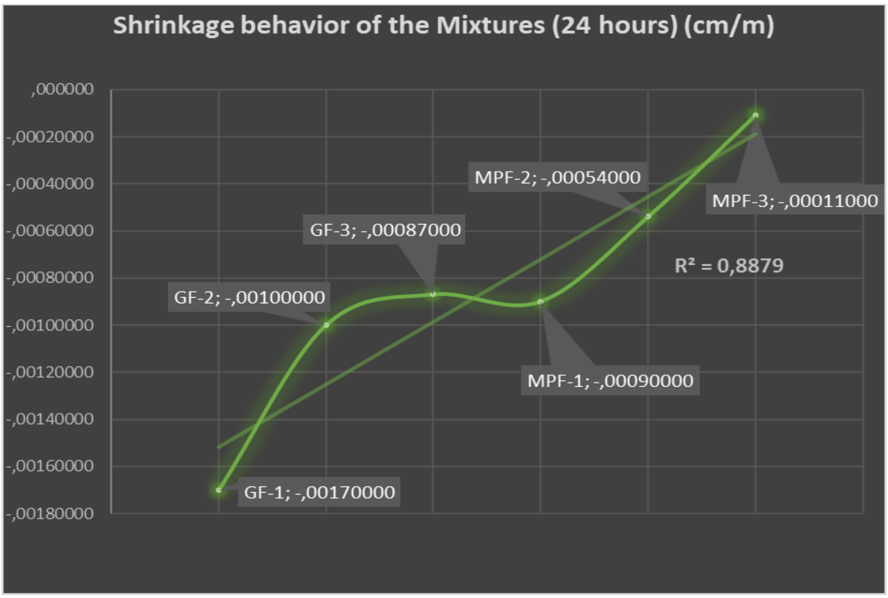

Fig. 3. Shrinkage behavior.

4. Conclusions

Gypsum based composites with GF and MPF have been analyzed for the mechanical performances and the comparison. The main findings can be summarized as follows:

- The increase in fiber ration in gypsum composites increases the mechanical strength values of the mixes.
- The MPF added gypsum composites showed better performances when analyzing flexural and shrinkage behavior of the designs; however, GF reinforced composites compressive strength values are higher.
- A good synergy was obtained between the MPF and gypsum based composites in respect to limiting shrinkage movements.
- Addition of 1.5% MPF presents the mechanical results for the gypsum composites.
- MPF can be preferred in replacement of GF due to their low cost and high specific performances in gypsum composite applications.

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