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Research Article

THE CORROSION RESISTANCE OF THE BASE GEOPOLYMER FLY ASH

Paweł Mazur[1], Janusz Mikuła[1], Jerzy S. Kowalski[1]

[1] Institute of Materials Science and Engineering, Cracow University of Technology, Aleja Jana Pawła II 37, 31-155 Kraków, Poland, e-mail: pawelmazur89@interia.eu: jamikula@pk.edu.pl; jskowal@mech.pk.edu.pl

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ABSTRACT
The article presents research on a new engineering material which becomes geopolymer. This is the material used to form a protective layer, to provide a high moisture absorption capacity, however, its composition is highly alkaline and, therefore, its absorption does not affect adversely the protected structures. The research included the effects of various corrosive environments for a change in weight of the test samples during the test, as well as the surface structure on a macroscopic scale.

Keywords: geopolymer, fly ash, corrosion resistance, new materials.

INTRODUCION

Geopolymer materials form a family of modern construction materials, exhibiting a number of properties that enable them to replace popular engineering plastics [2, 5]. Important researches have been conducted in both Poland and in the world to introduce geopolymer plastic for public use. The main proposed purpose is to replace them by not commonly used adhesives based on Portland cement-based materials. They look like the already mentioned Portland cement or natural stone [3]. Geopolymer mass can be used as a binder for various materials. In order to give them an aggregate-like structure commonly used cement concretes are used, however, the material using geopolymer has higher quality in every regard than popular concrete [2, 5].

The main advantages of plastic geopolymers is their high fire resistance, and superior mechanical strength than Portland cement. It is important to mention its strongly alkaline composition.

A basic geopolymer composition allows it to connect to construction steels widely used in the industry, while avoiding the formation of connections in the places of corrosion cells. Cracow University of Technology conducted extensive research on the properties of the material as well as on the development of new materials on the basis of and the search for new uses for them. One part of the study is devoted to geopolymer corrosion resistance to a number of chemical environments, as well as the possibility of combining the new plastic with steel surfaces to prevent their corrosion [1, 4, 6].

Geopolymer's high corrosion resistance to a number of highly corrosive environments present in the chemical industry as well as its resistance to abrasion and high temperatures allow new applications of the material. This material can be used in setting up protection for pipelines and industrial furnaces, as well as other large structures, not only industrial. Given the relatively low cost for construction of the geopolymer we can get effective protection against corrosion even at high temperatures without incurring high financial cost to provide thermal insulation.

Although most geopolymer plastics have a large absorption in environments containing electrolyte to the metal – geopolymer electrolyte can occur thanks to a strong geopolymer plastic composition of the basic charges at the interference between the surface of the cell is not corrosive. High moisture absorption can also be considered as an advantage, for example, for drying or room moisture control, where the walls are lined with it [1, 7, 8].

THE EXPERIMENT

The research material

Corrosion tests based on geopolymer ashes and coal-derived products were made (Table 1, Figure 1) to determine the resistance to various corrosive environments.

Table 1. Samples of the geopolymer

The composition of samples	Physical characteristics
• 100 g fly ash • 3 g NaOH • 25 ml of water glass • 10 ml H_2O • 2.5 ml plasticizer	• weight ≅15.2 g

Fig. 1. The example of the sample prior to testing

The study plan has taken into account the aspects of corrosion resistance in several environments of the geopolymer as well as the absorbency and concentration variations of NaOH as well as hydrochloric acid (Table 2).

Table 2. The solutions used in the study

Composition of solution	Concentration
H_2O (water from the water supply)	–
H_2O + NaCl	3%
H_2O + NaCl 75°C	3%
H_2O + NaOH	3%
	5%
	10%
Acetone	100%
H_2O + HCl	5%
	10%
	30%

The study was planned for a period of 49 days per test specimen in each of the solutions. During the course of the study sample weight was checked every two days between day 26 and day 49, after which the samples were removed from the solution and dried for two days in the open air.

Results and Discussion

To avoid errors in the conduct of research three control samples were placed in each solution to eliminate the possibility of accidental phenomena affecting the final results. When measuring the weight loss of all samples the same procedure was employed for the dried sample surface, with the exception of the samples placed in acetone. Material properties of geopolymer to donate stored moisture as well as highly volatile characteristics of acetone prevented repeatable mass measurement. Quick passing of the stored substance on the outer surface of the sample and highly volatile acetone properties enable rapid evaporation, which led to a rapid loss of weight and made it impossible to accurately measure the mass. Therefore, the standard procedure for drying the surface which evaporate after 40 minutes in the open air it is possible to measure the mass, but also it is not repeatable (Figure 2).

On the basis of the results of the samples placed in acetone, shows that geopolymer is resistant to the action of acetone

The solutions of NaOH for each concentration of the solution was observed to move from the solution into the material, which caused a significant increase in weight loss and surface hardness in the test samples (Figure 3).

After drying the samples to a piece of a 3% solution it retained their initial weight and structure. When the remaining the concentration of solution at 5% and 10% the saturation made geopolymer plastic outer surfaces increase the weight of the samples, leading to cracks in the material after its drying. The concentration of 5% resulted in a shallow surface cracks but at 10% breakage was so deep that the material was totally eliminated from use in this environment (Figure 4).

The concentration of the test samples with 10% NaOH solution at the area it was above 20% and decreased with distance from the outside area. Such a significant gain on the solution resulted in supersaturation which resulted in the destruction of the material (Figure 5, Table 3).

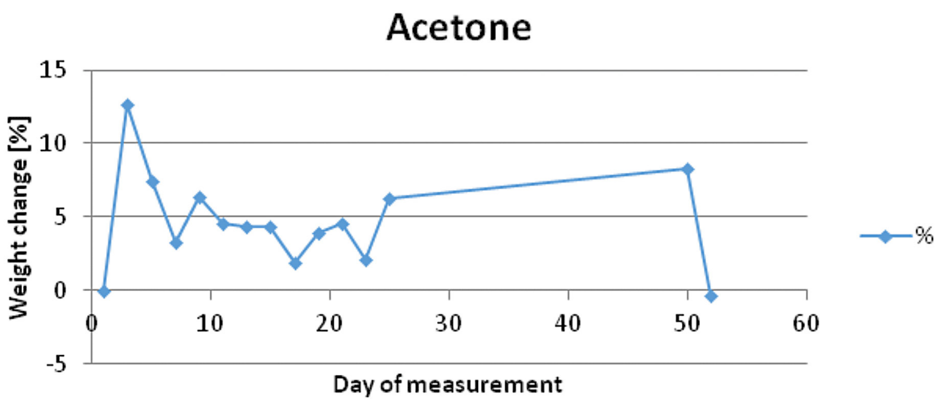

Fig. 2. The graph of the weight change of the measurement of samples immersed in acetone

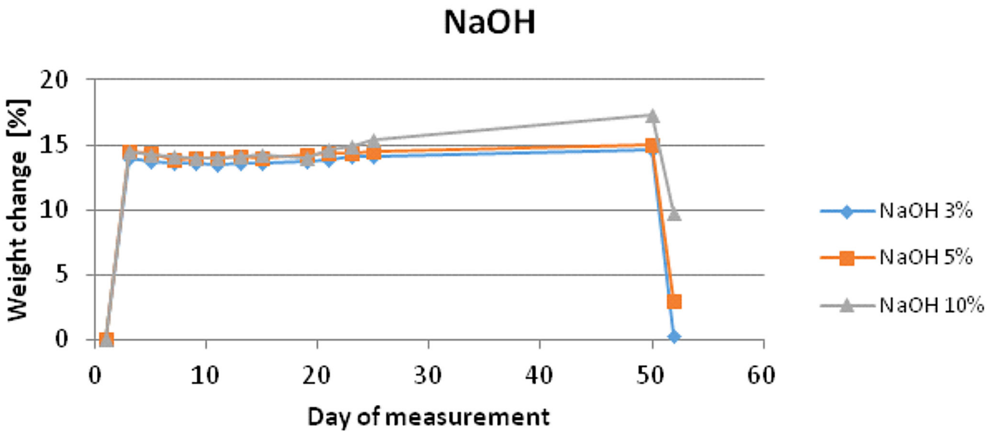

Fig. 3. The graph of the change in weight from the measurement for the sample immersed in NaOH

Fig. 4. Samples at 10% NaOH solution

As the only tested samples for which significant weight loss was recorded from HCl solutions. The increase in weight loss in the test samples was not associated with an increase in the concentration of hydrochloric acid (Figure 6).

The graphs present hydrochloric acid at a concentration of 5% and 30% had a similar loss in mass of about 2.5%, and the intermediate concentration of 10% hydrochloric acid weight loss is 8.2%.

Low weight loss of samples with 5% HCl solution is related to the geopolymer material resistance to hydrochloric acid in solutions containing low concentrations of the acid. In the case of samples in 30% HCl solution at the surface of the samples formed a tight adhering layer of solid well-inhibiting corrosion processes (Figure 7).

The solution on samples in 10% HCl also began creating a layer of pellet at a concentration of 30%, however, it does not have a tight layer of sludge on the surface of the sample. Under high concentrations of acid and the absence of a tight layer of the sediment the samples underwent rapid corrosion process. In other solutions, there was no case of corro-

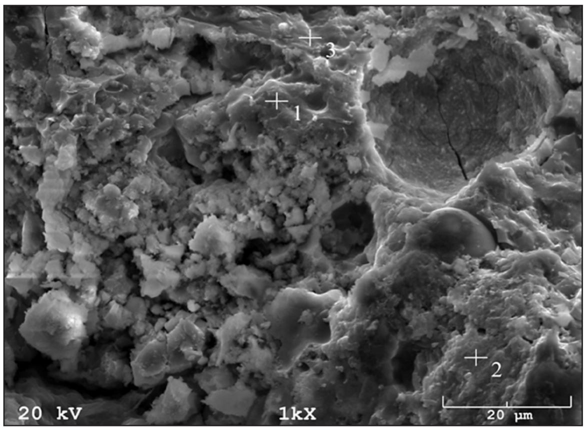

Fig. 5. Microstructure of the geopolymer in the 10%solution of NaOH

Table 3. The final composition of the material placed in 10% NaOH

Elt.	Line	Intensity (c/s)	Conc.	Units	Error 2-sig	MDL 3-sig
O	Ka	139.17	54.188	wt.%	1.743	0.728
Na	Ka	136.61	23.667	wt.%	0.777	0.364
Mg	Ka	2.33	0.401	wt.%	0.259	0.369
Al	Ka	43.80	5.835	wt.%	0.383	0.319
Si	Ka	116.70	13.568	wt.%	0.492	0.272
K	Ka	7.88	0.870	wt.%	0.166	0.185
Ca	Ka	9.58	1.097	wt.%	0.174	0.179
Fe	Ka	1.60	0.376	wt.%	0.224	0.299
Total			100.000	wt.%		

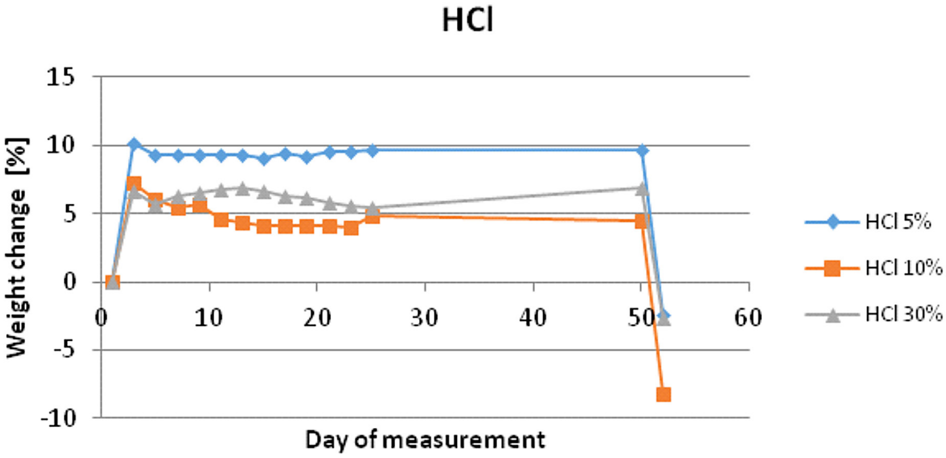

Fig. 6. The graph of weight change of the measuredsamples immersed in HCl

Fig. 7. Samples of the solution of HCl 30%

sion and only the formation of the precipitate formed from the mineral compounds contained in the solution (Figure 8).

From the results obtained for all the solutions it is showed that the material has excellent properties for enhancing the hygroscopic weight by up to 15% through the absorption of the solution. It should be noted, however, that depending on rates of solution absorbed differ by about 5%.

The amount of solution absorbed determine the difference in mass between the first and second measurement of the mass of the test samples, in turn, the geopolymer material was able to absorb (moisture) to the ambient in less than 48 hours. The final weight is the weight of the initial sample plus a sample of the precipitate hiatus or mass acquired by the geopolymer ions from the solution.

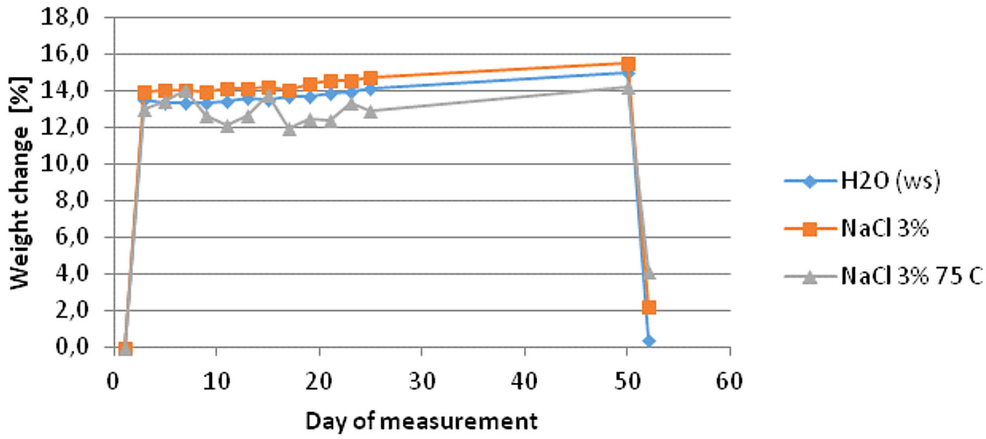

Fig. 8. The results of weight change

CONCLUSION

Research has shown a number of properties of geopolymer materials to enable its use as a material resistant to various aggressive environments. Thanks to its unique hygroscopic material that can be used to control humidity in chemical environments, by absorbing excess moisture from the products in chemical industry. Room or storage tanks whose walls were made of plastic allow geopolymer maintain the stored substances at constant level of humidity.

High resistance to the material at 30% hydrochloric acid. This points to the possibility to use such materials in industrial pipelines carrying concentrated acids, and its basic composition that would prevent the formation of corrosion on the steel walls, which would be covered with a geopolymer material. All the results are very promising, but require broader studies to confirm the correctness of the results.

REFERENCES

1. Bartoszewski M., Filipowicz S.: Wybrane zagadnienia ochrony katodowej rurociągów przed korozją. Prace Instytutu Elektrotechniki, z. 232, 2007.
2. Davidovits J.: Geopolymer – Chemistry & Applications. Institut Geopolymere, France 2008.
3. Davidovits J.: Geopolymeric Reactions in the Economic Future of Cements and Concretes. Geopolymer International Conference, France 1999.
4. Mikuła J.: Technika wytwarzania powłoki ochronnej. Wyd. Politechniki Rzeszowskiej, Rzeszów 1979.
5. Provis J., van Deventer J.: Geopolymers structure, processing, properties and industrial supplication. CRC Press.
6. Stansbury E.E., Buchanan R.A.: Fundamentals of Elektrochemical Corrosion. ASM International 2000.
7. Surowska B.: Wybrane zagadnienia z korozji i ochrony przed korozją. Wydawnictwo Politechniki Lubelskiej, Lublin 2002.
8. Young S., Feng D., Lukey G., van Deventer J.: Chemical characterisation of the steel-geopolymeric gel interface. Colloids and Surfaces A: Physicochem. Eng. Aspects, 302, 2007, 411-423.