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	Maria Daniela Martinez Palacio
Student number	5222834

Studio		
Name / Theme	Building Technology/Sustainable Design Graduation Studio	
Main mentor	Dr. Stijn Brancart	Structural Design
Second mentor	Dr. Serdar Asut	Design Informatics
Argumentation of choice of the studio	Understanding and evaluating the structural constraints of reusing steel sections and integrating that research with computational tools can help bridge the gap in the design process of circular construction. The overall goal is to incorporate and facilitate circularity in the built environment by reusing structural steel and thus reduce the environmental impacts of the construction industry.	

Graduation project	
Title of the graduation project	Integrated Design with Reused Steel: Facilitating the Reuse of Structural Steel in New Construction
Goal	
Location:	Delft, NL
The posed problem,	According to the World Building Council, towards the middle of the century, the world's population approaches 10 billion and its global building stock is expected to double in size (World Green Building Council 2022). The building industry is responsible for 39% of the total greenhouse gas emissions in the world, of which 11% are embodied carbon emissions from material production and construction (Bringing Embodied Carbon Upfront, 2019) and 7% of that is produced by the steel sector (IEA, 2020). Through this research, three main problems have been identified as fundamental issues that need to be addressed in the construction industry: the embodied carbon emissions, the improper management of waste disposal, and the depletion of non-renewable resources. These main challenges are mainly due to the current "take-make-

	dispose" linear model that needs to transition into a circular economy. Looking into the steel production sector, the recyclability of steel does not cause degradation to its properties. Currently 70% of steel is recycled, which reduces the use of primary resources, however this process is nevertheless very energy intensive.
research questions and	By gaining a better understanding of the current challenges in the building industry as well as the current process of reusing structural steel for new construction, the main objective of this research is to promote and facilitate the circularity of materials in the built environment, focusing on structural steel. The main research question is formulated as follows: *How to facilitate the design process when integrating reusable steel structural profiles for new construction?* The following sub-questions will contribute to the main research question: 1. What are the current limitations of reusing steel structural components, more specifically H and I steel sections? 2. What is the current process of analyzing and evaluating the structural integrity of reused steel sections? 3. What are the current challenges in the different project phases, in terms of project coordination, to integrate reusable steel sections? 4. How can computational tools and digital data help to better integrate the available reused steel sections in new construction?
design assignment in which this will result.	According to the previously stated problems and research questions, the objective of this thesis is to determine the current challenges of incorporating reused steel sections in new construction and propose a design framework that could facilitate the design and coordination process. Additionally, this design framework will help support the development of a computational tool that connects the structural BIM models with a reused steel stock inventory. The hope is that integrating these two softwares will allow

	engineers and designers to make informed design decisions in regards to circular construction.

Process

Method description

PART I

This will be the initial research process, which will consist of extensive literature study to identify the current issues and to determine the latest advancements on the subject. The research will also entail the review of case studies as well as interviews with current professionals to understand the challenges and successes in the design process when reusing structural steel for new construction projects. Additionally, surveys will be sent out to the different parties that participate in a project team to determine the perceived importance of the challenges while working with reused steel elements for new projects.

PART II

In this study, a design framework will be proposed to facilitate the integration of reused steel sections in new construction. The framework will consist of a process-detailed guideline to facilitate the planning and design phases of a construction project. This guideline will incorporate the different phases of a project including: the disassembly of existing buildings, the salvaging of the building components, the planning phase, design phase and construction phase.

PART III

With the goal of facilitating the design process, a computational tool will be developed to integrate the available reused and reconditioned steel stock with BIM software currently used in the industry. This computational tool will allow engineers and designers to evaluate their BIM structural models with possible substitutions of reused or reconditioned steel sections based on the available reused steel stock inventory. Hence, promoting a more integrated design process that incorporates the entire project team during the early planning phases and allows the team to make informed design decisions towards a more circular building process. This computational tool will help bridge the gap between a steel availability stock and the BIM models during the design phases. This, with the overall objective to design with what is available.

Literature and general practical preference

LITERATURE

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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)?**

   Building Technology encompasses several engineering disciplines in combination with architectural design towards one of the dominant professions of the future: sustainable design (TU Delft, 2023). This thesis topic engages two chairs within the Building Technology track – Structural Design and Design Informatics - and implements the following three main focuses pertaining to the architectural profession: circular design, structural design, and computational design.

   Firstly, the research will support the current issues of fully transitioning from a linear economy to a circular economy. While circularity is not a new topic, it can be concluded from the research that implementing these changes in the built environment have been a fundamental challenge. Following, the research of analyzing and evaluating the structural integrity of existing steel sections and verifying its compliance with new criteria is essential to promote the reusability of structural steel components. Lastly, the implementation of design informatics will allow engineers and designers to make informed design decisions based on available data.

   The thesis topic and research align with the established principles of the Building Technology track in the sense that it embodies sustainable design in the architectural field while utilizing technical knowledge.

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

   As the thesis focuses on the subjects of circular design, structural design, and computational design, these topics play a large role in the building industry. Per the aforementioned problem statement, it can be derived that the building industry has detrimental impacts on the environment. The research focuses on three fundamental issues that need to be addressed in the construction industry: the embodied carbon emissions, the improper management of waste disposal, and the depletion of non-renewable resources.

   Implementing the reuse of steel sections in new buildings is a step towards circular construction and will consequently reduce the negative environmental impacts of the steel industry. However, there are various challenges of incorporating reused structural steel in projects. With the development of a design framework, the objective is to facilitate the planning and design phases of a project as well as the coordination that this entails among the project team.

   Furthermore, the design and development of a computational tool that bridges the gap between the available reused steel stock database with BIM software currently used in the industry will allow designers and engineers to make informed decisions when substituting new steel structures with reused steel components. In conclusion, this available knowledge will facilitate the coordination process to plan and solve project challenges early on in the design phase.