

Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences



Graduation Plan Building Technology

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Studio	
Name / Theme	Sustainable Design Graduation / Structural Design
Teachers / tutors	ir. Faidra Oikonomopoulou, dr. ir. Christian Louter
Argumentation of choice of the studio	During my studies, I have developed a great interest in glass structures. In my minor of Bend and Break and later in my master program I have followed several glass courses. I find glass structures to be beautiful, and there is still a lot to be explored about the material and its structural application in built environment. As a continuation of the courses I have already followed, I chose to graduate in a new field of application of glass structures: historic buildings.

Graduation project	
Title of the graduation project	Transparent restoration of a historic building by use of structural glass elements

Goal	
Location:	Slot Teylingen, Voorhout, Holland
The posed problem,	<p>In order to preserve monuments that are of great architectural, cultural-historical or emotional value, monuments can be restored. This way the monument can be come functional again, which is a form of preserving. However strict international agreements regarding the high requirements restorations have to fulfill, make the choice of a material for restoration complex. Structural glass can be a suitable material because of its unique combination of transparency and high strength properties, fitting the requirements the international agreements set.</p> <p>However the main problem is that restorations where original elements of a building are replaced by glass structures, have not often been done before. This means there are a lot of questions that need to be solved.</p> <p>The first sub problem is one the architectural aspect and the restoration philosophy: It should be determined in what way an old element</p>

	<p>should be replaced with a glass replacement. It can be discussed what should be done and what not in terms of copying the old elements of the original structure and the building. Achieving an harmonic integration with a glass structure in an old historic monument can be difficult while using such a modern material as glass. Also falsification should be prevented in order to make the restoration an architectural success.</p> <p>The second sub problem is on an technical/engineering aspect. It is unclear how to apply current knowledge in glass order to engineer an replacing glass structure of an original element. Also the question exists on how specific shapes or geometry could be made in glass. The detailing at the connection between glass and old building is critical, just as the point of how forces should be transferred through the supports in the old building.</p>
<p>research questions and</p>	<p>“How can structural glass be used in order to make a transparent roof restoration for Slot Teylingen?”</p>
<p>design assignment in which these result.</p>	<p>The main objective is to research how structural glass can be used in the restoration of a monumental building, by doing a design by research for a replacing glass structure for a selected case study building. Based on this design by research, general guidelines can eventually be formulated. Perhaps it could also lead to an innovation in the application of a new glass technique or element.</p> <p>The first sub-objective is researching how a replacing glass element can integrate architecturally harmoniously with the existing monument, in respect to the history of the building.</p> <p>The second sub-objective is researching how an original element can be designed and engineered out of glass. This will involve researching how the required shape of element can be made out of glass, looking at detailing in the structure itself as to the connections to the old building. The forces of the replacing elements should be transferred properly to in the monumental building.</p>

Process

Method description

The research can be subdivided in different phases. This is illustrated by Fig. 1 on the next page.

Literature study

In this phase, information is retrieved mainly from literature. In the first chapter, (background information) is gathered in order to answer the first six sub-research questions. This information is needed in order to formulate a clear context and firm arguments for the direction of the glass roof design. The first chapter about monuments will involve a research into the general philosophy behind restoration, and could be a good way to restore an original element from a monument in glass. Also this chapter will elaborate more deeply why glass is a suitable material for restoration.

Additionally, a meeting with Rob van Hees will help to find valuable information regarding the philosophy, as well as information about the chosen case study. This chapter gives some guidance in which research has to be done into the case study. Necessary information about Slot Teylingen gathered in the next part, regarding its past, its current state and the future of the building. First of all the pathology and history of the building will be researched, and specifically the shape and build-up of the original roof. Based on information gathered by a site visit and literature, the current state of the building is researched. Next, the future of the castle is discussed by determining a new use for the building, proposing interventions to the Donjon in order to make it functional again. This will be based on literature, but also in discussion with the NMO organization who owns the castle. The third chapter in the literature study is about glass. Here general and detailed technical information is gathered about the material properties, mechanical properties and production techniques. These three topics together can be used to formulate design requirements based on the restoration philosophy, the past & current & future of Slot Teylingen, and the material properties of glass.

Preliminary design

Information from the literature study allows proceeding to the second phase of the research, where the first design steps are made. First the major design decisions have to be made, like the shape of the roof and what the general structural build up should be. The question regarding the roof shape is done based on the design requirements that flow out of the three topics from the literature study. Once the shape is determined, a case study review is done in order to research ways of constructing the chosen specific roof shape in glass. The case study review will retrieve information from literature and from websites from companies that have design, and built glass structures. The projects will be clustered and categorized by structural type.

Drawing inspiration from the case study review, different conceptual designs are proposed. These designs are different in that they each represent a different way of constructing with glass. Out of these proposals, one has to be chosen. This selection is based on the design requirements that flow out of the literature study phase. The choice for one type will be a strong converging step, where this specific structural type will be elaborated.

Design research

In this phase the chosen conceptual proposal will be elaborated and designed to detail. First the main structural build-up will be elaborated and further developed, following by the design on a gradually smaller scale. Eventually the design will be validated by structural calculations done by hand and FEM calculation software like Diana and Matrixframe. 3D software like Rhinoceros will be used to design in 3d, and to make models. Finally, after this iterative process the design will be finalized, and a final render will be made of the design.

Feedback

At the end of the design stage, once the design has been finalized, the process can be evaluated. Based on the findings in the research, general design guidelines can be formulated for glass roof restorations of historic monuments and buildings. These guidelines can be used by future designers and engineers when another monumental building has to be restored, using structural glass.

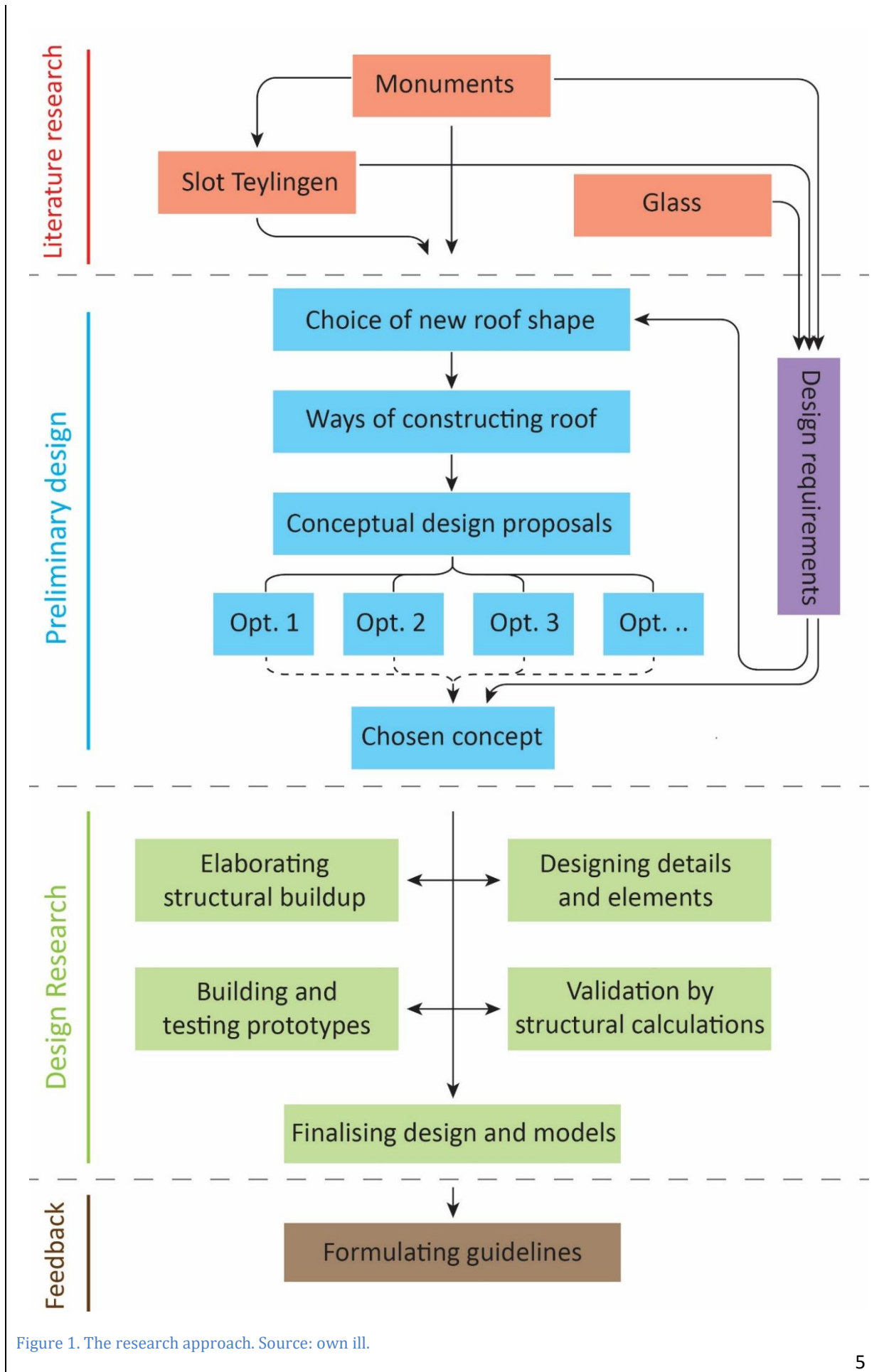


Figure 1. The research approach. Source: own ill.

Literature and general practical preference

Monuments and restoration philosophy

Hoogenberk, E. J. (1983). Geen sloop maar hergebruik. *Heemschut*, 60, p. 62-67.

International Council on Monuments and Sites. (1964). International charter for the conservation and restoration of monuments and sites. http://www.icomos.org/charters/venice_e.pdf

International Council on Monuments and Sites. (1994). *The Nara document on Authenticity*
Retrieved from <http://www.icomos.org/charters/nara-e.pdf>

Lefaki, S. (2005). A New Phase in the Architecture of Glass Constructions: The Use of Glass in the Protection and Restoration of Historic Buildings. *Glass processing days*(2003). Retrieved from www.glassfiles.com

Nelissen, N. (1999). *Herbestemming van grote monumenten : een uitdaging!* 's-Hertogenbosch :: Stichting Pandenbank Noord-Brabant.

Slot Teylingen information and documentation

Annema, W., Rijksgebouwendienst Bureau Rijksbouwmeester Adviesgroep Monumenten in Rijksbezit, Ministerie van Volkshuisvesting Ruimtelijke Ordening en Milieubeheer, & Kamphuis, J. (1994b). *Bouwhistorische documentatie en waardebeoordeling Voorhout, Ruïne van Teylingen Dl. 2*. 's-Gravenhage: Rijksgebouwendienst.

Gemeente Teylingen. (2015). *Toekomst van de Ruïne van Teylingen*. Retrieved from Utrecht/Sassenheim:

Nationale Monumenten Organisatie. (2015). Ruïne van Teylingen. Retrieved from <http://monumentenbezit.nl/rune-van-teylingen-voorhout>

Teylingen, S. B. K. (2015). Website van de Ruïne van Teylingen. Retrieved from <http://kasteelteylingen.nl/>

Glass material and structural properties

Haldimann, M., Luible, A., Overend, M., International Association for, B., & Structural, E. (2008). *Structural use of glass* Structural engineering documents ; 10; Structural engineering documents ; 10., Retrieved from Knovel

<http://app.knovel.com/hotlink/toc/id:kpSUGSED09/structural-use-of>

Glass as a structural material. Powerpoint slides of CT3290 Bend and Break 2 glass (2012-2013 Q2), TU Delft, (2013).

Veer, F. A. (2007). The strength of glass, a nontransparent value. *Heron*, Vol. 52(No. 1/2).

Verbinden van glas. Powerpoint slides of CT3290 Bend and Break 2 glass (2012-2013 Q2), TU Delft, (2013).

Glass structure and strength. Powerpoint slides of AR0105 Technoledge Structural Design (2014-2015 Q1), TU Delft, (2014).

Glass projects case study review

Nijsse, R. (2002). *Glass in structures : elements, concepts, designs*. Basel : London :: Birkhäuser ; Momenta.

Octatube. Structureel glas. Retrieved from <http://www.octatube.nl/systemen-oplossingen/1/structureel-glas/>

Schittich, C., Staib, G., Balkow, D., Schuler, M., & Sobek, W. (2007). *Glass Construction Manual* Retrieved from <http://DELFT.ebib.com/patron/FullRecord.aspx?p=1075514>

Reflection

Relevance

Societal relevance

By doing this research, new knowledge is created about how to execute restorations on monumental buildings in a very transparent and non-intrusive way. By doing this, monuments that have become vacant can now become functional again, while not losing their authenticity or atmosphere. By repurposing vacant monuments, these buildings become available for public again, increasing the cultural value of the area.

Also, succeeding in making a feasible architecturally and technically working glass roof design for a monument can be convincing teaser for the building industry in showing a new approach to restoration. Glass could be the answer to avoiding “falsified” monument restorations, because due to wrong choice of material it becomes unclear after restoration what part of the building is old and part is new.

Scientific relevance

By making a glass roof design for a monument, a new theoretical approach is developed for applying glass structures in monuments. First of all from an architectural point of view this could be a refreshing approach, which fits nicely in the restoration philosophy. The research would provide arguments for the strong relation between glass and the restoration science.

Next, from an engineering point of view it is a technical engineering challenge to construct an original element of a monumental building, in glass. The original element may have a complex shape, which has been made using a material that works completely different than glass. This requires proper translation into the structural build up that works for glass. The resulting design research may lead to new types of elements or geometry made. Another special engineering challenge is the combination of a structure made of a modern material, and an old structure, which rises challenges. The way forces are transferred will require good engineering solutions and detailing. This may lead to interesting new glass details.

This research is related to ongoing research of the Glass and Transparency group of the TU Delft. Here new ways of constructing with glass are developed, which opens a new market and application field for applying the knowledge of glass and glass structures: historic building and monuments.

Time planning

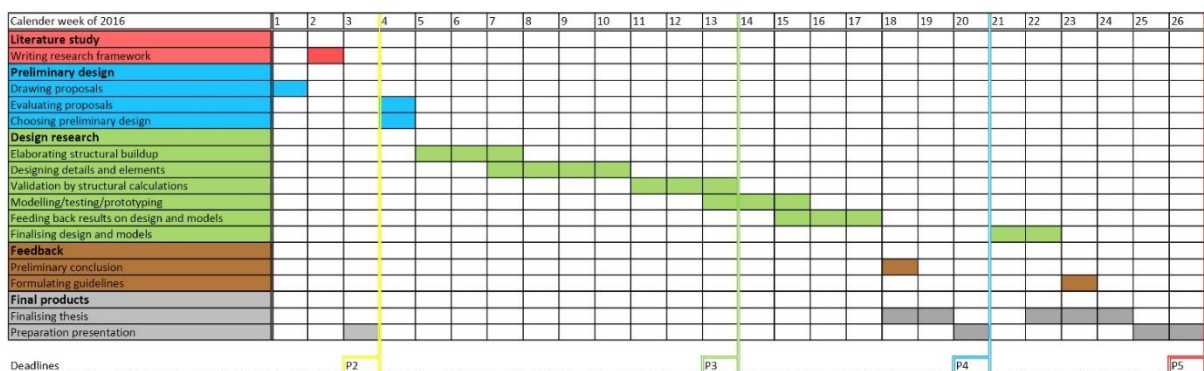


Figure 2. Time schedule. Source: own ill.