Use of layout optimization in the conceptual design of building structures

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Abstract

Numerical layout optimization is a powerful technique that enables structurally efficient arrangements of members in load bearing frameworks to be automatically identified. The technique can be applied to a range of constructions, including long-span roofs, gridshells, space-frames and tall building superstructures. It has some similarities with the more well-known topology optimization technique, but is better suited to the kinds of skeletal structures associated with building structures.

With layout optimization the design domain is discretized using a grid of nodes which are interconnected with discrete line elements, forming a 'ground structure'. Linear optimization is then used to identify the subset of elements forming the minimum volume structure required to carry the applied loading. The traditional layout optimization technique is prone to generate structures which are rather complex in form [1], and require interpretation before being used in practice. To address this, a rationalization technique has recently been developed which involves undertaking an additional geometry optimization step, adjusting the positions of the nodes to simplify and improve on the raw layout optimization solution [2].

Nevertheless, the structures obtained using traditional optimization formulations which simply seek to minimize the overall weight of a structure without taking account of other considerations are frequently not buildable using current generation construction industry practices. Whilst emerging manufacturing techniques such as 3D printing are opening up new possibilities, new more effective and efficient computational formulations are therefore required.

In this contribution interim outcomes from a current UK government sponsored research programme that seeks to address barriers to uptake of layout optimization within the construction industry will be described. Developments to date include new enhanced rationalization techniques and an interactive software tool which allows architectural and engineering designers to take advantage of layout optimization at the concept design stage. It will be shown that this tool can help the designer explore a wide range of potential designs, allowing them to take inspiration from the (often surprising) solutions proposed, though still maintaining control over aspects of the design that are important to them.

Keywords: **Layout optimization, Geometry optimization, Building structures, Conceptual design, Engineering design, Architectural design**

References

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