Stress-based Design of Gridshells for Wire-and-Arc Additive Manufacturing with Overhang Constraints

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ABSTRACT

Among various metal AM techniques, Wire-and-Arc Additive Manufacturing (WAAM) makes use of standard welding equipment mounted on top of robotic arms to build elements up to few meters span [1]. The so-called ''dot-by-dot'' WAAM printing consists in a spot-like deposition of the welded material to build metal bars for gridshells (double-curvature elements constructed from a grid). The design of spatial truss networks for fabrication using Wire-and-Arc Additive Manufacturing (WAAM) is addressed in this contribution, by combining funicular analysis and optimization to investigate multi-constrained form-finding [2].

A characterization of the structural behaviour of the bars manufactured by means of this metal AM technique is preliminary provided, based on available experimental tests. Interpolation laws are given both for the yielding stress and the critical stress in compression, depending on the printing direction.

Then, dealing with networks with fixed plan projection, a minimization problem is formulated in terms of any independent subset of the force densities and of the height of the restrained nodes. The maximum value of the ratio of the axial force in each branch of the network to the relevant yielding/critical force is used as objective function. Local enforcements are prescribed to set lower and upper bounds for the vertical coordinates of the nodes and to control the overhang angle with respect to the vertical direction in the AM process.

Gridshells retrieved by the proposed approach are presented and compared to those found when searching for spatial networks with minimum horizontal reactions, disregarding or considering overhang constraints. Peculiar features of the achieved layouts and of the proposed multi-constrained formulations are pointed out.

REFERENCES

[1] C. Buchanan, L. Gardner, *Metal 3D printing in construction: A review of methods, research, applications, opportunities and challenges*. Engineering Structures (2019) 180, 332-348.

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