

Integration of manufacturability in structural optimisation

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Summary

In complex structures, cast nodes are often applied to seamlessly and fluently guide the flow of forces through the joints in the structure. Computational optimisation could play a role to automatically form structural joints, with this kind of flow of forces, as a fast design tool and discovery technique. It could be used to give a crude indication of shape possibilities for the layout of the cast node. Although optimisation methods are quite suitable for the forming of equally stressed low weight structures, currently they do not often include aspects of manufacturability.

This paper explores the first steps taken to include these aspects in optimisation methods in the form of a computational design tool, which uses a modified ESO algorithm to optimise stress, weight and manufacturing criteria, translated to geometrical objectives, such as angles, surface areas, thickness, etc.

Keywords: Optimisation; Evolutionary Structural Optimisation; Manufacturability; Cast Nodes; Computational Morphogenesis.

1. Introduction

In complex structures, usually with high forces, cast nodes are often applied to seamlessly and fluently guide the flow of forces through the joints in the structure. Equal stress and smooth transition of forces are beneficial for the quality of the node and the entire structure.

Currently, the forming process of such nodes is a matter of the forgers experience with the material. However with new developments in complex structures, where there can be thousands of unique node layouts, this process based on experience is not so straight-forward anymore.

Other developments which complicate the structural design of these structures are the new developments in materials, such as Ultra-High Performance Concrete (UHPC), high-strength steel and composite materials. Here it becomes interesting to find new structural layouts for the system and joints, because of the different properties and behaviour of these materials. The experience with these materials is limited, so often steel structure layouts are imitated, while other structural layouts might be more efficient. New rationality for these materials still has to be found and new discovery methods might be able to play a role.

Next to this, cast nodes also contain a certain architectural quality of smoothness and cleanness which architects are discovering and incorporating in their design. Structural designers and engineers have the key role here to find and design these new layouts and technology could aid them in this process.

Computational form finding (geometrical and structural) and optimisation could play a role, as a fast design tool and discovery technique to gives a crude indication of shape possibilities for the layout of the structure.