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	Tjeerd Prins
Student number	5254485

Studio		
Name / Theme	Architectural Engineering	
Main mentor	Stephan Verkuijlen	Architecture
Second mentor	Mo Smit	Research
Argumentation of choice of the studio	I wanted the freedom to explore a subject of my own interest, within realistic and pragmatic limits and demands that I expect from a technically-oriented studio. I had no specific ideas for a graduation project at the start, but I was quite sure that I wanted to incorporate technical aspects, especially concerning materials and structures.	

Graduation project	
Title of the graduation project	A Strategy for Indigenous Wood Architecture
Goal	
Location:	Klarenbeek, Gelderland, Netherlands
The posed problem,	Wood construction reduces carbon emissions of the building sector. The current wood chain framework however impedes the aspirations to upscale wood production and shift to higher-value applications. Most Dutch wood construction is adapted to coniferous wood, provoking local forestry of exotic species. As a consequence, Dutch forests are less resilient in the face of climatic extremes and more susceptible to calamities (Van Kemenade et al., 2021). In addition to the ecological impact of poor resilience, annual reports by Oldenburger et al. (2022; 2023) and Teeuwen et al. (2024) show a declining national production, which can be attributed to drought and disease (Staatsbosbeheer, 2022). Moreover, our forests yield lower quality coniferous wood, as these species are not adapted to the climate (Fraanje, 1999). Being only 6% self-sufficient in its material wood production, the Netherlands relies on import (Probos, n.d.). Meanwhile,

	there is little attention for production of quality indigenous deciduous wood, making high-value application difficult. Approximately 80% of Dutch deciduous wood is used as firewood (Oldenburger et al., 2020). To conclude, within the existing wood chain framework, upscaling local production is undesirable and a shift to higher-value applications is unlikely. To overcome this obstacle, it is necessary to rethink the framework and to explore the potential of indigenous wood.
research questions and	To what extent is there potential to create new production forests with an alternative strategy for wood production and - application, adapted to the properties of indigenous tree species? Sub-questions: 1. What are the parameters of a desirable indigenous forest on the project location? 2. What are the appropriate management methods for such a forest? 3. What types, volumes and dimensions of wood can such a forest yield, and in what timespan? 4. How can these wood types be efficiently utilized in load-bearing constructions?
design assignment in which these result.	The goal of this project is to design a wood production hub within a new indigenous production forest. The *national termination policy of livestock farms with peak loads* is proposed as an opportunity to acquire real estate for this purpose. This wood production hub will consist of a mixed program that complement the production facilities, including recreational and educational functions. The challenge is to create a feasible, phased plan which aligns with the lifespan and material yield of the production forest. The research will contribute to this project in different ways. Firstly, it will determine the qualities of the surrounding production forest (the context). Secondly, resulting rotation periods will help to indicate phasing possibilities for the program (e.g. production facilities may only be required after a few decades, depending on when the forest be thinned or felled). Thirdly, this also helps to determine gaps in financial or temporal feasibility of the plan, resulting in an additional challenge for the design. Lastly, the research results in clear directions for materialization of the wood construction.

	This will result in a phased design for a forestry hub, aimed towards a new strategy for indigenous wood production and architecture.

Process

Method description

The ideal composition of an indigenous forest on the project location will be determined by a comparative analysis of inventories en documentations on old forests in proximity, including the *Beekbergerwoud* and the *Veluwe*. Sources include Weeda (2013; 2014), Maes & Van Loon (2011), Rövekamp & Maes (2002) as well as atlas material from (Stichting Wetenschappelijke Atlas van Nederland, 2001). This literary research will help to prototype the forest system(s), considering species and abiotic qualities.

The management methods and yield will be based on existing literature and silvicultural guides, that discuss forests that are comparable to the prototype forests from sub-question 1.

Finally the efficient application of the resulting wood types in construction will be studied. The book *Natuurlijk bouwen met hout* by Peter Fraanje (1999) will be the starting point for this query. Complementary articles on mechanical performance and archeological discoveries concerning the resulting wood types will be studied as well. Lastly, an analysis of the mechanical properties will be made, based on data from the Granta EduPack 2024 by ANSYS (2024) and the wood database of Centrum Hout (n.d.). This research will culminate in a matrix, stating efficient applications for the resulting wood types in specified elements of load-bearing constructions.

Literature and general practical preference

ANSYS. (2024). Granta EduPack 2024 R2 (24.2.1). [Database]. Retrieved from https://software.tudelft.nl/

Baeté, H., De Keersmaeker, L., Vandekerckhove, P., Christiaens, B., Esprit, M., Vandekerkhove, K. (2002). Monitoringprogramma Vlaamse bosreservaten – Bosreservaat Kersselaerspleyn Basisrapport. *IBW-rapport Bb 2002.005*. Instituut voor Bosbouw en Wildbeheer, Geraardsbergen

Centrum Hout. (2017). Sterktegegevens van gezaagd en gelamineerd hout. In *Houtinfo.nl*.

Centrum Hout. (n.d.). *Houtdatabase*. Houtinfo.nl. https://www.houtinfo.nl/toepassingen/houtdatabase

Daly, A. (2024). Timber supply through time – Copenhagen waterfronts under scrutiny. *Dendrochronologia, 83*, 126164. https://doi.org/10.1016/j.dendro.2024.126164

Dobrowolska, D., Hein, S., Oosterbaan, A., Wagner, S., Clark, J., & Skovsgaard, J. P. (2011). A review of European ash (Fraxinus excelsior L.): implications for silviculture. *Forestry, 84*(2), 133-148.

Duțu, A. (2021). An engineering view on the traditional timber frames with infills in Romania. In *Elsevier eBooks* (pp. 377–420). https://doi.org/10.1016/b978-0-12-821087-1.00005-3

Ecopedia. (n.d.a). *Bomenwijzer*. https://www.ecopedia.be/bomenwijzer

Ecopedia. (n.d.b). *Bostypen*. https://www.ecopedia.be/bostypen

Elkhaddar, A. (2024). The Ultimate Guide to Ash Wood: 10 Must-Know Facts. *Glamorwood*. https://glamorwood.com/types-of-wood/ash-wood/?srsltid=AfmBOoplFoavbL4GRtOjbnJBPWKICQhZso2wRIDTvyFWpF9BPlRcPZux

Ergun, S. F. Y., & Schuller, M. (2021). Timber frame system after the western influence on the houses of Istanbul. In *Eighth Annual CHS Conference* (pp. 339-346).

Fraanje, P. J. (1999). *Natuurlijk bouwen met hout: 33 boomsoorten die zich thuisvoelen in Nederland* [Print]. Uitgeverij Jan van Arkel.

Fraanje, P. (2000). Wateren van Hout. *NEDERLANDS BOSBOUW TIJDSCHRIFT 2000*, 57–61.

Hänninen, K. (2019). Bodegraven-Oud Bodegraafseweg: hout uit een Romeins castellum. *BIAXiaal 1082*.

Iliev, N., Varbeva, L., Tonchev, T., & Alexandrov, N. (2022). Growth and productivity of sycamore (Acer pseudoplatanus L.) in natural stands and forest plantations in Bulgaria. *FORESTRY IDEAS, 28*(63): 178–193

Klingen, S. (2021). Uitkapbos in Nederland. *Vakblad Natuur Bos Landschap*, *173*, 18–20.

Koczan, G., & Kozakiewicz, P. (2016). Comparative analysis of compression and buckling of European beech wood (Fagus sylvatica L.). *Annals of Warsaw University of Life Sciences, Forestry and Wood Technology*, (95), 81-90.

Lerink, B. (2023). *Ontwikkeling van het Nederlandse bos, 2001-2021*. CLO | Compendium Voor de Leefomgeving. https://www.clo.nl/indicatoren/nl006909-ontwikkeling-van-het-nederlandse-bos-2001-2021

Lignoma. (n.d.). *Ash wood*. https://www.lignoma.com/en/magazine/ash-wood/

Löf, M., Brunet, J., Filyushkina, A., Lindbladh, M., Skovsgaard, J. P., & Felton, A. (2015). Management of oak forests: striking a balance between timber production, biodiversity and cultural services. *International Journal Of Biodiversity Science Ecosystems Services & Management, 12*(1–2), 59–73. https://doi.org/10.1080/21513732.2015.1120780

Maes, B., & Van Loon, R. (2011). *Rapport autochtone beplanting Beekbergerwoud*. Ecologisch Adviesbureau Maes. https://www.ecologischadviesbureaumaes.nl/inventarisatie%20oude%20boskernen.html

Medović, A. (2021). Does History Repeat Itself? The Determination of Wood Species Used for the Construction of the Viminacium Amphitheatre. *Arheologija I Prirodne Nauke*, *17*, 41–52. https://doi.org/10.18485/arhe_apn.2021.17.3

Mohren, G. M. J., Van Der Aa, B., Muys, B., & Verheyen, K. (2015). Hooghout. *Forest Ecology*, 325–340. https://www.researchgate.net/publication/46383606_Hooghout

Oldenburger, J., Reichgelt, A., Boosten, M., Penninkhof, J., Teeuwen, S., Kremers, J., & Van Benthem, M. (2020). *Meer hoogwaardig gebruik van Nederlands hout*. Stichting Probos.

Oldenburger, J., Teeuwen, S., & Van Best, S. (2022). *Houtproductie en -gebruik in Nederland Productie, import, export en consumptie van houtproducten in 2020*. Stichting Probos. https://www.probos.nl/publicaties/rapporten

Oldenburger, J., Teeuwen, S., Beerkens, G., Op den Kelder, G., & Van Maaren, G. (2023). *Houtproductie en -gebruik in Nederland Productie, import, export en consumptie van houtproducten in 2021*. Stichting Probos. https://www.probos.nl/publicaties/rapporten

Popadić, R., Šoškić, B., Milić, G., Todorović, N., & Furtula, M. (2014). Influence of the Sawing Method on Yield of Beech Logs with Red Heartwood. *Wood Industry/Drvna Industrija, 65*(1).

Pramreiter, M., & Grabner, M. (2023). The utilization of European beech wood (Fagus sylvatica L.) in Europe. *Forests*, *14*(7), 1419.

Probos. (n.d.). *Kerngegevens Bos en Hout in Nederland*. Bos en Hout Cijfers. https://www.bosenhoutcijfers.nl/

Regio Stedendriehoek. (2023). Uitvoeringsagenda 2023-2030. In *Uitvoeringsagenda Regio Stedendriehoek*. https://regiostedendriehoek.nl/kennisbank/uitvoeringsagenda-regio-stedendriehoek-2023-2030/

Reh, R., Kristak, L., Kral, P., Pipiska, T., & Jopek, M. (2024). Perspectives on Using Alder, Larch, and Birch Wood Species to Maintain the Increasing Particleboard Production Flow. *Polymers, 16*(11), 1532. https://doi.org/10.3390/polym16111532

Rövekamp, C. J. A., & Maes, N. C. M. (2002). *Inheemse bomen & struiken op de Veluwe: autochtone genenbronnen en oude bosplaatsen*. Provincie Gelderland, Dienst REW, Afd. landelijk gebied.

Royal Botanic Gardens Kew. (n.d.). *Plants of the World Online*. https://powo.science.kew.org/

Schelhaas, M., Clerkx, A. P. P. M., Schoonderwoerd, H., Damen, W., & Oldenburger, J. (2018). Meer hout uit het Nederlandse bos. *Vakblad Natuur Bos Landschap*, (144), 14-17.

Short, I., & Radford, T. (2008). *Silvicultural Guidelines for the Tending and Thinning of Broadleaves*.

Smajic, S., Obucina, M., Antonovic, A., Istvanic, J., & Jovanovic, J. (2023). Analysis of yield and sawing methods during processing low value pedunculate oak (Quercus robur L.) logs to sawmill products. *32nd International Conference on Wood Science and Technology*. University of Zagreb, Faculty of Forestry and Wood Technology.

Staatsbosbeheer. (2022). *Het Nederlandse bos wordt steeds gevarieerder*. https://www.staatsbosbeheer.nl/wat-we-doen/nieuws/2022/07/7e-bosinventarisatie

Stichting Wetenschappelijke Atlas van Nederland. (2001). *Atlas van Nederland | Landschap | De potentieel natuurlijke vegetatie van Nederland en aangrenzend gebied*. Kartoweb. https://kartoweb.itc.nl/nationaleatlas/16landschap/28/28.html

SWS Forestry Services. (2016). Ash (Fraxinus excelsior L.). In *swsforestry.ie*. https://swsforestry.ie

Taj, M. A., Kazemi Najafi, S., & Ebrahimi, G. (2009). Withdrawal and lateral resistance of wood screw in beech, hornbeam and poplar. *European Journal of Wood and Wood Products, 67*(2), 135-140.

Teeuwen, S., Op den Kelder, G., Van Maaren, G., & Velthuis, J. (2024). *Houtproductie en -gebruik in Nederland Productie, import, export en consumptie van houtproducten in 2022*. Stichting Probos. https://www.probos.nl/publicaties/rapporten

Tomter, S. M., Kuliešis, A., & Gschwantner, T. (2016). Annual volume increment of the European forests - description and evaluation of the national methods used. *Annals of Forest Science, 73*, 849-856.

Van Benthem, M., & Teeuwen, S. (2018). *Wateren van Hout*. Stichting Probos.

Van Kemenade, L., & Maes, B. (2024). *Attentielijst bedreigde wilde bomen en struiken - Gelderland*. Rijksdienst Voor het Cultureel Erfgoed. https://kennis.cultureelerfgoed.nl/index.php/Attentielijst_bedreigde_wilde_bomen_en_struiken_-_Gelderland

Van Kemenade, L., Maes, B., Copini, P., & Brinkkemper, O. (2021). Behoud genenbronnen van autochtone bomen en struiken in de Bossenstrategie. *Vakblad Natuur Bos Landschap, 18*(172), 37-40.

Van Tussenbroek, G. (2022). Historisch hout in Amsterdamse monumenten 2: *Dendrochronologie - houthandel - toepassing*. (Publicatiereeks Amsterdamse Monumenten; Vol. 3a). Gemeente Amsterdam, Bureau Monumenten & Archeologie.

Veen, P. J., & Berris, L. B. (1994). Het Beekbergerwoud als genenreservaat. *De Levende Natuur, 95*(1), 2-3.

Vilkovský, P., Klement, I., & Vilkovská, T. (2023). The Impact of the Log-Sawing Patterns on the Quantitative and Qualitative Yield of Beech Timber (Fagus sylvatica L.). *Applied Sciences, 13*(14), 8262.

Weeda, E. J. (2013). Productie-oerwoud op z'n negentiende-eeuws. I. Mensen, planten en dieren in en om het Beekbergerwoud. *Stratiotes*, *45*, 29-50.

Weeda, E. J. (2014). Productie-oerwoud op z'n negentiende-eeuws. II. Plantenvondsten en vegetatie-elementen in en om het Beekbergerwoud. *Stratiotes*, *46*, 57-85.

Additionally, I will have personal communications with Max Salzberger about wood properties, yield, dimensions, applications and perhaps programmatic demands for production facilities. I hope this will strengthen both my research and design.

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)?

This graduation project relates to Architectural Engineering, because it is aimed at exploring the capacity of different wood types in load-bearing constructions of buildings. The hope is that this exploration will result in architectural expressions within this construction (e.g. different wood types in different parts of a truss construction), so that a new kind of architectural tectonics is created. The project does not necessarily relate to the rest of my master programme, other than the fact that I have often shown interest in wood construction and material efficiency. This graduation project can be considered a further advancement of those interests, which also explains the choice for my graduation studio.

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

My goal is to tackle problems associated with current wood production and construction methods, such as forest depletion, monocultural plantation-style forests, loss of biodiversity, soil degradation, poor residence and low wood quality. In this project I try to explore the potential for a new strategy within the wood construction narrative, centred around indigenous deciduous wood types in the Netherlands. This will hopefully add new insights in current architectural advancements in the societal goal to battle climate chance, by lowering carbon emissions and allowing for more efficient and location-true material use.

Similar research already exists, and there are advancements and innovations aplenty in the general field of wood construction, however when it comes to deciduous wood, the practical applications and examples are relatively limited. Peter Fraanje (1999) already highlights the lack of appreciation for these wood types compared to standardized applications of coniferous species. This is why I believe that this graduation project is valuable in the scientific field, and especially in architecture.