Landeyjahöfn
Ferry harbour on the South Coast of Iceland

Research and Development of the Ferry Port
and navigational criteria for the Ferry

Climate Change:
Global Change and Local Adaptation
6-9 June 2010
Hotel Rangá, Hella, Iceland

Presented by
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Maritime Administration

LANDEYJAHÖFN
The new Ferry Harbour on the South Coast of Iceland

EYJAFJALLJökull 14 April - ???

FIMMVÖRDÚHÁLS 20 March – 12 April 2010
The aim of the Ferry Port project between Vestmannaeyjar and the mainland:

- Cut the sailing distance for the ferry from 3 hours to 0.5 hours by navigating safely through the breaking zone with intensive wave breaking and heavy littoral drift.

- Find a location on the coast with overall dynamic stable offshore sandbar with minimum acceptable depth for navigation and with minimum net littoral drift along the shore.

- Design a layout for the Ferry Port where minimum sedimentation into the Port and minimum equilibrium depth in front of the entrance is achieved.

- Find a rock quarry for building the Icelandic Berm Breakwaters for the Port.
Surtsey
14 Nov. 1963 – 5 June 1967

Vestmannaeyjar – Heimaey
23. 01. 73 – 3. 07. 1973
Inshore wave recordings 2003 -
Offshore wave recordings 1987 -
Offshore Wave Data
ECMWF ERA 40 1958 -

Collecting Field Data

Grain size

River discharge 1962-2002

Wave rose 74-02

Regular bathymetries

Max tidal range 3 m

IMA’s tidal elevation and current

Wave analysis and sediment transport based on DHI’s Mike21 SW and Mike 21 FM, HD and ST and LITPACK
The exposed sandy South Coast of Iceland is dangerous for seafarers. Hundreds of vessels have perished here and hundreds of seafarers have lost their lives.
Navigational tests over the sandbar for the ferry

Navigational criteria were established for the ferry over the sandbar into the ferry port by:

- sailing a remote-controlled model ferry,
- counting the number of breaking waves at the bar,
- wave measurements at 18 m, 15 m, 10 m and 6 m in front, at the top and at 10 m depth landward of the bar and in front of the ferry entrance,
- evaluation of the total depth based on wave height, tidal elevation and the draft of the ferry.

The navigation is regarded safe for the ferry when up to 10% of waves break on the bar between 10 m and 6 m which stretches about 250 m along the navigational line.
Safe Navigational Criteria for different ferries over the bar with 6 m water depth and 10% breaking waves

Remote-controlled ferry, draft 4.0 m

\[ Hs = 3.4 + 0.2 \times WL \text{ down time } 3.9\% \]

Proposed Ferry, draft 3.3 m

\[ Hs = 3.6 + 0.2 \times WL \text{ down time } 2.8\% \]

Existing Ferry, draft 4.3 m

\[ Hs = 3.2 + 0.2 \times WL \text{ down time } 5.0\% \]

The Icelandic Information System on Weather and Sea State

Sediment transport at the Port

The main natural forces

- Sandy coast
- Wave energy
- Vestmannæyjar Islands
- River discharge from Markarfljot River
- Tide and tidal currents

The aim of the study was to investigate:

- And find the location with minimum net transport at the shore
- The overall stability of the bar and the depression in the bar
- Sedimentation rates into the Port
- Equilibrium depth in front of the entrance
River discharge of sediments 200,000 m³ after the flood.

**Jökulhlaup (Glacial flood):**

- Max. discharge: 2700 m³/s
- Total discharge: 75 10⁶ m³

Annual discharge of sediments 100,000 m³/yr

\[ Q_{100yr} = 1250 \text{ m}^3/\text{s} \]

**Grain size (mm):**

- D₆₀ measured 30 March
- D₆₀ measured 20 April 2010

Same specific density 2.8 /m³ except the samples furthest to the east.
Net: 0.3 mill m³/yr Eastgoing
Gross: 2.5 mill m³/yr

Net: 0.12 mill m³/yr Eastgoing
Gross: 1.2 mill m³/yr

Annual discharge 150,000 m³/yr

Net nearshore sediment budget, mill m³/yr

0.3
0.1
0.4

Bakkafjara

Annual discharge of sediments from the river 0.1
Average sediment transport, selected periods

Sediment transport along the inner part of the profile toward East for waves from W - SSE and toward West for SSE – E

Nov-Dec. 1985

Feb. 1989

The model and the prototype layout of the Ferry Port
Morphological changes near the ferry harbour

South east wave direction

Southwest wave direction

Hs = 3.7 m SW

Hs = 6.9 m SE
Bed level changes for constant waves from SW and SE

Waves from SW $H_s = 2.7$ m
Waves from SE $H_s = 6.9$ m

Area where the initial water depth decreases followed by erosion in case of constant waves.

In case of changing wave direction the sand formation migrates back and forth in front of the harbour, leading to enhanced sedimentation.
Rough estimate of long shore transport (based on offshore wave climate)

1/7 09 – 15/3 2010

 Normally: east going >> west going. This year: east going approx. = west going

Waverose 1 Oct - 30 Jan 2010

Comparison between nature and simulations

Transport toward East and West

Bathymetry 31 Jan 2010 Sedimentation into harbour 161,000 m³
Minimum water depth at the sandbar in metres

Water depth in m

<table>
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<th>Minimum water depth at the sandbar in metres</th>
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Quarry run in March 2009
Breakwater section
- Significant wave height $H_s = 6.1\text{m}$
- Necessary stone size for Ice BB up to 30 tons
- Availability of armour stones at Quarry site, 25 km distance.
- Quarry yield predicted 27-37% > 1t and 8-12% > 10t.

Landeyjahöfn October 2009
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Ferry Port project between Vestmannaeyjar and the mainland in conclusion:

- Technically and economically feasible to build a Ferry Port on the South Coast by navigating safely through the breaking zone in front of the Port.
- Only one location at the coast is with a dynamic stable bar with minimum acceptable depth for navigation and with minimum net littoral drift along the shore.
- Design the layout of the Ferry Port with minimum sedimentation into the Port and minimum equilibrium depth in front of the entrance is achieved.
- High quality rock quarry is available for building Icelandic Berm Breakwaters at the Port.
- The whole project fulfilled all international standards regarding design and safety.

Thank you