DEVELOPMENT OPTIONS FOR A&R SHIPYARD HARBOUR

Kaur Tull
Master Thesis

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Dipl.-Ing. Alexander Skalicky, A&R

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Key Topics

- Introduction
- Problem Description
- Sediments
- Multi-Criteria Analysis and Harbour Layout Selection
- Design Proposal of the Layout
- Cost Estimation
- Conclusion
Abeking & Rasmussen

- One of most well known shipyards;
- Over 100 years old;
- Located on the left coast of river Weser;
- 60km from the coast of the North Sea;
- 17km from Bremen.
Focus of the work

- On the small craft Harbour;
- Used by A&R for launching/docking of vessels;
- Used by the local Lemwerder Yacht Club as marina;
- Shared between A&R and Yacht Club;
- Decision making process is complex;
- Main goal is to give new proposals for Harbour layout.
Why to remodel the Harbour?

1. Vessel size limitations 83m for syncrolift;
2. Current entrance requires 90 degree turning angles;
3. Great tidal influence;
4. Frequent dredging required.
Sediments

- Average amount of sediments deposited 13cm/year;
- Literature analysis of the sediments for lower Weser region;
- 35-years of observation data used from Deutsches Gewässerkundliches Jahrbuch;
- During higher fresh water runoff values the sedimentation risk is higher.

![Graph: Monthly Average Freshwater Runoff of 35 years](image)
Amount of sediments

- Up to 57% of sediments from the yearly 13cm/year can be avoided
Multi-Criteria Analysis

1. Problems and goals defined;
2. 20 new layouts were brainstormed, each a bit different;
3. Multiple sessions of interviews with the stakeholders;
4. Defining the main Criteria and sub-criteria;
5. Finally resulting in a decision matrix;
6. Decision rules;
7. Results.
## Decision criteria’s and results

<table>
<thead>
<tr>
<th>Nr</th>
<th>Criterion</th>
<th>Weighting factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Entrance of the harbour</td>
<td>0.183</td>
</tr>
<tr>
<td>2</td>
<td>Maneuverability inside the harbour basin</td>
<td>0.208</td>
</tr>
<tr>
<td>3</td>
<td>Time to release a ship</td>
<td>0.120</td>
</tr>
<tr>
<td>4</td>
<td>Effect of tides/currents/sedimentation</td>
<td>0.175</td>
</tr>
<tr>
<td>5</td>
<td>Impact on the marina and its users</td>
<td>0.190</td>
</tr>
<tr>
<td>6</td>
<td>Complexity of the solution and need of public authorisation</td>
<td>0.125</td>
</tr>
</tbody>
</table>

### Weights

- **A. Skalicky**: 15.0%
- **E. Pietschik**: 5.0%
- **Weser Yacht Club**: 5.0%
- **K. Tull**: 25.0%

### Results from the multi-criteria analysis

<table>
<thead>
<tr>
<th>Layouts</th>
<th>Score (points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.55</td>
</tr>
<tr>
<td>2</td>
<td>7.60</td>
</tr>
<tr>
<td>3C</td>
<td>7.69</td>
</tr>
<tr>
<td>3D</td>
<td>7.52</td>
</tr>
<tr>
<td>4B</td>
<td>7.60</td>
</tr>
<tr>
<td>5B</td>
<td>7.69</td>
</tr>
<tr>
<td>6B</td>
<td>7.69</td>
</tr>
<tr>
<td>6C</td>
<td>7.69</td>
</tr>
<tr>
<td>6D</td>
<td>7.69</td>
</tr>
<tr>
<td>7C</td>
<td>7.69</td>
</tr>
<tr>
<td>8D</td>
<td>7.69</td>
</tr>
</tbody>
</table>

TOTAL 1.00
Top scored layout VS Current layout

<table>
<thead>
<tr>
<th>Boat Length Range (m)</th>
<th>Layout 6D No of boat places</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>6.10</td>
</tr>
<tr>
<td>6.11</td>
<td>7.60</td>
</tr>
<tr>
<td>7.61</td>
<td>9.10</td>
</tr>
<tr>
<td>9.11</td>
<td>10.70</td>
</tr>
<tr>
<td>10.71</td>
<td>12.20</td>
</tr>
<tr>
<td>12.21</td>
<td>13.70</td>
</tr>
<tr>
<td>13.71</td>
<td>15.20</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>105</strong></td>
</tr>
</tbody>
</table>

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<th>Boat Length Range (m)</th>
<th>Current Layout No of boat places</th>
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<td><strong>101</strong></td>
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</tbody>
</table>
Floating marina

- Design of the marina according to: A Code of Practice for the Design and Construction of Marinas and Yacht Harbours (The Yacht Harbour Association LTD);
- Technical experience of marina supplier company Top Marine OÜ;
- More and bigger boat places;
- Better distribution and use of space;
Sheet pile cofferdam

- Width 7.5m, Total length of piles 31m;
- Height from the ground 14m;
- Water level differences of 5m;
- Anchored at 2m from the top.
Design assumptions for cofferdam

1. Design according to Eurocode 7.
2. There is no loading from waves;
3. Active pressure from the soil inside the cofferdam;
4. Hydrostatic pressure from the water level differences;
5. Designed for movable crane load 40kN/m2 (Port Designers Handbook)
6. Calculated as an anchored sheet pile wall.
Preliminary design of floating door

- Width 6m, height 11.5m
- Smaller gate Length 20m;
  Bigger gate length 48m;
- Maximum draft at 9.5m;
- Maximum capacity of fresh water 1475t;
- Lightship weight 380t;
- Loaded weight 1855t.
Design assumptions for floating door

1. Designed according to Bureau Veritas rule:

2. There is no loading from waves;

3. There is no hogging or sagging effect as we assume no waves;

4. Main load is the hydrostatic pressure from the water level differences of 5m;

5. The structure is considered as simply supported.
Floating door on its place

+5.00m NN

RIVER SIDE

2000

WATER LEVEL (HWL)

HARBOUR SIDE

-2.00m NN

WATER LEVEL (SKN)

FLOATING DOOR

Concrete foundation for the floating door

Sheet pile wall with piles

pgh~50 kN/m²
Alternative solution for floating door

- Inflatable rubber gate;
- Good alternative for the smaller entrance;
- Initial cost cheaper than floating door;
- Entrance can be closed fast in case of storms/floods;
- Does not need considerable manpower compared to floating door;
- Quite new technology; less experienced suppliers and manufactures of this kind of structure.
Cost estimation and comparison

<table>
<thead>
<tr>
<th>Rank</th>
<th>Multi-criteria analysis results</th>
<th>Cost estimation analysis results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Layout (6D) - 7.69p</td>
<td>Layout (6C) - 9,396,400.00 €</td>
</tr>
<tr>
<td>2</td>
<td>Layout (6C) - 7.60p</td>
<td>Layout (6D) - 9,485,400.00 €</td>
</tr>
</tbody>
</table>

Layout 6D

Layout 6C
Visualization of the best layout
Goals achieved

✓ Less sedimentation problem → Less dredging;
✓ More and bigger boat places;
✓ Better accessibility of the harbour;
✓ Independence from the tides if harbour is closed;

Thank You!