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	Gabi Janse
Student number	5012570

Studio		
Name / Theme	Architectural Engineering	
Main mentor	Annebregje Snijders	Design
Second mentor	Jos de Krieger	Research
Argumentation of choice of the studio	In my opinion, the Architectural Engineering studio offers the potential to dive into a wide array of crucial topics. This includes addressing sustainable, technical and societal challenges. What particularly appeals to me is the studio's encouragement of experimentation and creativity, all while ensuring that the end results are both realistic and practical. I value the integrated approach to research and design that this studio advocates.	

Graduation project	
Title of the graduation project	Reclaimed steel components and their implementation in design in the TU Delft Campus North area
Goal	
Location:	TU Delft Campus North
The posed problem:	More knowledge on how to reuse and implement different types of steel components in an architectural design, to be able to align with objectives in TU Delfts sustainable vision and to prevent larger-scale environmental challenges.
Research question:	How can reclaimed steel elements from TU Delft's outdated campus buildings be assessed for component reuse?
Design assignment in which these result:	How can reclaimed steel components from unsustainable, outdated TU Delft campus buildings be implemented in the architectural design of a new circular campus building?

The building sector accounts for 40% of national CO_2 emissions. Among the contributors to this environmental impact, steel production stands out as one of the most energy-intensive and CO_2-emitting industries globally. For example, Tata Steel IJmuiden, a major steel producer, is the largest polluter of the Netherlands (Frisse Wind Nu!, 2023). Shifting towards a more circular system for steel elements, could be achieved through urban mining and component reuse. *Urban mining* is the activity of recovering materials from anthropogenic stocks, where buildings are one of the most important stocks, since these are responsible for the highest rates of natural resource extraction (Bender & Bilotta, 2019). *Component reuse* is the practice of salvaging and reusing specific building elements from existing structures in new/other constructions, aiming to reduce waste and promote sustainability (Alaka et al, 2012).

Delft University of Technology aims to achieve carbon neutrality by 2030, aligning with its Sustainable Vision 2022. However, outdated construction methods have left several TU Delft campus buildings below current sustainability standards; The Faculty of Electrical Engineering, Mathematics and Computer Science (EWI), Yellow Chemistry (GS) and Applied Physics (TN) are the first on the list of comprehensive renovation or demolition (Blom & van den Dobbelsteen, 2019). EWI has one of the highest energy consumptions on campus and along with its fire-safety issues, its fate has been a topic of debate. GS is sold due to its decay and whether to demolish or renovate its parts, rests with the new owner. TN ranks lowest in energy performance of all TU buildings (Blom & Van den Dobbelsteen, 2019). In the Sustainable Vision the goals for reuse and new construction are established. New buildings should consist of 10% of materials harvested from to be renovated or to be demolished campus buildings. Of the outdated campus projects, 80% of the materials that will become available should be reused in new (campus) buildings (Gameren & Van den Dobbelsteen, 2022). This is relevant to the urban development of TU Delft Campus South, spanning 320.000 m^2, what in the near future will be filled with numerous new campus and office buildings (Posad Maxwan & TU Delft CRE, 2019). Since steel elements were widely used and applied in numerous ways during the period the outdated buildings were completed (approx. 1945-1970), it is advantageous to investigate whether these steel components are suitable for reuse.

However, a critical issue is the lack of comprehensive information on the availability and reuse potential of steel components. Existing studies predominantly examine primary structural steel, while last-century construction methods showcase more diverse steel applications (Birhane et al, 2023). Without a systematic approach to reuse, steel components of the outdated campus buildings, despite their potential, may likely end up as demolition waste or scrap. Thus, the objectives outlined in the Vision will not be realized, while contributing to larger-scale environmental challenges. Therefore, the first part of the research will focus on developing an assessment method for the reuse potential of steel components that could be applied on the campus buildings. The research question will be;

- How can reclaimed steel elements from TU Delft's outdated campus buildings be assessed for component reuse?

By determining whether the component has enough potential to be reused, it can be decided whether or not to use it in a new project. The final project will be a sustainable building constructed as much as possible from reused steel components from the case study buildings. Goals for reuse have been drawn up for the P2 presentation.

The building's function will be to improve social interaction between students. The campus has limited space for initiatives, associations, and workshops, with a program focused on academic activities during regular hours. Smaller associations struggle to find accommodations in the city due to negative perceptions. A lack of facilities for social interaction on campus persists, potentially alienating students from student life. Many students living independently express difficulty in forming connections. National surveys indicate high rates of anxiety, depression, and loneliness (Van der Veldt, 2022). Social interaction boost the sense of belonging and enhances wellbeing, which in most cases leads to increasing study results. This is why the new circular building will establish spaces to encourage social interaction. A program of requirements is drawn up and will be integrated with the goals for reused steel components.

The last part of the research is on how to architecturally implement the elements in the new social building. All elements have a variety of characteristics and different ways of how to assemble them. It will be a challenge to find the right place and purpose for the by the method selected elements. The design question will be:

- How can reclaimed steel components from unsustainable, outdated TU Delft campus buildings be implemented in the architectural design of a new circular campus building?

Process

Method description

Context analysis on:
- TU Delft Campus North, park connecting Echo and Civil Engineering

Literature study on:
- Why reusing steel components? (reuse vs recycling & demolition)
- Which components will be investigated and why?
- Which factors influence the reusability potential of a steel component and how? (environmental impact, costs, longevity)
- How to convert the reuse potential of the components into a value assessment?

Case studies:
- EWI (Faculteit voor Elektrotechniek, Wiskunde en Informatica)
- TN (Technische Natuurkunde
- GS (Gele Scheikunde)

Research by design:

- Implementation of conventionally reused and repurposed steel elements
- Testing different configurations by sketching and digital 3D models
- Integration with program into an coherent design

Literature and general practical references

Important sources literature study:

Durmirsevic, E. (2006). Transformable Building Structures; Design for disassembly as a way to introduce sustainable engineering to building design & construction. Proefschrift, Delft University of Technology, Netherlands.

European Commission, Directorate-General for Research and Innovation, Sansom, M., Meijer, J. (2002). Life-cycle assessment (LCA) for steel construction: final report. Publications Office.

Haas, C., Walbridge, S., Yeung, J., et al. (2017). Understanding the total life cycle cost implications of reusing structural steel. Environmental Systems and Decisions, 37, 101–120.

Hradil, P., Sansom, M., Ungureanu, V., & Vares, S. (2019). Economic potential and environmental impacts of reused steel structures. Structure and Infrastructure Engineering: Maintenance, Management, Life-Cycle Design and Performance, 16(4), 750–761.

Sources used in this text:

Alaka, H., Charef, R., Morel, J., & Rakhshan, K. (2020). Components reuse in the building sector: A systematic review. Waste Management & Research, 38(4), 347-370. DOI: 10.1177/0734242X20910463

Bender, A.P., Bilotta, P. (2019). Circular Economy and Urban Mining: Resource Efficiency in the Construction Sector for Sustainable Cities. In: Leal Filho, W., Azul, A., Brandli, L., Özuyar, P., Wall, T. (eds) Sustainable Cities and Communities. Encyclopedia of the UN Sustainable Development Goals.

Birhane, M., Fishwick, R., Kanyilmaz, A., et al. Reuse of Steel in the Construction Industry: Challenges and Opportunities. Int J Steel Struct 23, 1399–1416 (2023).

Blom, T., & Van den Dobbelsteen, A. (2019, July 25). CO2-roadmap TU Delft. Finale versie 2.9_190725. TU Delft, Faculteit Bouwkunde, Afdeling Architectural Engineering + Technology, Leerstoel Climate Design & Sustainability

Frisse Wind Nu!. (2023). Feiten & cijfers over de impact van Tata Steel. Cijfers via RIVM. Via https://www.frissewind.nu/ feiten-over-tata-steel

Gameren, D., & Van den Dobbelsteen, A. (2022). Sustainable Vision: Ambition and Action Plan for a Climate University. Via https://research.tudelft.nl/ Gameren, D. & van den Dobbelsteen, A., (2023). The Sustainable Campus: Working towards a Carbon-Neutral University. In Measuring Net.

Relevance

Research on the reuse of steel building components, beyond structural elements, remains underexplored. This research has the potential to contribute to the attainment of the new sustainability objectives outlined in the TU Delft's sustainable vision for new buildings. Given that a substantial portion of campus buildings will undergo renovation or demolition, and considering that the selected case study buildings contain numerous steel components, the development of an assessment method for the reuse potential of these elements could be highly valuable. The research could serve as a proposal for project developers working at TU Delft Campus South, aiding in the achievement of the targeted 10% reuse rate. On a broader scale, establishing a protocol for handling these components can inspire designers to harvest locally & implement reclaimed steel components, effectively reducing the volume of steel demolition waste.