Contribution ID: **851** Type: **Oral Presentation**

Removing size effect on 3D-printed material's strength by controlling its microstructure

Monday, 22 May 2023 11:35 (15 minutes)

Additive manufacturing, commonly called 3D printing, is increasingly applied in numerous disciplines. The most common type, Fused Deposition Modelling, manufactures 3D-printed parts by extruding a filament of molten material layer upon layer. Upon solidification of the molten filament which cross-section has rounded corners, air gaps are created between each layer (Biswas, Guessasma, and Li 2020). Given the presence of those air gaps, this 3D-printed material can be defined as a porous material, for which mechanical properties are then dictated by the classical laws of poromechanics. Considering the internal length scale introduced in the system via porosity, we postulate that these manufacturing imperfections influence the 3D-printed material mechanical size effect, which has been shown to exist in various studies (Bell and Siegmund 2018; Wu, Chen, and Cheeseman 2021). Here we show that this size effect can effectively vanish if air gaps and sample size are simultaneously scaled. By fine-tuning certain printing parameters such as printing speed (Lanzotti et al. 2015) and printing temperature (Afonso et al. 2021), we find it feasible to maintain the shape and distribution of air gaps while varying sample size. Given the possibility of scaling the 3D-printed material's microstructure along with the sample size, we are left to check whether this is enough to effectively remove the size effect phenomenon previously observed. From our results on cubic samples of 3D-printed polylactic acid (PLA) (Figure 1), we obtain similar stiffness (3.1% differences) and uniaxial compression strength (3.2% differences) when the microstructure is scaled with the sample size, whereas 19.8% differences in stiffness and 12.6% differences in strength are obtained when the microstructure is fixed, see Figure 2. With this study, 3D-printed material mechanical size effect can be linked to the printing parameters straight-forwardly, which is a starting point towards predicting more directly the mechanical behaviour.

Participation

In-Person

References

Afonso, Jo˜ao Ara´ujo et al. (2021). "Influence of 3D printing process parameters on the mechanical properties and mass of PLA parts and predictive models". In: Rapid Prototyping Journal 27.3, pp. 487–495. DOI: 10.1108/RPJ-03-2020-0043.

Bell, Darren and Thomas Siegmund (2018). "3D-printed polymers exhibit a strength size effect". In: Additive Manufacturing 21, pp. 658–665. DOI: 10.1016/j.addma.2018.04.013.

Biswas, P., S. Guessasma, and J. Li (2020). "Numerical prediction of orthotropic elastic properties of 3D-printed materials using micro-CT and representative volume element". In: Acta Mechanica 231.2, pp. 503–516.
DOI: 10.1007/s00707-019-02544-2.

Lanzotti, Antonio et al. (2015). "The impact of process parameters on mechanical properties of parts fabricated in PLA with an open-source 3-D printer". In: Rapid Prototyping Journal 21.5, pp. 604–617. DOI: 10.1108/RPJ-09-2014-0135.

Wu, Chao, Chen Chen, and Chris Cheeseman (2021). "Size Effects on the Mechanical Properties of 3D Printed Plaster and PLA Parts". In: Journal of Materials in Civil Engineering 33.7. DOI: 10.1061/(asce)mt.1943-5533.0003787.
2

MDPI Energies Student Poster Award

No, do not submit my presenation for the student posters award.

Country

Netherlands

Acceptance of the Terms & Conditions

Click here to agree

Energy Transition Focused Abstracts

Primary author: Ms ZHANG, Xinrui (Delft University of Technology)

Co-author: LESUEUR, Martin

Presenter: Ms ZHANG, Xinrui (Delft University of Technology)

Session Classification: MS22

Track Classification: (MS22) Manufactured Porous Materials for Industrial Applications