This paper applies topology optimisation to the design of structures with periodic and layered microstructural details without length scale separation, i.e. considering the complete macroscopic structure and its response, while resolving all microstructural details, as compared to the often used homogenisation approach. The approach takes boundary conditions into account and ensures connected and macroscopically optimised microstructures regardless of the difference in micro- and macroscopic length scales. This results in microstructures tailored for specific applications rather than specific properties. Manufacturability is further ensured by the use of robust topology optimisation. Dealing with the complete macroscopic structure and its response is computationally challenging as very fine discretisations are needed in order to resolve all microstructural details. Therefore, this paper shows the benefits of applying a contrast-independent spectral pre-conditioner based on the multiscale finite element method (MsFEM) to large structures with fully-resolved microstructural details. It is shown that a single preconditioner can be reused for many design iterations and used for several design realisations, in turn leading to massive savings in computational cost. The density-based topology optimisation approach combined with a Heaviside projection filter and a stochastic robust formulation is used on various problems, with both periodic and layered microstructures. The presented approach is shown to allow for the topology optimisation of very large problems in Matlab, specifically a problem with 26 million displacement degrees of freedom in 26 hours using a single computational thread.

General information
State: Published
Organisations: Department of Mechanical Engineering, Solid Mechanics
Contributors: Alexandersen, J., Lazarov, B. S.
Pages: 156-182
Publication date: 2015
Peer-reviewed: Yes

Publication information
Journal: Computer Methods in Applied Mechanics and Engineering
Volume: 290
ISSN (Print): 0045-7825
Ratings:
BFI (2019): BFI-level 2
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): SJR 2.883 SNIP 2.033
Web of Science (2017): Impact factor 4.441
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.31 SJR 2.691 SNIP 1.945
Web of Science (2016): Impact factor 3.949
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.91 SJR 2.728 SNIP 2.104
Web of Science (2015): Impact factor 3.467
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.41 SJR 2.381 SNIP 2.1
Web of Science (2014): Impact factor 2.959
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.5 SJR 3.015 SNIP 2.227
Web of Science (2013): Impact factor 2.626
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes