P5·Graduation presentation

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Architectural Engineering

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Theme | Floating & Energy
Teacher | Ir. M.W. Kamerling (Wim)
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Title of the graduation project | Energy and floating “embodied energy potentials on sea”
CONTENT

Part 1 : Introduction

• What is my graduation about?
• Why this specific topic?
• How will the objective be achieved?

Part 2 : Understanding the theory

• Wave theory
• Location potentials
• Wave energy
• Floating theory

Part 3 : Design

• Urban plan, autonomic
• Architectural quality’s
• Technical solutions
Part 1:

Introduction
What is my graduation about?
1. Research, on environmental conditions

wind
1. **Research, on environmental conditions**

- **Wind**
- **Sun**
1. Research, on environmental conditions

- Wind
- Sun
- Water
2. **+ DESIGN**, sustainable architecture by integrating the environmental conditions

- thermal mass
- light reflection
- view
- wave energy
3. **FLOATING**, to introduce new kind of sustainable energy

figure 11 ‘overtopping waves on Scheveningen beach’
4. + Scheveningen
Why this specific topic?
1. Embodied energy potentials on sea
1. Embodied energy potentials on sea

‘De Noordzee bevat een zee aan energie’, this is a quote of the National government of the Netherlands, to make a statement when announce the future plans of green energy. They mean that there are lots of potential in green energy we don’t use.
figure 19 ‘world wave power climate’
2. Introducing new kind of sustainable energy types

Friction

Air compression

Wave lift - Overtopping

figure 20 'wave energy generator'
3. Future planning

What will happen?
• Strengthening tourism program Scheveningen Harbour with leisure, museum attractions, spa and hotels.
• Relaunching Scheveningen-Bad by adding new attractions and strengthen existing tourist attractions, particularly leisure, (live) entertainment and hotels.
3. Future planning

What will happen?
- Strengthening tourism program Scheveningen Harbour with leisure, museum attractions, spa and hotels.
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Dialogue ideas about Scheveningen:
- In Scheveningen you live in a village, this should remain so.
- There must be a middle way between residents and businesses.
- Sustainable building and renewable energy.
- User groups must be reconciled.
4. Proven combination
How to react on these 4 topics?

Floating!!
How to react on these 4 topics?

Floating!!

- introducing iconic building that satisfies the future planning
- strengthen relation tourism and boulevard
- solution for location moving tide
- don’t disturb the existing urban environment
Problem statement

“The development of water powered energy technology is getting behind on other sustainable energy sources “

- first generation - hydroelectric dams
- second generation - solar panels and wind turbines
- third generation - biomass gasification and biorefinery
Thesis objective

This introduced two important design parameters and a problem definition

1] relation with the location, (qualities) > views, orientation,

2] relation towards the sustainability design,
Thesis objective

1] relation with the location, (qualities) > views, orientation,

2] relation towards the sustainability design,

   A] Controlling water

   B] Floating building

   C] Energy generation
Thesis objective

1] relation with the location, (qualities) > views, orientation,

2] relation towards the sustainability design,

  A] Controlling water
  B] Floating building
  C] Energy generation

- The problem definition is formed by the location. The question is ‘how could these location-specific factors be used in- and contribute to- an architectural design?’.
Thesis objective

1] relation with the location, (qualities) > views, orientation,

2] relation towards the sustainability design,
   
   A] Controlling water

   B] Floating building

   C] Energy generation

- The problem definition is formed by the location. The question is ‘how could these location-specific factors be used in- and contribute to- an architectural design?’.

More specific, the research question has been formulated as: How to develop sustainable architecture driven by water energy?
How

will this objective be achieved?
1. Engineering question

Research questions – How to develop a sustainable floating building on sea, powered by water energy?

Research on most efficient water energy technology
1. Engineering question

Research questions – *How to develop a sustainable floating building on sea, powered by water energy?*

Research on most efficient water energy technology

- sun
- wind
- tide

potentials use for sustainable design on sea
2. Architectural goal

Design assignment – Merge the engineering technics discovered in the research on water powered energy technology with the architectural design demands.
2. Architectural goal

Design assignment – Merge the engineering technics discovered in the research on water powered energy technology with the architectural design demands.
Integration architecture & Engineering

- Rigged floor connected to buoy and body flows into structure RED
- Passive shading
- Flexible space
- High comfort space
- Thermal mass from sea water
- Energy generation GREEN
- Light
Part 2: Research

Understanding the Theory

- **Wave theory**
  - origin

- **Location potentials**
  - wave height
  - wave direction

- **Wave energy**
  - efficiency

- **Floating theory**
  - Archimedes, law of flotation
1. Wave energy

Classificatie | d/L
---|---
Diep water | ≥ 1/2
Overgang | 1/20 – 1/2
Ondiep water | ≤ 1/20

Wave type classification

Shallow water

Deep water
Figure 16: Classification of the spectrum of ocean waves according to wave period, Munk, Walter H. (1950)
2. Location potentials

- depth
- tide
- wave direction
- wave height
Spot for obtaining numbers wave height
average wave height

Figure 28: Average wave height, determined by measurements every 6 hours, 365 days a year, between 2003 and 2011.
Figure 28 'Average wave height, determined by measurements every 6 hours, 365 days a year between 2003 and 2011.'
Figure 28: Average wave height, determined by measurements every 6 hours, 365 days a year between 2003 and 2011.
wave height vs direction

Average wave direction in time %

Wave direction in time %: < 1m

Wave direction in time %: 1m < 1.5m

Wave direction in time %: 3.5m < 4.5m

Wave direction in time %: > 4.5m

figure 29 'wave direction North Sea'
interesting direction

Wave direction in time %: 1m < 1.5m
3. Wave energy generation

\[ P = \frac{1}{4} \rho o g h^2 v \quad [\text{W} / \text{m}] \]

\[ v = g \frac{T}{2} \pi \quad [\text{m} / \text{s}] \]
1 year energy potential scheveningen

wave height (m)

wave period (s)

Kw/m2
1 year energy potential scheveningen

- wave height (m)
- wave period (s)
- Kw/m2

winter
1 year energy potential scheveningen

- Wave height (m)
- Wave period (s)
- Kw/m2

Summer
4. Archimedes, law of flotation

In air

5000 kg

1 cu. m

In fresh water

4000 kg

1 cu. m

1000 kg
Figure 9.7. - 1 Concept design Revolt House
Design restrictions and requirements:

Goals:
- lightness
- transportable/mountable
- sustainability
- safety
- simplicity

draught, rotation, transportation, assembly
Part 3: “collaborating view and energy qualities”

Design

Part 3:

- **Urban plan**, autonomic
- **Architectural**, quality’s
- **Technical** solutions
The architectural design

congress center and public domain, Scheveningen by Erik van der Thiel
The architectural design

Efficiency

The depth of the sea in combination with the length of the waves determine the energy level of the embodied potential energy in the sea. With this number the minimum distance from building to coast be can measured.
The architectural design

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The depth of the sea in combination with the length of the waves determine the energy level of the embodied potential energy in the sea. With this number the minimum distance from building to coast can be measured.

The maximum distance will relate to the maximum depth of the building. In order to make a close connection the existing program of the boulevard and the center of The Hague.
The architectural design

**Efficiency**

The depth of the sea in combination with the length of the waves determine the energy level of the embodied potential energy in the sea. With this number the minimum distance from building to coast be can measured.

The maximum distance will relate to the maximum depth of the building. in order to make an close connection the existing program of the boulevard and the center of The Hague.

**Boundary conditions:**

- minimum dimension 100m
- most stabile form in relation to surface is circular
- symmetrical approach to improve the stability
The concept

**Orientation** wave direction

**Dominate direction** only wave sides are designed to lift the waves
The concept

**Programmatic layout** conference rooms orientated in the middle of the building, close to the center of stability.

**View** hotel, restaurant and workspace orientated to the outside of the building to make profit of the urban context with panorama view.

**Shield** towards the elements, wind and sun to lower the energy demand and optimize the outside comfort.
The concept

**Horizontal lines** are accentuated to create passive sun shading

**Center beacon** to give the circular formed design an direction and provides open floor spaces to the urban context

figure 46 ‘design diagrams’
Hybrid ventilation
ATRIUM
Natural air supply by under pressure
Natural air exhaust by over-pressure
Backup fan incl. heat recovery
Stack effect
Natural daylight by reflective atrium facades
Backup fan incl. heat recovery
Night cross-ventilation
Evaporative cooling
 PCM's in ceiling
Night cross-ventilation
Surface water: 4°C-17°C
Heat pump
Heat exchange
Heat pump conditioning by ΔT water
Heat pump conditioning by ΔT water
Evaporative cooling
Winter
Winter
Summer
Summer
1 Urban approach

Orientation
- wave direction
- 10 minutes
figure 50 ‘fit in urban context, connections’
1 Urban approach
1 Urban approach
1 Urban approach
2.1 Entrance building
2.2 Central reception
2.3 Central foyer

Level 0
2.4 Central foyer
2.5 Congress hall
2.6 Leisure space
2.7 Leisure
2.8 Work/study space
2.9 Entrance hotel / restaurant

Level 0
2.10 Hotel bar / connection to restaurant

Level 4
2.11 Leisure deck hotel

Level 4
2.12 Hotel room
3 Technical solutions

- floating / energy
- construction
- facade / climate
3.1 Floating body

form follows force

‘force scheme’

q1

‘construction scheme’

F1
stability floating body
Condition 2

figure 81 ‘Orca calculation condition 2’
Condition 3

figure 82 'Orca calculation condition 3'
Calculation whit ballast tanks 2m

By raising the height of the ballast tanks with 1m the extra load will also be doubled to 19600 kN. This is enough to create an heel of 0.001 degrees. The ballast tanks can also be used to raise and lower the ramp by heeling the building over. This ensure an more efficient energy supply

<table>
<thead>
<tr>
<th>Condition</th>
<th>weight kN</th>
<th>Trim LCG</th>
<th>Heel TCG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Codition 3</td>
<td>293.821</td>
<td>-12.7 mm</td>
<td>4 mm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Condition</th>
<th>sinkage</th>
<th>Heel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Codition 3</td>
<td>3.865 mm</td>
<td>0.001 deg</td>
</tr>
</tbody>
</table>

The sinkage of the finalized body will be around the 4m. This number compares to an upwards force of 40kN/m² on the floating body. In chapter 2.3, the integration of the floating body, this will be calculated and designed into an manufacturable structure.
stability floating body + energy potential

3500 kWh/y 1 average dwelling, 2.4 persons = 0.4 kWh
310 dwellings summer

or

20,000 m² office
3.2 Construction

Figure 94 'atrium scheme Q wind'
WATER PRESSURE

figure 96 ‘total form follows force scheme’
Prove of stability (GSA) 4,5 mm displacement
- interaction spaces
- panoramic view
design floating structure

2x2 grid
figure 105 ‘construction scheme’

1: 400mm steel tube
2: HEA 400
3: IPE 300
4: Cast concrete 300mm
3.3 Facade

figure 120 ‘passive sun shading’
integrated armature
normal ventilation and light armature

normal balustrade
integrated balustrade

normal ventilation and light armature
integrated armature
MAIN CONSTRUCTION
- steel profiles and column form will form the upper construction that will lead the forces through the floating body
- HEA 400
- Tube 400mm, coated fire resistant

SUB CONSTRUCTION
- an HEA 240 profile forms a straight line between the two columns
- under the profile, perpendicular two rectangular profiles are added to carry the facade element

MESH
- mesh, coated black to absorb the heat before it enters the building
- mesh dimensions: 150*50 mm
- depth: horizontal 50 mm
- depth: vertical 30 mm
- mesh rotates in front of sliding door (can be made by Dejo)

SLIDING DOOR
- black tinted glass
- in front a mesh to catch morning and evening sun

COMPOSITE ELEMENT
- pre-laminated in factory
- polyester, coated by hars and with (reflecting material), inside filled with high dense foam

FLOOR SECTION 825mm
- steel frame, in between steel boxes (staalplaat betonvloer) in work casted concrete to create a rigid plane
MAIN CONSTRUCTION
- steel profiles and column form will form the upper construction that will lead the forces through the floating body
- HEA 400
- Tube 400mm, coated fire resistant

SUB CONSTRUCTION
- an HEA 240 profile forms a straight line between the two columns
- under the profile, two rectangular profiles are added to carry the facade element

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SLIDING DOOR
- black tinted glass
- in front a mesh to catch morning and evening sun

COMPOSITE ELEMENT
- pre-laminated in factory
- polyester, coated with hard material, and with (reflecting material), inside filled with high dense foam
Part 2

- light + ventilation integrated
- mesh added to filter the morning and evening sun
indoor space with open doors
Thank you!