Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

The graduation plan consists of at least the following data/segments:

Personal information	
Name	Guus Gooskens
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Studio	
Name / Theme	Building Technology
Teachers / tutors	Prof.dr.ing. U. Knaack Dr. M. Turrin
Argumentation of choice of the studio	A studio where all disciplines merge to create innovative and sustainable design solutions for the built environment, which as a result will give me a holistic mindset and toolbox to solve future problems

Graduation project	
Title of the graduation project	The Potential of for integrating functionalities in solid structural elements of building envelopes using a bottom-up, bio-inspired design approach utilizing capabilities of additive manufacturing
Goal	
Location:	Amsterdam
The posed problem,	The building industry is responsible for 40-50 per cent of resource consumption, 35 per cent of CO2 emissions, and 50 per cent of waste generation worldwide. There are great opportunities to integrate functionalities in a predesigned heterogeneous material composition or meso/microstructures to create functionally graded and optimized materials, like found in nature. However, state of the art CAD software seem to lack capabilities to support this design approach which has become attainable with current AM production techniques.
research questions and	What software optimization strategy must be developed to support the design approach for resource savings by integrating functionalities in solid structural elements in the building envelope using a bio-inspired, data driven, bottom-up, compliant to additive manufacturing fabrication constraints?

Design assignment in which these result.	Develop and verify a data driven design approach inspired by nature that is able to develop an optimized building envelope concept within a given design space and boundary constraints (structural, thermal, acoustic, etc.) and at the same time, complies with AM production constraints.

Process

Method description

Introduction

- My personal story
- Story of Arup
- AM developments in engineering
- Introduce and outline AM capabilities, design approaches
- Define problem statement building industry
- Relate to AM opportunities
- As a follow up, describe objectives, research questions and approach/methodology

Research

- Elaborate on bottom-up and bio-inspired design approach of cellular structures with references from nature and engineering
- Exploratory study on what functional requirement of a building envelope could be integrated using this approach and select one or more based on impact
- Analysis of different optimization strategies for this design approach

Develop design approach

- Develop data-driven design approach that will opt to give an optimal result, given a certain design space and boundary conditions and requirements.

Verification

- Different verification strategies - numerical, FEA, simulations, etc -must be compared to study and test all different design approaches. Results must either automatically or manually feed back to the design approach to asses different design approaches and optimize this process

Asses, reflect and conclude

- In order to show how this design approach can be applied in practice, a fictional case study should be described with a given design space and boundary constraints. The verified design approach should be showcased here in a real life scenario.
- To asses its value, a comparison should be made between this design result and one of a traditionally designed case with similar constraints.
- Reflect and conclude on results, feasability, relevance, futere work and personal experience

Literature and general practical preference

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Egham, U. K. (2014). Gartner Says Consumer 3D Printing Is More Than Five Years Away. Retrieved June 10, 2015, from http://www.gartner.com/newsroom/id/2825417

Gao, W., Zhang, Y., Ramanujan, D., Ramani, K., Chen, Y., Williams, C. B., . . . Zavattieri, P. D. (2015). The status, challenges, and future of additive manufacturing in engineering. Computer-Aided Design(0). doi: http://dx.doi.org/10.1016/j.cad.2015.04.001

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Herczeg, M., McKinnon, D., Milios, L., Bakas, I., Klaassens, E., Svatikova, K., & Widerberg, O. (2014). Resource efficiency in the building sector. Rotterdam: Ecorys.

Klein, T. (2013). Integral Facade Construction, Towards a new product architecture for curtain walls. Delft University of Technology, Faculty of Architecture, Delft.

Oxman, N. (2011). Variable property rapid prototyping. Virtual and Physical Prototyping, 6(3-31).

Oxman, N., Keating, S., & Tsai, E. (2011). Functionally Graded Rapid Prototyping. Innovative Developments in Virtual and Physical Prototyping.

Williams, C. B., Mistree, F. M., & Rosen, D. W. (2005). Towards the Design of a Layer-Based Additive Manufacturing Process for the Realization of Metal Parts of Designed Mesostructure. Paper presented at the Proceedings of the 16th Solid Freeform Fabrication Symposium, Austin, TX.

Reflection

Relevance

Global initiatives show that there is great potential and need for improvement. One flagship initiative is the "Resource efficient Europe", adopted by the European Commission in January 2011, aims to help decouple economic growth from the use of resources, support the shift towards a low carbon economy, increase the use of renewable energy sources, modernize the EU's transport sector and promote energy efficiency. The RERM is a vision set out by the EU to make all buildings nearly zero-energy and highly material efficient.

Relevance on AM

- GE plans a $3.5B investment in research in additive manufacturing
- Obama said in a speech "the 3-D printing that has the potential to revolutionize the way we make almost everything". Following this up, a federal commitment was launched of $200 million to develop the technology

Time planning