Topology Optimization of Masonry Structures

Reflection

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Relation to studio topic and master programme

It is important to design sustainable buildings and structures to develop the built environment while having a minimal negative impact on the environment we live in. Designing masonry structures has the potential to lower the embodied energy needed to construct buildings. By optimizing the topology of masonry structures, the energy needed could be further reduced. The relation between this thesis and the studio topic (design informatics) is the required computational effort to calculate and keep track of the data involving the generation of initial (masonry) topologies, discrete element analysis, and topology optimization. In this process a physical structure is simplified from its geometrical representation to a numerical model. By performing structural analyses on this model, the physical structure itself can be optimized using a topology optimization algorithm. The result of this should be an optimal design based on structural principles.

Using computational tools and reasoning in order to find or generate an optimized design is inherently related to Building Technology and MSc AUBS, and can be regarded as a form of design by research.

Relevance

The relevance of this research on the building industry can be seen in the optimization of masonry designs (which can be modelled as discrete element structures). This thesis may result in a useful tool to create efficient structures that save on labour and resources. Apart from the creation of designs however, it can also be used to restore or reinforce existing masonry structures more effectively. An important note is that within the scope of this thesis the shape of these masonry elements can be chosen arbitrarily, as long as they can be approximated by voxels or tetrahedra.

Regarding the scientific relevance, this project may fill in a certain void within the field of topology optimization. Especially as this thesis outlines a method to optimize discrete element structures it may be useful, because this is not nearly as developed as finite element analysis-based topology optimization. As of now, no discrete element analysis-based topology optimization algorithm exists to optimize three-dimensional structures where non-linear material behaviour is considered.

Design by research

The relation between research and design lies mainly in the results and applications of topologically optimized structures.

These structures may aid designers in developing lighter, and at the same time, robust structures. This may give designers more freedom in their overall designs, as the structural performance of the exact configuration of the masonry elements is less of a concern. The developed algorithm could be used to try computing optimal structural topologies for a given architectural design or boundary conditions. As this could take a long time to perform on large structures, it is an option to perform this optimization on smaller parts of it and then assemble the larger structure from its constituent parts.