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On the extent of the domain of influence of a Michell structure

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Abstract

The Michell-Hemp criteria for establishing the optimality of a least-weight framework to carry prescribed loads require that the virtual displacement field in which the structure lies must satisfy certain kinematic constraints; specifically, the virtual strains within the displacement field must be within certain limits. In order for the solution to be optimal in a specified design domain, these virtual strain constraints must be satisfied throughout the whole of the domain.

Studies of Michell structures generally involve consideration of the virtual displacement field, where the virtual strains outside the boundaries of the structure are non-zero (frequently, at the prescribed limiting values) across the whole design space. However, this need not necessarily be the case, and various studies have, for certain circumstances, established rules for identifying regions in which additional kinematic constraints may be added without affecting the optimal structural form.

This paper outlines a general framework for identifying the extent of the “active” design domain, in which a Michell structure lies. This is done by considering the potential virtual strain between a point on the “optimal” structure and a distant point, at which kinematic constraints are applied. It will be shown that, outside that domain, the virtual deformation field may be safely assumed to be rigid. Numerical truss layout optimization examples are presented which demonstrate the approach.

One practical application of this study is that it provides a rigorous means of identifying when the availability of a new support location has the potential to affect the optimal structural form.