Nonlinear finite element modelling and analysis of large repetitive lattice-type structures for additive manufacturing

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For many years now, Lattices Structures (SLs) are widely developed in the area of additive manufacturing which uses different types of materials (e.g. metals) for various applications in fields such as aeronautical, automobile, medical, ... Indeed, this forming process based on the material addition associated with successive layer stacking makes it possible to design structures that can combine both the innovation and aesthetics while coupling functionality, performance and robustness. As a result, SLs have the key advantage of being lightweight structures having in the one hand, an excellent weight/performance ratio and then in the other hand, extremely good physical/mechanical properties in terms of structural hold and resistance to strong external loads including shock and impact. From a general point of view, SLs belong to the class of repetitive (near-)periodic discrete structures (e.g. truss, foam, ...) with large or small sizes which can be modeled by several approaches more or less relevant depending on the type of structure in consideration. In the first part of this present work, a finite element modelling and analysis are proposed in order to test, assess and discuss the numerical capacities of both 3D continuum and beam elements for predicting both explicitly, efficiently and accurately the nonlinear mechanical behaviour of SLs [2]. The feasibility, validity and limitation of these two mechanical models are therefore presented through some numerical examples using a finite element software (Code_Aster). In the second part of this study, a numerical homogenization procedure is proposed for modelling the nonlinear macroscopic mechanical response including anisotropic compressive behaviour associated with these SLs [1]. The method used is based on the definition of a homogeneous equivalent medium where the homogenized macroscopic mechanical behavior is then determined under quasi-static uniaxial and multiaxial load conditions. Once again, the predictive numerical abilities associated with this numerical approach for providing an efficient and accurate macroscopic mechanical behaviour in regard to SLs are performed and evaluated on some specific examples with Code_Aster.

References

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