# Topology Optimization in Architectural Spaces: From Logical to Rational Design Domains

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## Abstract

The building industry is a major part of the climate change debate as cement accounts for a significant share of global CO2 emission, while steel has around 26% of its production used in buildings [1]. Regardless of material choice, architects and engineers are continuously challenged to provide solutions that minimize the amount of material, cost of fabrication and operation. Material efficient design is a broadly researched area that aims to reduce the impact of climate change while meeting the demand of a rapid growth in global population.

The pursuit of minimizing the amount of material in construction precedes our present-day environmental dilemma. The processes of optimization and form finding have been explored for over a century, providing many opportunities of reassessing our approach to building design. Topology Optimization (TO) is one of the many heavily researched processes today, producing a variety of techniques including SIMP [2] and BESOS [3].

However, the research conducted on the applications of TO in the architectural field is limited. This paper proposes an alternative process and investigates the significance of assigning the right Design and Non-Design Domain in the TO process and its effects on the optimization results. The existing approach relies on defining the Design Domains in areas that are usually allocated for structural elements. This research challenges the norm of where structure is allocated to evaluate the results against the criteria of minimizing material. The study investigates the idea of interpreting the Design Domains in a more rational perspective, using anthropometric data to create efficient spaces with minimum material use.

The methodology involves modelling load bearing elements that evaluate scenarios with different design domains, through a comparative study between two tools that use different topology optimization techniques; BESOS and SIMP. The research is part of the Material Balance Research group projects in Politecnico di Milano, where a case study is conducted on a roof canopy in an attraction park in Orlando to investigate the results on a practical project. The study illustrates the impact of assigning the right design domain on the optimization process, not only on the performative and material distribution, but in terms of meeting design criteria and creating usable spaces. It also reexamines the idea of optimization and highlights the concept of an optimized design not necessarily being the best design. It provides an alternative method for TO applications in architecture design and form finding techniques.

## References

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