TOPOLOGY OPTIMIZATION FOR FREE-FORM BUILDING ENVELOPE DESIGN WITH ADDITIVE MANUFACTURING

P4 Reflection

Student:
Bayu Prayudhi

Student number:
4416368

Members of graduation committee:
Dr. M. Turrin (first mentor)
Prof.dr.ing. U. Knaack (second mentor)
Shibo Ren (guest supervisor)

The relationship between research and design

The research and analysis on Topology Optimization (TO) design method address the subject on the perspective of implementing TO as a new design tool for designers. The output is a design framework with specific design parameters which will be implemented in the design phase. The research analysis on the subject of Additive Manufacturing (AM) runs in parallel an simultaneously presents a new sets of parameters which are also influence the design framework. The research and design process conducted as a non-linear loop which runs in multiple iterations. The design framework implementation on the case study often presents new design challenge and problems which need to be addressed back in the schematic research phase. These iterative process produce many hypothesis which in the end are evaluated as a final design product of the research by design.

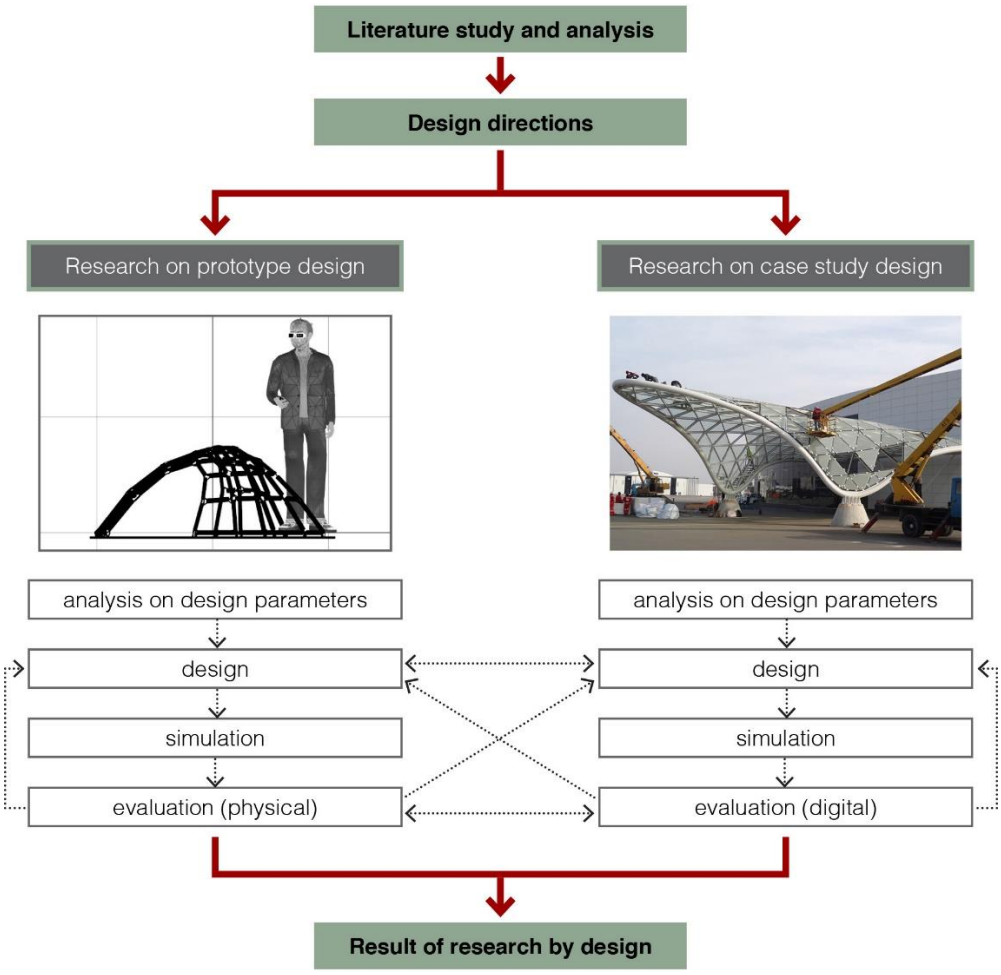
The relationship between the theme of the graduation lab and the subject chosen by the student within this framework

The research focuses on a new method of design and fabrication which sits in an area of research topic on computational design for structural performance and digital fabrication. The TO and AM technology are in general applies to a wide range of design and engineering subject which would not be possible to be covered in this research thesis. Therefore, freeform envelope was chosen as a case study, providing a detailed design problems for implementing the research by design. The design context of freeform structure gives a very detailed level of complexity which helps answers the main question of the research which is to maximize the potential of TO and AM technology.

The relationship between the methodical line of approach of the graduation lab and the method chosen by the student in this framework

The building technology track tackles on the gap connecting architectural design and engineering. This research mainly integrates study on structural design and computational design with implementation of innovative digital fabrication. The term “optimization” has always been the keyword in both topics of study. The study is not only focused on creating final design result but also inventing a new design methodology with the goal of having a design that performs better in any specific context.

The methodology of the research starts with literature study and analysis of state of the art of the chosen subject which sets the framework of the design methodology while also predetermines preliminary design decision for the research. The research and design are conducted on two different scale of research, a prototype design and real case study design. Each of these research area has its own design problem within the same topic of research. The prototype scale is where the problems are investigated in a highly detailed manner. The research design on the prototype validates the methodology and general framework to be implemented in the real case study. The general research does not follow a linear framework from prototype to case study project, it rather runs parallel and informs each other with iterative feedbacks. The prototype design gives full control of the research and design strategy on a very detailed level which is not necessarily applicable on the scale of the case study project.



The relationship between the project and the wider social context

Topology optimization in general is a part of structural form-finding computational design method. The technology was meant to inspire designer and engineer create their designs. It is a design tool which helps designers in making a design decision, with respect of other design requirement that influenced the performance and the purpose of the design. In the other industry such as aerospace and automotive, topology optimization generated design is arguably could replace the engineer's job in designing the structural shape. Moreover, the additive manufacturing process made it possible to greatly reduce the needs of engineer's alteration from raw computer generated design to functional physical object. The bigger question would be: Are we going to have a product which was designed and manufactured completely by a computer software?

If we are talking about a specific performance driven products such as parts of an airplane or car, which have highly regulated performance criteria for specific functions, perhaps the answer is yes, machines and artificial intelligent could provide a complete design and manufacturing solutions while human is merely needs to prepare the problem to solve. However, architecture and the built environment industry works in a much bigger scale of social context. There is never been a single definite solution for one architectural problems, including the building structural problems. Buildings are meant to last for generations while the designers was only involved in a small part of the building's lifetime. Computational optimization focuses on a very specific problems. However, the problems in architecture are always dynamically evolve. That is the part where designer's and engineer's intuition cannot be replaced with computer algorithm.

In conclusion, the design and fabrication methodology presented in this research with TO and AM is becoming a design tool which helps designers to make design decisions. It changes the traditional design methodology in such a way that actually reduce the design complexity for the designer which is taken care of by the algorithm and gives more freedom for the designers to focus on the more important issue in the context of architecture and the built environment design.