Table 5. Compressive strength results of 7 and 28 days

Mix ID	Compressive strength			
	7 days Strength		28 days Strength	
	(MPa)	C.R %	(MPa)	C.R %
100 MK (control)	48.37	_	51.38	_
10C	43.48	-10.11	52.26	1.71
20C	42.65	-11.83	39.37	-23.37
30C	35.3	-27.02	33.51	-34.78
10C+B.F	50.02	3.41	50	-2.69
20C+B.F	32.97	-31.84	33.63	-34.55
30C+B.F	29.94	-38.1	34.72	-32.43

C.R (Changing Ratio) % = [(strength of the sample – strength of control sample)/strength of control sample]*100%.

As is shown in the results, replacing metakaolin with colemanite reduced the compressive strength of 7 days samples and this reduction in the strength increased with the increasing of the amount of colemanite in the mixes. The strength decreased almost 30% in the non-fibrous mix with 30% colemanite. In fiber reinforced samples, it was observed a slight increase in compressive strength with the sample 10% colemanite. At the age 28 days, in the non-fibrous sample, the mix with 10% colemanite showed high increase in the strength comparing to the age 7 days, and it was also slightly higher than the reference mix. In fibrous mixes, the sample of 10% colemanite showed strength close to the reference one. The other samples with 20% and 30% content of colemanite showed higher reduction than non-fibrous samples with the same content of colemanite.

3.1.2. Flexural strength

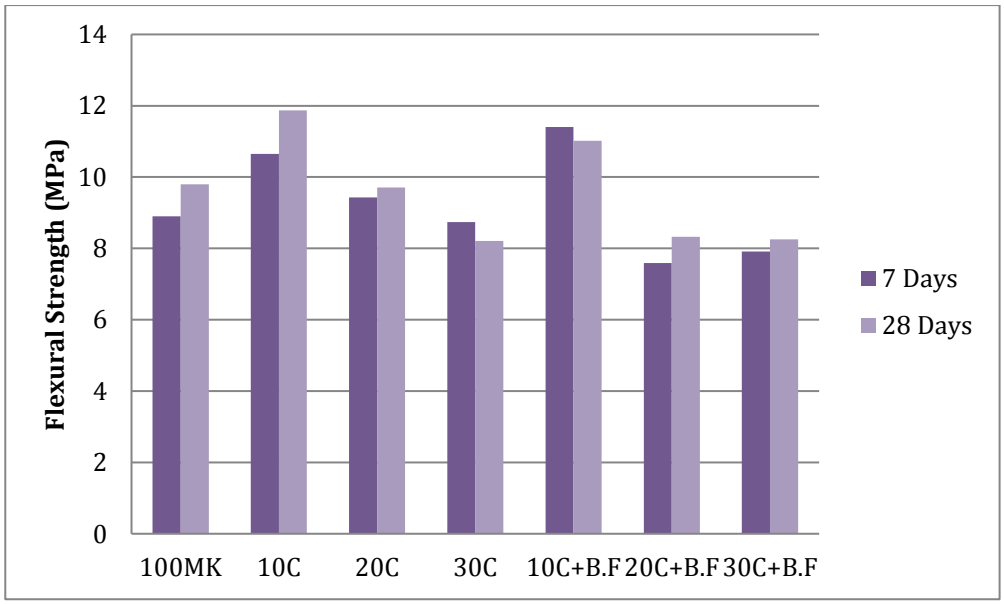

Fig. 2. The flexural strengths of the mixes

Table 6. Flexural strength results of 7 and 28 days

Mix ID	Flexural strength			
	7 days Strength		28 days Strength	
	(MPa)	C.R %	(MPa)	C.R %
100 MK (control)	8.901	_	9.798	_
10C	10.649	19.64	11.868	21.13
20C	9.43	5.94	9.706	-0.94
30C	8.74	-1.81	8.211	-16.2
10C+B.F	11.408	28.17	11.017	12.44
20C+B.F	7.59	-14.73	8.326	-15.02
30C+B.F	7.912	-11.11	8.257	-15.73

Fibers, in general, have the ability to increase the flexural strength of geopolymer. Back to the results, at the age 7 days, it was noticed that non-fibrous mixes with colemanite showed higher flexural strength than the control mix, like the sample with 10% colemanite had 20% increase in terms of flexural strength. Adding basalt fiber to the mix had a good improvement at the age 7 days in the mix of 10% colemanite with basalt fiber, reached up to 30% and 11.408 MPa comparing to the control mix, however the other mixes with higher content of colemanite had a reduction with more than 10% of the flexural strength. At the age 28 the best results were in the mixes; 10% colemanite and 10% colemanite with basalt fiber (11.868 and 11.017 MPa respectively).

4. Conclusion

Colemanite is considered as a waste material and could be used as partial replacement material. The results showed:

1. Replacing metakaolin with colemanite up to 10% by weight could give positive results. On the other hand, using colemanite more the 10% wt. adversely affects the mechanical strengths in general.

2. The reduction caused by using colemanite up to 20% wt. yielded acceptable results in terms of compressive strength; also it showed an increase in the flexural strength.

3. Basalt fiber had an important improvement in terms of flexural strength in the mix where the colemanite content did not exceed 10% wt. The increase reached 30% higher than the reference mix.

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