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Optimization of materials with desired nonlinear properties utilizing internal contact

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In a previous work, the application of a third medium contact model to topology optimization was demonstrated successfully [1]. While classical contact methods are less compatible with topology optimization, this approach produced promising results by utilizing the void material region in the design domain as a contact medium. This is achieved by an appropriate nonlinear void material model, which, becomes increasingly stiff once compressed between solid regions in the structure. As a result, it transfers contact forces when ultimately compressed.

Here, the described contact-aware design optimization method is applied to the design of periodic materials with desired nonlinear macroscopic mechanical properties. Such materials can be used for various purposes like energy absorption, crashworthiness or other applications that gain from a material with inherent mechanisms like functionality.

The optimization aims at obtaining a desired load response by minimizing the deviation of the actual load response from given target values at a series of loading stages. It is shown how internal contact can function as a design feature by causing a significant change in the load response at a specific level of macroscopic compression. Contacting beams can enhance the effective material stiffness, but contact could also be utilized to trigger internal buckling and hence result in softening. The results demonstrate the potential and versatility of the approach, which also can be adapted to other optimization problems like the design of compliant mechanisms.

REFERENCES

[1] Bluhm, G.L., Sigmund, O. and Poulios, K. Internal contact modeling for finite strain topology optimization. *Comput. Mech.* (2021) **67**: 1099-1114.