Generation and numerical validation of 3D optimized lattices in the context of additive manufacturing

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ABSTRACT

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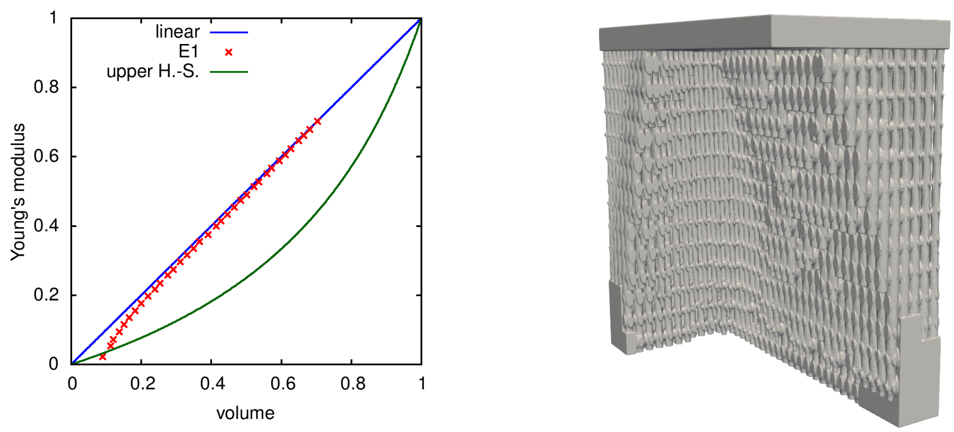
Considering the Hashin-Shtrikman bounds for isotropic periodic two-phase materials as Young's modulus versus volume fraction [1], we can conclude the non-optimimality of isotropic lattices in terms of stiffness maximization of a macroscopic structure. However, the linear material interpolation scheme can be used as a theoretical bound that indicates potential for anisotropic lattices with performances within these two ranges, cf. Fig. 1a.



(a) (b)

Figure 1: (a) Linear elastic stiffness-to-volume of linear and Hashin Shtrikman interpolation schemes and one exemplary orthotropic lattice. E_1 is Young's modulus in x-direction. (b) Optimized lattice structure with void and solid cells.

We follow this presumption and based on a benchmark example we discuss the performance of homogenized optimization results with feasible lattice cells which meet manufacturing constraints as well as the contribution of additional solid and void cells in the lattice design (Fig. 1b). Subsequently we describe the process of generating lattices based on these optimization results, elaborate challenges that comes along when working towards their manufacturability, and provide numerical validations and comparisons with the homogenized results.

REFERENCES

[1] Bendsøe, M. P., & Sigmund, O. (1999). Material interpolation schemes in topology optimization. Archive of applied mechanics, 69(9-10), 635-654