Graduation Plan

DESIGN RESEARCH PROJECT

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- Ir. F. Heinzelmann (Florian) | ReVolt House

Argumentation of choice of the studio:
The architectural engineering studio is for me the best choice, because there is a strong relation between architecture and engineering (technology). Coming from a technical background, this specialisation is the most related to me and I thought this was the most interesting and fun specialization to do.

Title:
Floating Buildings
*Research the possibilities for a floating theatre on sea.*
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5. REFERENCES AND FIGURES
This learning plan sets out the planning of the graduation project of Theo Mestemaker, student Architectural Engineering (AE) at the TU Delft (Delft University of Technology).

This graduation/learning plan provides information about the research topic, and the process of the research and design. For this research a technical fascination needed to be chosen and a function for a building that I would like to design. My chosen fascination is floating structures and the function for the building is a theatre. So the final product of the design process is going to be a floating theatre.

At the start of the project a location was determined by the AE studio, the location is Scheveningen Harbour, a part of The Hague (The Netherlands). The main idea is to place the floating theatre on the North Sea, which is harder to do then placing it on land or water inland.

As a side study I am participating in the ReVolt House project, this is the entry from the TU Delft for the Solar Decathlon Europe 2012. With this project I am designing, advising and calculating the properties for the floating system. In this way I am already familiarising myself with the design and engineering aspects of floating. My work on the ReVolt House can have further influences on my design. There are a lot of aspects of sustainability integrated into the project, which might be interesting for my own graduation project. Also rotation towards or from the sun, which is a aspect of floating and sustainability could be integrated into my design.
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PRODUCT

PROBLEM STATEMENT

Sea level rise and land subsidence (figure 1, 2, 3, 4, 5)
The rise of the sea level is a natural phenomenon. Several measurements in New York and Rotterdam show a sea level rise of between 170 and 220 millimetre. These measurements are made during the last 100 years. The sea level rise in New York and Rotterdam could be attributed to the regional subsidence of the earth’s crust, due to the subtraction of water and because it is still slowly readjusting to the melting of ice sheets since the end of the last ice age. For these two cities, the land subsidence is between the 3 to 4 mm per year. In Jakarta the land subsidence is probably the main factor for the sea level rise, because some part of the cities are sinking at rates of 38 mm per year, mainly due to groundwater extraction.

This is an important issue, because two third of the cities in the world is built near water, and 50 per cent of the people live there. And still we are still spending money and building material on buildings that are in danger of being destroyed by nature, due to flooding. It should be better to invest in a more adaptive system like floating structures, which are not dependable on the current water protection systems.[1]

Due to this mayor problem, I have decided to research the possibilities of floating structures. Also I have chosen to research if it is possible to place the floating building in the North-Sea, instead of building it in the ‘more save’ harbour. This is mainly because, if the sea level is rising and the dykes are breaking, then the water that is flooding the country, could have the behaviour of the water in the sea, like the height of the waves. A building that is designed for water inland could probably not withstand the impact of the sea. Therefore it is more interesting to research a floating building on sea then on water inland. Also the effects of the ocean on the building are a lot larger compared to a building on water inland, due to the tide and the waves.

To the question of what building would you like to design that has been asked to me after the P1, the answer for me was a theatre. For me theatres always has been interesting, because of the dynamics and flexibility of the stages. Also I have been to Rome, during the summer of 2011 and there I really got touched by the atmosphere of the ancient theatres in Rome, like the Colosseum (large amphitheatre, built 60 A.C.). For me this means that theatres are special buildings that already could give a certain drama, even before the show starts.

And why do I make the theatre floating? Because the dynamic aspects, like flexibility, are important features of theatres. When a building floats, it is very easy to move it, without much energy. Imagine if we do this with the stage. During the show you can move the floating stages and replace them. Also it is possible the have very large stages, because the sea is incredible large. Even large boats or planes could be shown in the show.
Problem statement and research questions

The problem statement is:
How is it possible to realise a floating theatre on sea?

Research questions that are related to this problem statement are:
- How can a structure float?
- What is the difference between the behaviour of floating structures in still inland water and on sea?
- Which different kind of theatres do exist and which is suitable for on the water?
- How flexible does the theatre and the stage needs to be?
- What is the relation between the building and the harbour/mainland?
- Which size does the theatre needs to be and how many stages?
- Which facilities are necessary for a floating theatre?
- Which part of the theatre is floating and which part is fixed?

Specific questions will be added during the design process, when they are within the problem statement.

Design assignment

The general design assignment is: “Design a floating theatre”. This theatre needs a certain amount of flexibility/mobility. To determine the parameters of the building and get a more specified design assignment, I did several studies.

Different studies
- Floating bodies;
- Theatre typologies;
- Timeline of tribunes;
- Timeline of stages;
- Technical data for theatres (angles/slope);
- Aspects of flotation;
- Floating related to theatre functions;
- Location related to the harbour (relation with harbour/land);
- Location research.
Floating bodies (figure 6, 7)
There are different kind of structures for floating bodies. An offshore oil platform has a different structure than a boat or a building. These floating bodies all have different aspects regarding to flotation. A SPAR-platform for example is a very rigid platform, which practically does not move in the water (it is almost like a building on land). A pontoon moves with the motion of the waves and tide. So for the different functions, different floating platforms can be used.

Theatre typologies (figure 8, 9)
A theatre is a space where a performance takes place. A building specialized for presenting performances. The main parts of a theatre are the tribunes for the audience and the scene or stage. These two parts mainly determine the appearance and main layout of the theatre. Therefore to determine the typologies of theatres, the relation (position) between the stage and the tribunes is most important.

To determine the basic shape of my theatre, it is good to know which types and shapes there are for theatres.

Mainly we can determine four different types of theatres:
- Arena or theatre-in-the-round stage;
- Theatron / prescenenium stage;
- Proscenium-arch / picture-frame stage;
- Spatial space (stage).

Arena or theatre-in-the-round stage
The arena is the most elementary theatrical situation. People assemble a closed ring around a flat piece of ground to witness a event. For larger groups, natural slopes in the landscape provide rising ground to provide a good view angle. Most simple form is people sitting around a campfire with one person standing telling a story.

Theatron / prescenenium stage
The word theatron, which is Greek, means a space for watching. This is very similar to the arena, except the audience is now arranged in a segment of a circle and there is a larger stage, with an area for a orchestra and a area for the actors (proscenium). A big difference between a Greek and Roman theatre is that the Greek theatre is built on a natural slope and the Roman theatre is build on a flat piece of land, and there is a building structure under the audience.

Proscenium-arch / picture-frame stage
The stage of this type is enclosed on three sides and the audience is allowed to view trough a frame opening on the fourth side.
So it looks like looking trough a picture frame. There are also gallery levels to provide a good view.

Spatial space (stage)
This type was invented to reunite the stage with the auditorium / tribune, to form a single whole again. The gallery levels where removed again. The performance could go through the whole building. More different kind of theatres should be able to perform in this type of theatre.
Timeline of tribunes (figure 10)

1. The last 2000 years, the shape of the tribunes has changed. First around the year 0, the main shape was the shape of the Greek and Roman theatres. The basic shape of these theatres is a segment of a circle. The arena type, was also used during this period, but less common. One of the most well know theatres is the amphitheatre in Rome, called the Colosseum. The Colosseum is a mix between the arena and the roman theatre. The shape is called the roman elliptical theatre.

2. Later on, more U-shaped theatre arises, these theatres had the scene in the middle and where also used for ‘Roman’ games, like circus games and chariot racing.

3. During the Renaissance period the theatres where more focussed on the drama scenes. Mostly the theatres were three stories high, and built around an open space at the centre. The shape had a overall rounded appearance. The theatres where rather small around 500-1000 people could be seated on the tribunes.

4. Since 1876 the V-shape is introduced, this is a more easy to build shape then the Renaissance shape. Also the amount of spectators can be increased very simple and the shape gives a optimal viewing angle. This shape is nowadays the most used shape for theatres.
Timeline of stages (figure 11)
1. The Greek and Roman theatres had a very basic square shape. At the back and on the sides was the scene building, where all the facilities of the theatre were located. The Roman theatre had a large painting at the back of the theatre, which was the background for the play.

2. During the Renaissance the people started to develop the depth of the theatre. The square stage was opened up and buildings where placed on it so the stage had for example the appearance of a street. In this way the people needed less imagination during the play.

3. Around 1750, people wanted a more changeable stage. Because they where newer technologies, the introduction of the Tellari stage was possible. Here the ‘pre-couisses’ could be changed during the breaks of the play.

4. Around 1770, the Tellari stage made place for the coulisse stage. During small breaks in the play, the background could be changed very easy. They used curtains to close the stage and when the curtains reopened, the stage was changed. This is nowadays the most used type of stage.

5. The round horizon is a stage that is mostly used for one-man-shows, like cabaret, or for television shows.

6. Nowadays the new developments are rotating tribunes, with multiply stages or sliding staged in front of a tribune. This kind of stage is probably the best choice for a floating theatre, because it has the highest flexibility.

Technical data for theatres (figure 12, 13)
There is a lot of data available for viewing angles, orientation and organisation. One of the most used information sources is the book Architect Data, from the German Architectural Engineers Ernst and Peter Neufert. This book contains a lot of information that can be used by architects to determine the scale of the building components.

The information that I use for my theatre is for example the organisation schemes, the elevation of the tribunes and position of the seats. This general data gives an idea what the guidelines are to design a theatre.
Aspects of flotation (figure 14)
My study to the aspects of flotation gave simple results, but the advantages of these aspects to a building are great. Horizontal movement (x and y-axis), is probably the most simple and easiest to use aspect. The flexibility that it creates is very large and gives great possibilities for a floating theatre, for example it can be used for changing the stages.scenes or transporting the theatre into a other place between the scenes.

Vertical movement (over the z-axis) is the second aspect. This aspect is always there, because the building is always immerged into the water and due to the movement of people in the building and the effect of the waves on the building. This aspect can also be used when I choose to use a vertical (lift) stage, the stages can then sink into the water. This is probably not the best choice, because then the sea should be very deep on that location.

An other aspect is rotation (around the z-axis) this is an interesting aspect to use, the tribune can be rotated around the different scene or the other way around. Also it can be used to orientate the tribune towards a background (the harbour, the horizon or the boulevard) or towards the different scenes.

The last aspect is skewing (rotation around the x and y-axis) this aspect will probably always occur, due to the effect of the waves. This can provide an extra input to the drama of the theatre, but can also give problems like seasickness.

Floating theatre functions (figure 15, 16)
In the previous paragraph I already showed some of the possibilities that floating can create for a theatre. In figure 15 the diagrams show the movements that can be done. These movements can be applied on both objects.

However there are also other facilities necessary for a theatre like; toilets, a bar, foyer, technical space, backstage, dressing rooms and so on. These functions will probably be more fixed, like when built on land. It is probably not very practical to have a floating toilet, that moves up and down.
Location related to the harbour (relation with harbour/land) (figure 17)

To determine the location of the theatre I did several studies. Some of the questions that I asked myself are: where should it be placed?, how do you get there? which depth do I need for my theatre? which part is fixed, which part is floating?

In this way I tried to determine possible locations for the theatre. The relation with the harbour/land is probably in the urbanism point of view the most important. The exact location is not yet determined, because I still have to more research on this point. But it won’t be too far from land, because it is a public function which should be available for everyone. The further away from the harbour, the less connected it is.

Figure 16 - Different options for movements of theatre functions and fixed or movable parts

Figure 17 - Connection between theatre and harbour/land
GOAL

The main intention of this graduation project is to proof that it is possible to build a floating usable building on sea, instead of on land of water inland. That it is possible to building outside our conventional land borders, so outside the save dyke system and to be afraid of the water.

The intentions of this graduation project are, next to the described goals in the previous sections, also personal for me. I want to become an architect and engineer (architectural engineer), with this graduation project I can show what I have learned during my study and proof that I am capable of handling to what it takes to be and architect and engineer.
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METHOD DESCRIPTION

The research is mainly divided into three levels

1. Theoretical level:
   This is the basis for the design and mainly consists of research that is aimed at generating knowledge (theory) about floating and theatres.

2. Empirical level:
   This level focuses on the evaluation of the gathered knowledge and thinking about what could be applied on the design.

3. Application Level:
   This level focuses on the application of the knowledge on the design. And this is the real design phase.

At the P2, the second survey (NL: tweede peiling), I should be at the stage of the empirical level. Until the P1, the first survey, I did a technical research on the theory of floating and floating structures. From the P1 until the P2, I am doing a more architectural related study. From the P2 until the P5 I will be designing and calculating my own building.

Tasks to do before P1 (first survey)

- Literature study on the theory of floating; hydrostatics;
- Literature study on floating structures; buildings and civil engineering;
- Explaining and calculation of floating structures;
- Researching and calculating the possibilities for the floating body of the ReVolt House (Solar Decathlon Europe 2012).

Tasks to do before P2 (second survey)

- Architectural study on different floating objects;
- Architectural and technical study on theatres;
- Explaining and calculation of floating structures;
- Location research;
- Design / Sketch ideas for my own building;
- Researching and calculating the possibilities for the floating body of the ReVolt House (Solar Decathlon Europe 2012).

Tasks to do before P3 (third survey)

- Continue with the architectural study on different floating objects;
- Continue with the architectural and technical study on theatres;
- Specify a location;
- Design and evaluate my building;
- Build models of designs;
- First floating calculations of the designed building;
- Test different floating structures (model);
- Researching and calculating the possibilities for the floating body of the ReVolt House (Solar Decathlon Europe 2012), this will continue until the ReVolt House is being built.

Tasks to do before P4 (fourth survey)

- Continue with the architectural study on different floating objects;
- Continue with the architectural and technical study on theatres;
- Specify a location;
- Design and evaluate my building;
- Build models of designs;
- Final floating calculations of the designed building.
Tasks to do before P5 (fifth survey)
- Prepare
- Continue with the architectural and technical study on theatres;
- Specify a location;
- Design and evaluate my building;
- Calculate the designed building;

LITERATURE AND GENERAL PRACTICAL PREFERENCE

All the literature that is necessary for the research that I am going to use needs to be relevant to my research subject. It is hard to say which literature I am going to use this depends on the insights that I am getting during the design process.

Literature / information that is used (or going to be used):
- Literature about the theory of floating;
- Architectural books about theatres and public buildings;
- Architectural data for technical input for the design of theatres, like the Neufert book;
- Plans for the location, made by third parties, like the government.
- Data of the KNMI (dutch weather institute), about the wave heights;
- Sea maps, information about the depths of the sea;
- Data of NASA, about the sea level rise.
- Theatre precedents, with different scales/sizes;
- Floating precedents, like floating houses and public buildings.

Books / Articles
Curtis, W.J.R., (2009), Modern Architecture since 1900, Phaidon Press London
Dokkum, K. van, (2003), Ship Knowledge: A Modern Encyclopedia, Dokmar, Enkhuizen
Dijk, W., van, (2003), Drijvend wonen, Metro
Heide, N., ter, (2009), Betoniek: Spelregels voor 100 jaar, Uitgeverij Æneas
Kamerling, M.W., (2005 ), Het ontwerpen van pontons voor drijvende gebouwen, Delft University of Technology, Delft
Keuning, Olthuis, K. (2010), Float: building on water to combat urban congestion and climate change, Frame Publishers, Amsterdam

Knabb, R.D., Rhome, J.R., Brown, D.P., (2005), Tropical Cyclone Report: Hurricane Katrina, National Hurricane Center

Leupen, B. ea. (2005) Ontwerp en Analyse. (Rotterdam) 010


Watkin, D., (2001), De westerse architectuur ‘een geschiedenis’, Uitgeverij Sun Nijmegen


Videos
Discovery Channel: Build it Bigger, Season 5 Episode 6: Amsterdams Futuristic Floating City
Discovery Channel: Mega Engineering, Season 1 Episode 3: City At Sea

Internet
Attika Architecten, http://www.attika.nl
Deltasync, http://www.deltasync.nl
Dutch docklands, http://www.dutchdocklands.com
Ecoboot, http://www.ecoboot.nl
Waterstudio (Koen Olthuis), http://www.waterstudio.nl
RELEVANCE

The research is relevant, because I am thinking about a problem which we have to solve in the future. Also the aspect of sustainability is introduced in the design process, which is an important issue these days, due to the economical and energy crisis and the climate change.

Social and political this project could make a new Dutch statement. The Netherlands are well know for its fight with water and as a real problem solver for this issue. With a project like this, we can show that we are not afraid to built outside our ‘save’ dyke system, and showing that there are also other solutions for the sea level rise problem.

Personally for me this research is relevant because I can learn a lot of it, as an engineer and architect. For example the impact of the dynamic aspects of floating/water on the architectural appearances and experience of a building.

TIME PLANNING

Because I already finished all my other courses of the Master 1 and 2, so I have all the time for the courses of the master 3 and 4. I also spend a lot of time on the floating calculations of the Revolt House project.

Mainly my time frame is according to the schedule of the TU Delft.

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References

Figures
Figure 1 - Map of the world showing high risk areas, source: Mestemaker, T.W.J. | Data obtained from NASA, http://climate.nasa.gov/index.cfm

Figure 2 - Forecast 2100 Netherlands, source: http://tudelft.nl/actueel/dossiers/archief/drijvende-stad/waarom-drijvende-stad/

Figure 3 - Floor plan of an ancient Roman theatre, source: Mestemaker, T.W.J.

Figure 4 - Ancient Roman theatre with floating stages, source: Mestemaker, T.W.J.

Figure 5 - New Orleans after flooding, source: http://neworleans.metblogs.com/files/2011/08/new-orleans-flooding.jpg

Figure 6 - Different pontoons, source: Mestemaker, T.W.J.

Figure 7 - SPAR platform, source: Mestemaker, T.W.J.

Figure 8 - Theatron / prescenenium stage, source: Detail magazine 2009 issue 3.

Figure 9 - Proscenium-arch stage / picture-frame, source: Detail magazine 2009 issue 3.

Figure 10 - Timeline of tribune shape, source: Mestemaker, T.W.J.

Figure 11 - Timeline of stage shape, source: Mestemaker, T.W.J.

Figure 12 - Proportions of a stage, source: Neufert Architects Data.

Figure 13 - Elevation of the tribune, source: Neufert Architects Data.

Figure 14 - Different aspects of flotation; horizontal movement, vertical movement, rotation and skewing, source: Mestemaker, T.W.J.

Figure 15 - Floating related to theatre functions; one to four tribunes, source: Mestemaker, T.W.J.

Figure 16 - Different options for movements of theatre functions and fixed or movable parts, source: Mestemaker, T.W.J.

Figure 17 - Connection between theatre and harbour/land, source: Mestemaker, T.W.J.

(These references apply to the data used in this report)