Development of the port of Eemshaven, The Netherlands
Including Innovative quay structures

Ir. G. Hamoen
Content

• Introduction
• Innovative quay structures Juliana harbour and Beatrix harbour
• Ro-Ro terminal AG Ems
• Energy park: Wilhelmina port quay structures
• Dredging design and tender documents
Introduction

• After 20 years of moderate development Port of Eemshaven rapidly expanding from 2004:
  • Ro-Ro terminal
  • LNG terminal
  • Bio value
  • Energy park
• Witteveen +Bos leading as consultant in all major projects from 2004 till date
• Port Authority: Groningen Seaports
Introduction: project location
Introduction: project location

Westlob:
- Juliana harbour
- Beatrix harbour
- Ro-Ro AG Ems
- Dredging tender

Artist impression © GSP.
Introduction: project location

Eastlob:
- Energy park
- Dredging tender
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Innovative quay structures at Juliana harbour and Beatrix harbour

- Beatrix harbour under construction
- Ro-Ro terminal
- Quay Beatrix harbour phase 1
- Quay Julianaharbour phase 3
- Ro-Ro terminal
Summary Terms Of Reference
Juliana harbour phase 3 and 4

- Length 700 m in two phases:
  - Phase 3: 350 m (completed 2007)
  - Phase 4: 350 m (under construction)
- Retaining height 21.5 m and average tide 3 m
- Reach stacker, mobile crane LHM320, p=60 kN/m²
- Bollards: load 1000 KN double; c.t.c. 20 m
- Wooden fenders
- Technical lifetime 50 years
- Vessel size: 6,000 – 60,000 DWT
- Inland vessels: CEMT class Vb
Summary Terms Of Reference
Beatrix harbour phase 1 and phase 2

- Length 675 m constructed in two phases:
  - Phase 1: 375 m (completed 2007)
  - Phase 2: 300 m (completed 2009)
  - phase 3+4 design completed 2010, 700 m
- Retaining height 15 m and average tide 3 m
- Reach stackers, mobile crane LHM320, \( p = 60 \, \text{kN/m}^2 \)
- Bollard load 600 KN double; c.t.c. 22.4 m
- Harbour basin to be dredged upon completion quays
- Wooden fenders
- Technical lifetime 50 years
- Vessel size: 10,000 DWT
- Inland vessels: CEMT class Vb
Innovative design coping beam

- specific request from Client and funding org.
- limit construction time
- limit groundwater extraction during construction
- maintenance costs
- safety during construction
- cost reduction

- no expansion joints allowed!
- limited anchor length (horizontal)
Innovative design coping beam

Four (4) alternatives were generated:

1. U-shaped precast beam, placed on combi-wall piles, combined with a prefab wall beneath the U shaped beam in front of the combi wall

2. Single precast plate in front of the combiwall

3. U-shaped precast beam, placed on top of the combiwall

4. Traditional cast in place coping beam
Details of 4 alternatives

Alternative 1

Alternative 2

Alternative 3

Alternative 4
Alternative 1 – U shaped pre-cast beam
Alternative 1: typical cross section
Alternative 1: proposed building sequence
Alternative 1: detailed design
Characteristics Detailed Design
Juliana harbour

- Combi-wall 1620 mm t=18 to 27 mm, X70, L=35 m
- Intermediate sheet piles Larssen 24
- Screw injection grout anchors:
  - c.t.c 1.27 m,
  - pre-stress load 900 kN,
  - design load 2246kN (anchor rod)
  - 1946 kN (grout body).
  - Auger diameter SI anchors: 350 mm.
- Wooden fenders 400*500 mm
- Contractor chose alternative 2 with single prefab frontwall and temp. sheetpiles
Juliana Harbour, Eemshaven
Juliana Harbour, Eemshaven
Characteristics Detailed Design
Beatrix harbour

- Combi-wall 1220 mm t=18 to 22 mm, X70, L=28 m
- Intermediate sheet piles Larssen 24
- Screw injection grout anchors:
  - c.t.c 1.12 m,
  - pre-stress load 300 kN,
  - design load 1446 kN (anchor rod)
  - 1086 kN (grout body).
  - Auger diameter SI anchors: 350 mm.
- Wooden fenders 400*500 mm
- Contractor selected tender design alternative 1
Beatrix Harbour

Photograph by Koos Boertjens
Beatrix Harbour
Beatrix Harbour
Follow up precasted coping beams in other projects (1)
Follow up precasted coping beams in other projects
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Ro-Ro Terminal Ag Ems

• Client: AG Ems
• Ferries for Borkum line
• Limited design and construction time:
  • client delivery of steel (combi wall, anchorage, heavy discussions with Arcelor!)
  • construction during dredging of Beatrix harbour
• 12 m retaining height, hydraulic ramp
• all utilities
• Opening by H.M. Queen Beatrix in March 2008
Construction works inspection......
Ro-Ro terminal AG Ems
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Energypark: quay walls Wilhelmina Harbour

- Nuon and RWE: developers of the coal driven energy plants
- Client: BAM, Joint venture with BAM infraconsult
- Scope: D&C&M bidding design, final design, detailed design
Main Dimensions
Bases of Design (2)

Other particulars:

• Primary sea defences: effect on safety factors
• Limited working space (40 m)
• Connection to cooling water inlets
Cooling water inlets

- Cooling water inlet
  - NUON
- Cooling water inlet
  - RWE
Bidding phase: Alternatives

Alternatives:
- vertical wall
- low relieving platform: long and short base

Selected:
- low relieving platform with short base and vibro-piles (pressure) and MV anchorage (tension 6000 kN per anchor)
Final Design and the influence of FEM calculations

Combi wall: inclined 5:1

Calculations with Msheet (spring model) vs Plaxis (FEM model) (Ultimate Limit State)

FEM model to determine reduction induced by raked combiwall in bending moments (20%) and local failure mechanisms
Final Design
Construction phase (ongoing) (1)
Construction phase (ongoing) (2)
Construction phase (ongoing) (3)
Construction phase (ongoing) (4)
Construction phase (ongoing) (5)
Construction phase (ongoing) (6)
Construction phase (ongoing) (7)
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Dredging design and tender documents

- Beatrix harbour phase 1: completed 600,000 m³
  - liquefaction analysis
  - re-use of dredged material in terminal areas
  - first 5 meters dry excavation
- Beatrix harbour phase 2: under construction 600,000 m³
- Juliana harbour phase 3: completed 250,000 m³
- Juliana harbour phase 4: under construction 250,000 m³
- Wilhelmina harbour deepening and expansion Wilhelmina harbour and deepening Doekegat channel: 7,600,000 m³
- LNG harbour 2,700,000 m³
- Scour protection and revetment design all harbours
THANK YOU FOR YOUR ATTENTION