Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

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

Personal information	
Name	Mick van de Leur
Student number	4867165

Studio		
Name / Theme	Architectural Engineering	
Main mentor	Stephan Verkuijlen	AE+T
Second mentor	Gilbert Koskamp	AE+T
Argumentation of choice of the studio	Architectural Engineering was chosen because it unites two disciplines that are, in my opinion, too often regarded as separate. I think that Architecture and Engineering are indispensable to one another and should not be regarded as two distinct fields. Architectural Engineers are technical designers that come up with integrated solutions that are feasible, innovative, and well-designed. To me, this studio balances the analytic with the creative and the rational with the innovative. Furthermore, the freedom of the studio allowed me to research some of the most topical issues related to our discipline and allowed me to explore my future role and position as an architectural engineer. I think this studio is a great way to conclude my study here in Delft.	

Graduation project	
Title of the graduation project	A sustainable framework for growth
Goal	
Location:	Campus Technische Universiteit Delft
The posed problem,	The TU Delft envisions a growth from 28k students now, to 40k students in the (near) future. At the same time, the TU Delft upholds sustainability targets that are very ambitious (CO_2 neutral, circular, and climate adaptive in only 7 years!). These two developments appear paradoxical because historically, growth did not correspond with sustainability.

research questions and	**Main:** How can the structure of multistorey timber buildings be designed when taking material efficiency as a guiding principle? **Sub:** 1) What constitutes a multistorey timber building and why is it significant? 2) Which parameters govern the structural design of multistorey timber buildings? 3) How can material efficiency be quantified and by which criteria is it defined? 4) Which structural design is more efficient in terms of material use? (case study)
design assignment in which these result.	The assignment is to find a way to accommodate the growing student population whilst complying with TU Delft's ambitious sustainability goals. The research into multi-storey timber structures should give me the tools to work on the design assignment.

Problem statement:

The building sector is responsible for 36% of global energy use and nearly 40% of energy-related CO_2 emissions (UNEP, 2018). Clearly, the built environment has a critical share in anthropogenic climate change. Fortunately, many policies are in place to mitigate the environmental impact. However, most policies focus on capping the operational energy of buildings rather than the embodied energy of building materials. Energy-efficient buildings will reduce energy use and carbon emissions in the long run. But, without a simultaneous focus on embodied energy and carbon, the savings that could be made now are lost (Pomponi et al., 2018).

The most effective strategy for mitigating embodied emissions is to intervene at the material level. Either by using less of the same material or by substituting with alternative materials (Pomponi et al., 2020). Biobased products such as wood proved viable alternatives to steel and concrete and store carbon instead. However, the sustainability of wood is not absolute. Engineered timber relies on plastic adhesives and requires energy-intensive processing. And although wood is renewable, its availability is not absolute.

Globally, the UN (2018) projects 2.3 billion new urban dwellers by 2050. Consequently, we are facing huge housing and infrastructural challenges. Continuing to build with materials that have a high embodied environmental impact could be detrimental. On a local scale, this development happens analogously in Delft. The TU Delft envisions a large growth in its student population whilst upholding very ambitious sustainability targets.

Objective:
In general, the aim is to find out what 'sustainability' truly entails, because repeatedly misusing the term will not ensure our continued existence (Zwerger, 2019).
Specifically, the research aims to find a way how we should build with material efficiency as an objective. Material efficiency in this case means how to build with the least environmental impact.
The research should provide a general framework that can be applied to the design. The design proposes a way for the TU Delft to meet its ambitious targets regarding sustainability and the growing student population. Specifically, the old applied physics building (building 22) will be redesigned and expanded accordingly. Building 22 is the worst-performing building of the TU Delft in terms of energy use and needs to be renovated. Combining renovation with new construction might open up interesting design options.

Design question:
How can the TU Delft accommodate the growing student population whilst complying with its sustainability goals?

Research question(s):
Main:
- How can the structure of multistorey timber buildings be designed when taking material efficiency as a guiding principle?

Sub:
- What constitutes a multistorey timber building and why is it significant?
- Which parameters govern the structural design of multistorey timber buildings?
- How can material efficiency be quantified and by which criteria is it defined?
- Which structural design is more efficient in terms of material use? (case study)

Process

Method description

Research:
The study comprises a two-phase research design where two strategies are combined in sequence. First, a qualitative literature study is conducted to highlight the significance of timber high rises and the considerations that occur during their design. The literature study aims to answer the first three sub-questions which should set the framework for the case study.
The case study, which comprises the second part of the research, is done through representation and simulation. It starts with a 3-dimensional representation of the Karel Doorman in Rotterdam. By applying different scenario inputs and generating various alternative representations we can start to speak of simulation (Groat and Wang, 2013). The aim of the case study is to find out how we can build materially efficient. By replacing the structure of the Karel Doorman with several different materials and by assessing/quantifying the variants on the environmental impact, the final sub-question should be answered. The aim is to derive important generalizations from the comparative differences and find causal links which can be used in the design.

Design:
The materially efficient way to build, as researched, is used as a starting point for the design. Combining this with situational research and research by design it should be possible to come to a coherent solution for the design assignment.

Literature and general practical preference

Literature used thematic research

Allwood, J. M., Ashby, M. F., Gutowski, T. G., & Worrell, E. (2013). Material efficiency: providing material services with less material production. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *371*(1986), 20120496. https://doi.org/10.1098/rsta.2012.0496

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Herzog, T., Natterer, J., Schweitzer, R., Volz, M., & Winter, W. (2004). *Timber Construction Manual* (1st ed.). Birkhäuser Architecture. https://ebookcentral-proquest-com.tudelft.idm.oclc.org/lib/delft/reader.action?docID=1075578

Hudert, M., & Pfeiffer, S. (Eds.). (2019). *Rethinking wood: Future dimensions of timber assembly*. Birkhäuser. https://doi.org/10.1515/9783035617061

Ibelings van Tilburg Architecten. (2010). *Werktekeningen Karel Doorman* [Dataset].

Kaufmann, H., Krötsch, S., & Winter, S. (2018). *Manual of Multistorey Timber Construction*.

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Meijer, E. (2014). Weighting: applying a value judgment to LCA results. *PRé Sustainability*. https://pre-sustainability.com/articles/weighting-applying-a-value-judgement-to-lca-results/

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Literature used in design assignment (thusfar)

Asselbergs, T., Snijders, A., Smit, M., Parravicini, M., & Gbaguidi, C. C. S. (2021). Introduction aE graduation studio. AE Journal, 12.

Blom, T., van den Dobbelsteen, A., & Department of Architectural Engineering+Technology TU Delft. (2018). *CO2-roadmap TU Delft*. https://d2k0ddhflgrk1i.cloudfront.net/Websections/Sustainability/CO2-roadmap%20TU%20Delft.pdf

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Reflection

1. What is the relation between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS)?

   In the Architectural Engineering studio, innovative solutions in engineered architectural design are sought. Central to the studio is understanding existing potential, knowing the possibilities of renewal and discovering how to innovate, design and initiate change (Asselbergs et al., 2021). This closely relates to the graduation. Firstly, the research focuses on a field that has quite recently started to proliferate; embodied-energy and -carbon (and other indicators). Its seeks to provide a sustainable way forward which is also a central theme to aE. Thus, the research is topical and addresses some key-issues relating to aE. Secondly, the design explores possibilities for the TU Delft to meet their goals that might appear contradictory. In the design, the existing potential of renewal of building 22 is elaborated, and therefore closely relates to the studio topic.
   The relation between the studio and the master track Architecture is evident. The way society is shaped can be envisioned through architecture. It deals with topical issues and tries to provide a way forward through integral design-solutions.

2. What is the relevance of your graduation work in the larger social, professional and scientific framework.

   The graduation is relevant in a larger framework because it literally bridges the gap between theory and practice. Almost exclusively, the literature that I have used describes scenario's, solutions and issues in words. This makes sense, but usually does not sketch or envision a way forward compellingly. On the other hand, many designs do not rely on a analytic research as a foundation. Many designs, in my opinion, rely on oversimplified reasoning. Moreover, some design relies only on the 'mythical' wisdom of the designer who is unable to explicitly explain why something is designed the way it is. I think the research reinforces the design and vice versa and is therefore relevant in the larger social, professional, and scientific framework.