Development of 3D Printing Technology for Geopolymers

Kinga Korniejenko, Michał Łach, Janusz Mikula, Maria Hebdowska-Krupa, Dariusz Mierzwiński, Szymon Gądek and Marek Hebda

Institute of Materials Engineering, Faculty of Materials Engineering and Physics, Cracow University of Technology, Jana Pawła II 37, 31-864 Cracow, Poland, michal.lach@pk.edu.pl

Keywords: Geopolymer, 3D Printing, Additive Manufacturing, Large-Format 3D Printer, 3D Printing in Civil Engineering.

1 Introduction

Nowadays, the using geopolymers for 3D printing in the large-format printer is a great challenge. It offer a new perspectives for the construction industry, but the development of this technology is connected with a lot of barriers. The article shows the main idea of the advanced large format 3D printing for geopolymers with using an ergonomic printing method as well as materials research in modern filaments in the form of geopolymers. It is focused on problems that appear during the first trials of development 3D printing technology.

The basic properties are connected with possibility of effectiveness 3D printing process are viscosity and time of bounding (Labonnote et al., 2016; Rahul et al., 2019). This basic properties are connected with the thixotropic, that is understood as high yield strength and low viscosity behavior of the materials and they include (Labonnote et al., 2016; Panda and Tan, 2019):
- pumpability - reliability with which material is moved through the delivery system,
- extrudability - depositing material through a deposition device,
- buildability - resistance of wet material to deformation under loads,
- and open time - period during which the aforementioned properties remain consistently within acceptable tolerance.

The basic challenge is received the material that is sufficiently fluid and at the same time have sufficient viscosity to retain its shape after the printing process (Panda and Tan, 2019; Panda et al., 2018). Moreover, not only the material properties decided about the possibilities of effective process. The other elements connected with technology are also important. All of this factors happen that there is only a limited understanding of the material requirements for 3D printing technology (Labonnote et al., 2016; Rahul et al., 2019).

2 Materials and Methods

Samples were prepared using sodium promoter for activation the metakaolin with some pigment addition. The trials has been made on the laboratory 3D printer for concrete – WASP 2040 with pneumatic feeder.

3 Results

The samples some multilayers plate have been prepared using 3D printing method – Figure 1.
The printed samples were characterized by different quality.

4 Conclusions

The most important problem was viscosity of the material. It was regulated by ethanol addition. After receiving the required viscosity the main challenge was layer stability. The other challenge was brittle material behavior after the curing time and cracking during the drying process. There are planned further work on material stabilization.

Acknowledgements

This work has been supported by Smart Growth Operational Programme 2014–2020, IV Increasing the research potential, 4.1.4: Application projects, funded by the National Centre for Research and Development in Poland, within the framework of the grant: Development of 3D printing technology for construction and facade prefabricated elements made of concrete composites and geopolymers, grant no. POIR.04.01.04-00-0096/18.

ORCID

Kinga Korniejenko: https://orcid.org/0000-0002-8265-3982
Michał Łach: https://orcid.org/0000-0001-5713-9415
Janusz Mikula: https://orcid.org/0000-0001-9514-7870
Maria Hebdowska-Krupa: N/A
Dariusz Mierzwiński: https://orcid.org/0000-0003-2292-3546
Szymon Gądek: N/A
Marek Hebda: https://orcid.org/0000-0002-8583-9459

References

Labonnote, N., Romquist, A., Manum, B. and Rüther, P. (2016). Additive construction: State-of-the-art, challenges and opportunities Automation in Construction, 72(3) 347–366. doi: 10.1016/j.autcon.2016.08.026

Panda, B. and Tan, M.J. (2019). Rheological behavior of high volume fly ash mixtures containing micro silica for digital construction application Materials Letters, 237, 348–351. doi: 10.1016/j.matlet.2018.11.131

Panda, B. Unluer, C. and Tan, M.J. (2018) Investigation of the rheology and strength of geopolymer mixtures for extrusion-based 3D printing Cement and Concrete Composites, 94, 307–314. doi: 10.1016/j.cemconcomp.2018.10.002

Rahul, A.V., Santhanam, M., Meena, H. and Ghani, Z. (2019). 3D printable concrete: Mixture design and test methods, Cement and Concrete Composites, 97, 13–23. doi: 10.1016/j.cemconcomp.2018.12.014