The Influence of Short Coir, Glass and Carbon Fibres on the Properties of Composites with Geopolymer Matrix

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Introduction

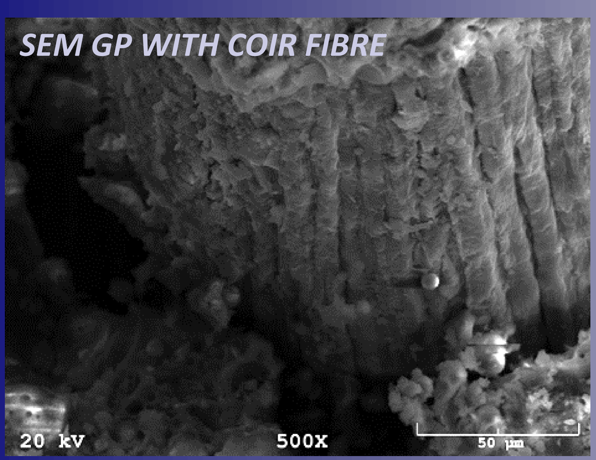
The main purpose of the provided research is to analyse the influence of short coir, glass and carbon fibre admixture on mechanical properties of fly ash based geopolymer, especially flexural and compressive strength. Glass fibres and carbon fibres have been chosen due to their high mechanical properties. Natural fibres have been chosen because of their mechanical properties as well as for the sake of comparison between their properties and the properties of the artificial ones. As raw material fly ash from the coal power plant 'Skawina' (located in: Skawina, Lesser Poland, Poland) was used. The chemical composition of the fly ash is typical for class F. Fourth series of fly ash based geopolymer for each fibre were cast: 1, 2 and 5% by weight of fly ash and one control series without any fibres. Each series of samples were tested on flexural and compressive strength after 7, 14 and 28 days. Additionally, microstructural analyses was carried out after 28 days

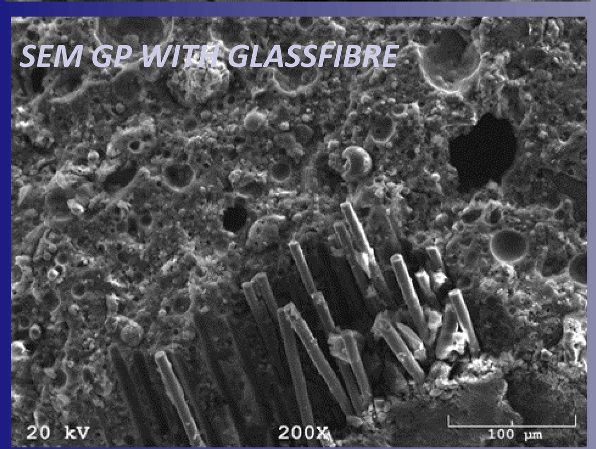
Samples

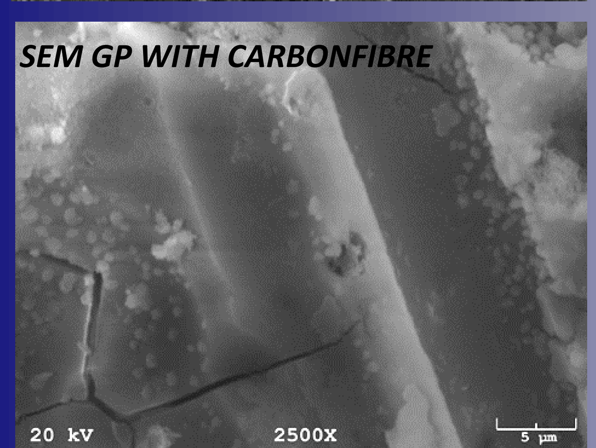
- 0 Reference sample (matrix)
- K 1% Geopolymer with 1% coir
- E 1% Geopolymer with 1% glass fibre
- C 1% Geopolymer with 1% carbon fibre
- K 2% Geopolymer with 2% coir
- E 2% Geopolymer with 2% glass fibre
- C 2% Geopolymer with 2% carbon fibre
- K 5% Geopolymer with 5% coir
- E 5% Geopolymer with 5% glass fibre

Research methods

- Compressive strength tests were carried out according to the methodology described in the standard EN 12390-3. The tests were carried out on the Matest 3000kN device on cubic samples of 50 x 50 x 50 mm on 15 samples.
- Bending strength tests were carried out according to the methodology described in the standard EN 12390-5 on the Instron type 4465 universal testing machine and on the Matest 3000kN device on prismatic samples of 50 x 50 x 200 mm on 5 samples.
- A JEOL JSM-820 scanning microscope was used for the SEM research. The materials were sprayed with a thin layer of gold using a JEOL JEE-4X sputtering machine. The observations were made at various magnifications (50 - 2,000 x).







Experimental results

Table 1: Results of compressive strength tests

	0	K 1%	E 1%	C 1%	K 2%	E 2%	C 2%	K 5%	E 5%
7 days									
Compressive strength [MPa]	17.7	22.7	29.2	29.7	21.8	21.2	29.4	20.2	28.8
Standard deviation	5.8	8.0	3.1	5.3	3.9	3.5	2.7	4.2	7.5
14 days									
Compressive strength [MPa]	22.5	29.4	29.0	29.8	32.1	27.4	33.6	22.8	30.5
Standard deviation	2.0	9.4	7.2	4.5	6.1	6.2	6.1	3.4	6.1
28 days									
Compressive strength [MPa]	23.3	29.8	29.1	35.3	33.4	34.3	36.5	30.6	34.5
Standard deviation	4.4	6.1	2.6	6.9	5.1	2.8	4.8	3.9	3.0

Table 2: Results of bending strength tests

	0	K 1%	E 1%	C 1%	K 2%	E 2%	C 2%	K 5%	E 5%
7 days									
Bendig strength [MPa]	5.2	4.8	6.2	8.9	6.1	5.5	9.6	4.4	5.7
Standard deviation	0.5	0.4	0.5	2.2	1.2	0.7	0.9	0.8	1.0
14 days									
Bendig strength [MPa]	5.0	5.3	6.4	9.4	6.6	5.6	11.4	4.3	5.6
Standard deviation	0.7	1.0	0.6	3.3	0.2	0.6	3.4	0.3	0.7
28 days									
Bendig strength [MPa]	6.2	5.3	6.4	10.0	6.5	6.2	13.3	4.4	6.0
Standard deviation	0.6	0.4	1.0	1.0	0.3	0.5	3.9	0.7	0.7

After 28 days, the compressive strength for composites with fibers - improvement in properties between 25.0% and 56.5%. For the bending strength, a clear increase in the strength is for composites with the carbon fibers in the amount of 1 and 2% (62.4% and 115.6%).

Conclusions

New composites based on geopolymer, reinforced with coconut, glass and carbon fibers, were obtained, and the possibilities of their use as construction materials, in particular as materials for use in construction, were determined. The limitations related to the use of new materials were also investigated. The possibility of using particular types of fibers as reinforcement for selected composites on a previously prepared geopolymer matrix was assessed, depending on their type and quantity as well as the seasoning time of the samples. The structure and mechanical properties of the composites based on geopolymers were analyzed and their behavior depending on the amount of reinforcement was determined. Then, on the basis of the obtained results, the possibilities of using the new composites as an environmentally friendly construction material were described. For this purpose, the analysis of conventional materials used so far for selected construction applications was performed and their properties compared with the obtained composites. The conducted analyses indicate that selected composites based on a geopolymer reinforced with fibers are a construction material that has better mechanical properties than traditionally used building materials, i.e. concrete.

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