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	Joost van Eijk
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Studio		
Name / Theme	Building Technology / Phyton & digital manufacturing	
Main mentor	Pieter Stoutjesdijk	FPD
Second mentor	Hans Hoogenboom	DI
Argumentation of choice of the studio	To challenge myself in becoming a better designer/engineer, I want to integrate python within my graduation. Python is a skill I have not developed yet, but I can see its potential in combination with grasshopper and parametric modelling. Combining this programming language with a topic that has a positive environmental and societal impact led me to the topic of reuse of waste wood.	

Graduation project	
Title of the graduation project	Reuse of waste wood in the Netherlands to create affordable housing with the help of CNC milling and a parametric model.
Goal	
Location:	Delft, The Netherlands
The posed problem,	In the Netherlands, a significant amount of solid B waste wood is being downcycled to engineered board or even incinerated for bio energy every year. In 2015 this amount was estimated around 370.000.000 kg, this is 23% of the total waste wood from that year. This is a problem because this waste wood has the potential to be reused as a building material. The second problem is that this re-used waste wood cannot compete with the standardized prefabricated building elements that are available on the market, at least not in a financial way. What happens right now is that some of the wood get sorted manually and sold in shops for second-hand building materials to furniture

	makers or other small projects. There are no methods that can fully utilize this stream of solid B wood. The improving techniques of digital manufacturing, parametric architecture, laser scanning and machine learning might offer solutions for this problem.
research questions and	**MAIN RESEARCH QUESTION:** How can automatically sorted and scanned waste wood in the Netherlands be reused as a building material, for affordable housing, that is created with CNC milling and a parametric model? SUB QUESTIONS: How can a database of waste wood be linked to a parametric model? How can waste wood be used to create affordable housing? Which CNC milled wood joints can replace the use of metal connectors such as screws and nails?
design assignment in which these result.	The goal is to develop a script that links a parametric model of a house to a database with scanned waste wood. When the desired dimensions of the house are determined the script selects the most suitable pieces of waste wood and generates the house with a form finding algorithm. CNC milling is used to create 'wood on wood' joints and replaces other connecters such as screws and nails. Besides form finding, the script fulfills some other requirements: - minimize material waste during manufacturing. - choose which types of wood to use based on strength classification. - adjust economic value of the wood based on the current and future stock. - design based on esthetical properties of the waste wood. - etc. After running the script, the parametric model generates the required toolpath for CNC milling. To validate the script and the parametric model a randomize function is implemented in the archive of waste wood. To validate the toolpath generation a prototype will be milled from of a segment of the house.

Due to climate change the need for a circular economy keeps increasing and new initiatives rise, like urban mining. However, waste will always be of existence in our society. Recycle techniques improve and we find new ways to process this waste, but most of this recycling means downcycling, especially with wood. In the Netherlands there are two widely used options for waste wood. It can downcycled into an

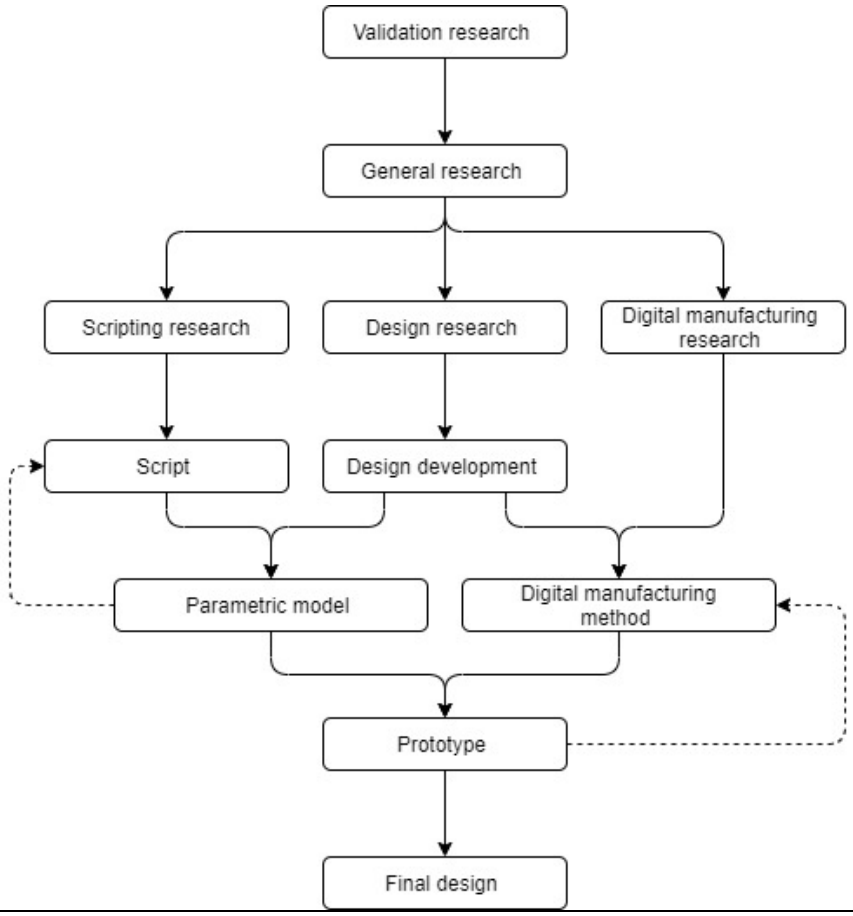
engineered board or incinerated for bio energy. Both options score low in the circular economy and the ladder of Lansink (6 R's). The problem is that an engineered board cannot be recycled again due to contamination. The only other option is incineration for bio energy and thereby releasing CO^2. This also means that with the current processing method for waste wood, the circular economy cannot be achieved.

Reusing waste wood as a building material instead of downcycling it to an engineered board, contributes to the circular economy. However, reusing waste wood is an intensive manual process. Designing a house with these irregular pieces of wood is a time-consuming task and needs to be repeated for every project. Besides that, all the wood needs to be manually processed before it can be used as a building product. In the Netherlands manual labor is expensive and therefore this has never been a feasible option for waste wood.

With my research I want to remove this manual process. By scanning the reusable waste wood, a database can be created with the characteristics of and the dimensions. Combining this database with a parametric model and CNC milling creates a process where manual labor is minimized. The parametric model works for every dimension and therefore removes the process of designing the house for each specific situation. CNC milling can create an easy to assemble structure with irregular pieces of wood.

Process

Method description



The research starts with a validation study to see if there is enough waste wood that can be reused as a building material in the Netherlands. The general research consists of obtaining knowledge about waste wood processing methods in the Netherlands. After the general research there will three parallel studies with the topics; scripting, design & digital manufacturing.

Scripting will consist of a literature study and learning how to code in python. The literature study is about algorithm aided design, parametric architecture and determining the requirements of the script. Learning how to code is necessary to make use of the python component within grasshopper.

Design explores the different techniques of building houses with wood. To understand how a house can be build with waste wood, a literature study is applied about the history of wooden structures and wooden joints. Also, a framework for a case is determined, this will include the parameters for affordable housing.

Digital manufacturing will give a clear summery of different digital manufacturing methods. After deciding the final design of the house and which wood joints are applied, the most suitable manufacturing method can be chosen.

The parametric model parametrizes the design of the house and combines it with the script. The script will improve for as long as time will allow it, therefore creating a positive feedback loop between the script and the parametric model.

The parametric model and the chosen digital manufacturing method will result in a prototype of a structural wall element. The goal of the prototype is to test the generated toolpath for the digital manufacturing and the wooden joints. If the automatic toolpath generation is insufficient the script can be modified. If the wood joints are failing, they can be altered in the design.

When the prototype is sufficient a final design can be generated.

Literature and general practical preference

The literature research will focus on the following topics:

1. Wood waste & wood recycling
2. Wood construction
    a. History of wood construction
    b. Wood joints
    c. Characteristics of wood
3. Parametric design
    a. History of parametric design
    b. Grasshopper
    c. Python
4. Digital manufacturing

Reflection

The goal of Building Technology master track is to teach the student to become a sustainable designer. A designer who can fill the niche between architecture and engineering. A designer who is aware of innovative and sustainable building components and how to integrate them into the build environment.

Finding new ways to reuse waste wood is in my opinion a topic that fits perfectly within the field of a sustainable designer. Preventing the downcycling or incineration of potential building material will reduce carbon emissions and therefore help preventing further global warming.

By addressing a current problem on the Dutch housing market, this graduation research has a positive impact on society by creating affordable rental housing for households with a middle income within metropolitan areas, especially the Randstad.