

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.

Personal information	
Name	Anouk de Vries
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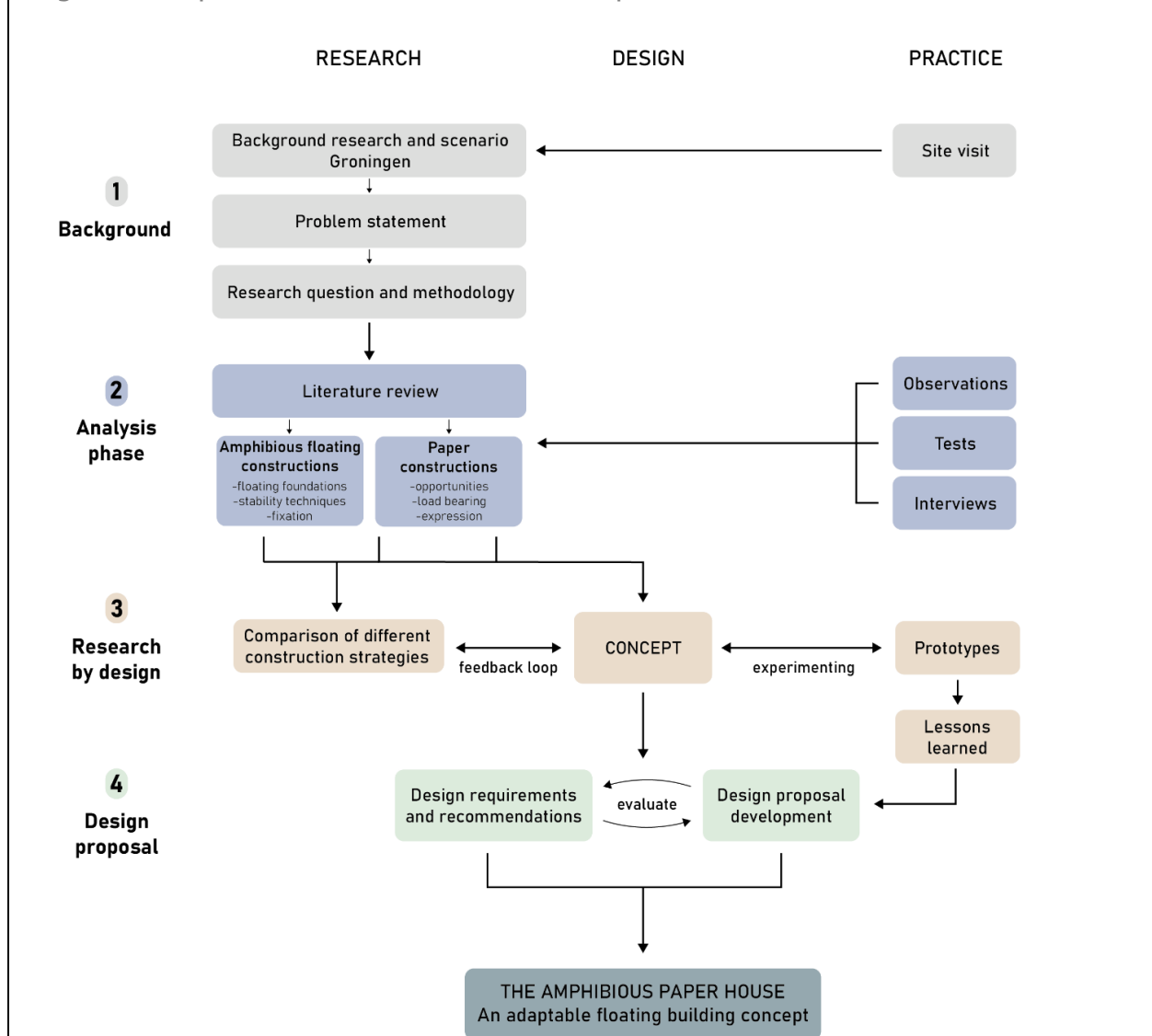
Studio		
Name / Theme	Technologies and Aesthetics / Form Studies & Design of Construction	
Main mentor	Geert Coumans	History, form and aesthetics
Second mentor	Ir. Claudia van Leest	Architectural Technology
Research mentor	Prof. Dr. Ing. Ulrich Knaack	Architectural Engineering + Technology
Argumentation of choice of the studio	This studio allows me the freedom to pursue my personal technical fascinations. The focus on technological construction design, biobased building materials, innovative architectural solutions and model making is what makes me excited about this studio. It combines the aspects that I find interesting to research and I like how this all comes together in the final design phase, in combination with my own creativity. I think this graduation studio can give me a complete set of knowledge about engineering and architecture, which I can take with me in my future architectural career.	

Graduation project	
Title of the graduation project	The Amphibious Paper House. <i>The development of a building concept that incorporates lightweight paper constructions and responds dynamically to changing water levels in the future wetlands of Groningen.</i>
Goal	
Location:	Floodplain near the Reitdiep river in Oldehove, Groningen
The posed problem	This research addresses two global challenges: being able to deal with the rising water level in the built environment and reducing the environmental impact of the construction industry. The first challenge focuses on how to navigate and adapt to the constant rise in water levels. This is a critical concern that directly influences how we design, construct and inhabit our spaces. The second challenge revolves around rethinking the commonly used building materials as a first step of a transition from a linear to circular and sustainable built environment.

Research questions	<p>Main research question: "How can buildings effectively adapt to fluctuating water levels in Dutch polder landscapes by incorporating a lightweight paper-based construction and an adaptable dynamic floating foundation?"</p> <p>Sub questions:</p> <ol style="list-style-type: none"> 1. What are the current typologies of living with the water in wetlands? 2. What technical principles are there for amphibious constructions that can dynamically accommodate varying water levels while ensuring stability and structural safety? 3. Why and how to enhance constructional and load-bearing purposes with the material paper when applied to architectural building structures? 4. How can the principles of amphibious foundations and paper-based constructions be applied innovatively in a residential building design for a floodplain in the Reitdiep area?
Design assignment in which these result	<p>The design assignment is intended to develop a building concept that incorporates lightweight paper constructions and responds dynamically to changing water levels in the future wetlands of Groningen. This can work as a pilot project to show how architects can tackle climate challenges by rethinking their construction techniques and building materials.</p>
Process	
Method description	
<p>This thesis will be carried out using a variety of research methods, including an analysis of case studies, a literature review of floating constructions and paper constructions, material studies by testing, and an experimenting phase through research by design. In the end the research will result in a list of preconditions for a design proposal, which is a basis for further development of an amphibious paper housing project.</p> <p>Multiple case studies are selected to provide insight into specific topics. Three of these case studies are described in chapter 2 and give insight in floating building constructions. In chapter 4, there are studied paper construction case studies to learn more about the techniques and applications of paper-based constructions in architectural projects over recent decades. The advantages and limitations of these projects will be evaluated.</p> <p>Furthermore, a comprehensive literature review will be conducted to analyze the techniques of amphibious foundations. Because an amphibious construction is a new development, many techniques can be researched from floating buildings as they have</p>	

many similarities. The literature is additionally utilized to understand the methodologies for calculations on the floating platform and the weight of the building which can be used during the design phase. The focus of the research is on achieving stability within the construction, looking into the depth and size of the pontoon, the fixation of the building and the possible size for this type of constructions. In addition to literature research, tests are used for these subjects.

Next, the focus shifts to lightweight constructions, investigating paper structures. This exploration delves into the potential of paper-based materials for sustainable structural applications. The experimenting phase represents the practical application and testing of the constructional properties of the material. It relies on the insights gained from material research, including the structural, environmental, and design aspects of using paper in construction. The experiments can consist of testing the strength of paper construction prototypes, trying out different tube joining techniques, and testing it weathering circumstances. During this experimenting phase, I will investigate the potential benefits, challenges, and innovations of using paper-based materials in architecture. A comparison with traditional building materials as wood and steel is made to give a complete overview of the material's potential.



Literature and general practical references

Precedents:

- Floating Office Rotterdam – Bartels & Vedder
- Amphibious House UK – Baca Architects
- Amphibious housing Maasbommel – Factor Architects
- Disaster Relief center – Shigeru Ban
- Ring Pass Delft - Octatube
- Wikkellhouse – Fiction Factory
- Westborough Cardboard School – Cottrell & Vermeulen

Literature:

- Anderson, H.C. (2014). *Amphibious architecture: living with a rising bay*. [master thesis]. California Polytechnic State University.
- Ayan, O. (2009). *Cardboard in architectural technology and structural engineering : a conceptual approach to cardboard buildings in architecture*. [Doctoral Thesis]. ETH Zurich.
<https://doi.org/10.3929/ethz-a-006080626>
- Baca Architects. (2015). *Amphibious House*. baca. <https://www.baca.uk.com/amphibioushouse.html>
- Bartels, Vedder (2021). *Global center on adaptation, Rijnhaven, Rotterdam, Nederland*. Bartels & Vedder Interdisciplinair Ingenieurs & Consultancybureau.
<https://www.bartelsvedder.nl/portfolio/global-center-on-adaptation-gca-rijnhaven-rotterdam-nederland/>
- Brouwers, J. (2022). *Vervuilende betonindustrie kan bouwstop veroorzaken, waar blijft het duurzame alternatief?* KRO-NCRV. <https://pointer.kro-ncrv.nl/vervuilende-betonindustrie-kan-bouwstop-veroorzaken-waar-blijft-het-duurzame-alternatief>
- Calcasa. (2023). *Klimaatrisico's hangen als een donkere wolk boven de woningmarkt: woningen potentieel 325 miljard minder waard*. PONT Klimaat. <https://klimaatweb.nl/nieuws>
- CBS (2019). *Construction sector leading in waste and recycling*. Statistics Netherlands.
<https://www.cbs.nl/en-gb/news/2019/45/construction-sector-leading-in-waste-and-recycling>
- De Herde, A., Evrard, A. (2005). *Beton en rationeel energiegebruik*. [report]. In Dossier cement. Published by Febelcem. https://www.febelcem.be/fileadmin/user_upload/dossiers-ciment-94-08/nl/35_nl.pdf
- Factor Architects. (2011). *Project review: Floating homes 'De Gouden Kust'*. Maasbommel, the Netherlands.
- Gemeente Woerden. (2019). *Veenetië. Een onderzoek naar de haalbaarheid van drijvend bouwen in veenweidegebied*. [Report]. Hoogheemraadschap De Stichtse Rijnlanden. Zuid-Holland.
- Haasnoot, M., Diermanse, F. (2022). *Analyse van bouwstenen en adaptatiepaden voor aanpassen aan zeespiegelstijging in Nederland*. Deltares. 11208062-005-BGS-0001
- Jasiolek, A., Noszczyk, P., Latka, J.F. (2023). *Paper-based building envelopes – Thermal and environmental properties of original envelope designs*. [Article]. Wroclaw University of Science and Technology, Poland. <https://doi.org/10.1016/j.buildenv.2023.110755>
- Het Groninger Landschap (2015). *Hunzevisie 2030*. [report].
- Knaack, U., Bach, R., & Schabel, S. (2022). *Building with paper: Architecture and Construction* [Book]. Birkhäuser.
- Kijne, H., Rolvink, R., van Elderen, B., Sachsamanoglou, M., Chronopoulou, E. (2020). *Reitdiep water heritage*. Publication of MORE landscape and VE-R. Reitdiep Groningen.
- Latka, J. F. (2017). *Paper in architecture* [Doctoral Thesis]. Delft University of Technology.
<https://doi.org/10.7480/abe.2017.19>
- Latka, J. F., et al. (2022). *Properties of paper-based products as a building material in architecture – an interdisciplinary review*. Journal of building engineering.
<https://doi.org/10.1016/j.job.2022.104135>
- Morad, A., Faggal, A. A., & El-Metwally, Y. S. (2012). *Efficiency of corrugated cardboard as a building material*. [Thesis]. Ain Shams University. <https://doi.org/10.13140/RG.2.2.24879.53927>
- Roos, W. (2003). *Damage to buildings*. Delft Cluster.
https://open.rijkswaterstaat.nl/publish/pages/141833/2003-139_delft_cluster_1-233-9_damage_to_buildings.pdf

Stahl. (n.d.). *What are bio-based materials?* <https://www.stahl.com/beyond-chemistry-from-a-to-z/what-are-bio-based-materials>

Ter Steege, H.M. (2022). *Daar waar 't Reitdiep ooit liep*. [Master thesis]. University of Groningen.

Vaccari, M. S. (2008). *Environmental assessment of cardboard as a building material*. [Master Thesis]. Oxford Brookes University. <https://www.researchgate.net/publication/332120001>

Van Winkelen, M. (2007). *How high can you float?* [Master thesis]. Delft University of Technology.

Varkey, M.V., Philbin, M.P. (2022). *Flood risk mitigation through self-floating amphibious houses - Modelling, analysis, and design*. [Article]. APJ Abdul Kalam Technological University, India. Elsevier.

World Resources Institute (2023). *Aqueduct Floods*. Aqueduct tools. <https://www.wri.org/aqueduct/tools>

Witsen, P. P. (2012). *Floating Amsterdam. The development of IJburg's waterbuurt*. [Publication]. Municipality of Amsterdam and Projectbureau IJburg. Waterbuurt West.

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)?

The graduation project: "The Amphibious Paper House" is directly connected with the topic of "Form Studies & Design of Construction" and the "Architecture master track" as it approaches an alternative strategy for living in wetlands with a new construction technique of adapting foundations and the use of a lightweight biobased paper construction. The use of a bio-based material aims to make the built environment more sustainable and circular, which are important research topics within the architecture program. Moreover, this studio gives the freedom to experiment with new and innovative construction techniques, by focusing on both the mechanical properties and the aesthetical characteristics of the material. This is where the engineering and architecture aspect comes together, which my project tackles by looking into the possibilities of the relatively new building material paper and the technical possibilities of semi-floating buildings.

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

The research of my graduation work tackles two global challenges: being able to deal with the rising water level in the built environment and reducing the environmental impact of the construction industry. In the professional framework, the project seeks to allow building in areas at flood risks and coming up with strategies to mitigate critical materials concerns and make this approach visible to stakeholders in the architecture and construction field. The emphasis on adaptability to the water level can be a vital point of discussion about the Dutch housing future and its limited land available for new construction.