



EXPANDING TÓRSHAVN HARBOUR

Ensuring a safe and optimised breakwater design

Tórshavn Harbour needs to expand in order to increase its capacity and to accommodate larger ships. Designers of the new harbour had one major limitation – the coastline in front of the historical Skansin Fortress had to stay intact. To help them fulfill this requirement, we tested and optimised a proposed 1.3 km long breakwater to ensure the harbour expansion could proceed without interfering with Skansin's coastline.

THE LARGEST AND BUSIEST PORT IN THE FAROE ISLANDS

Tórshavn Harbour – located in the south-eastern part of Streymoy – is the largest and busiest port in the Faroe Islands. Located midway between Norway and Iceland, it is a popular base for North Atlantic fishing fleets and is a natural stop for North Atlantic cruises – every summer, 50 cruise ships call at Tórshavn. The port is also the largest port in the Faroe Islands for containerised cargo, with direct links to Iceland, Scandinavia, continental Europe, and the United Kingdom.

In order to enable larger ships to enter, the city council planned and approved the expansion of Tórshavn Harbour. The planned expansion will triple the harbour area from its current 45,000 m² to 135,000 m² and add two 300 m long quays. The expansion will also include a new 1.3 km long breakwater and cover a marina in front of the old fortress Skansin. The only natural location for the expansion is in front of the fortress, however it was a requirement that the coastline in front of Skansin remain intact.

CLIENT

Tórshavn Harbour

CHALLENGE

Need to safely expand Tórshavn while ensuring the coastline in front of the old Skansin Fortress remained untouched

SOLUTION

Using a full package of modelling solutions to test and optimise breakwater design

VALUE

Ensured a safe and optimised breakwater design

LOCATION / COUNTRY

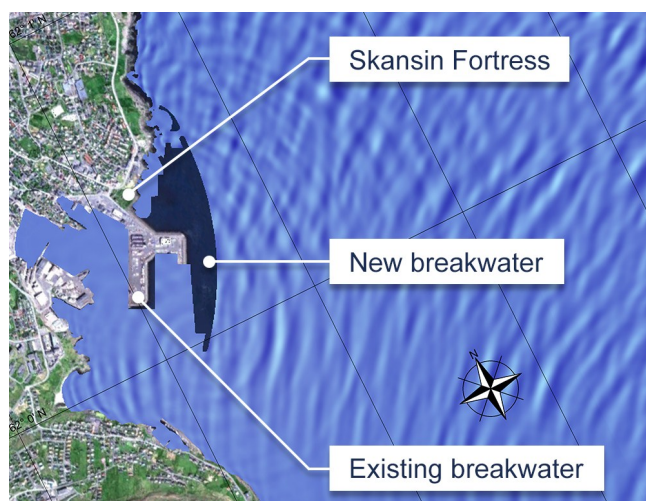
Tórshavn, Faroe Islands

SOFTWARE USED

MIKE 21



Three-dimensional physical modelling of breakwater head in severe storm conditions. © DHI



A plot from the numerical model. © DHI

To meet this requirement, the designers decided to detach the new harbour area from the coastline by placing a marina between Skansin and the harbour area.

HINDCAST OF WAVE DATA TO DETERMINE DESIGN WAVES

For this project, we analysed 34 years of hindcast data from two numerical models in order to determine the expected wave height with a return period of 100 years. This included two historical severe storms on 22 January 1984 and 31 January 2008.

Next a detailed MIKE 21 Spectral Waves (SW) model was used to transform the offshore waves to the site. The model showed large differences in wave height along the breakwater. The significant wave height was more than 1.5 m higher in the northern part of the breakwater compared to the southern part, where the existing breakwater is located.

This led to different design criteria along the breakwater and allowed for design optimisation. Based on design waves from the hindcast data, we provided detailed guidance on the design of the breakwater.

NUMERICAL MODELLING OF WAVE DISTURBANCE IN THE EXTENDED HARBOUR

We modelled wave disturbance for the existing harbour and two alternative layouts of the harbour extension using MIKE 21 Boussinesq Waves (BW). The modelling showed that the harbour extension will provide a reduction of the disturbance in the existing basin while the new basin will have a disturbance level comparable to the level in the current one. The modelling also showed that the entrance to the marina will have high levels of disturbance, since the wave heights were amplified due to the bathymetry.

In connection with the harbour disturbance modelling, we carried out ship motion modelling using our numerical model WAMSIM to determine the effect of the waves on moored ships. The models confirmed that the movements of ships at the new quays will be comparable to the movements at the existing quays.

PHYSICAL MODEL TESTS OF BREAKWATER DESIGN

The breakwater design included densely placed stones in the armour layer of the breakwater. Using two-dimensional (2D) physical modelling, we optimised the design of the breakwater – with the client – by testing and confirming the benefits of densely packing the armour stones. As part of the design optimisation, we also tested a steeper slope of the breakwater, which proved stable and thus significantly reduced the amount of material needed for the breakwater.

We utilised three-dimensional (3D) physical modelling of the northern breakwater head at the entrance to the marina. Using this model, we localised an area that was extremely exposed due to special conditions in the bathymetry in front of the breakwater. We then tested an updated design in this area using larger armour stones. At the same time we were able to reduce the size of the armour stones in other parts of the breakwater, thus creating a safer design without using unnecessarily large stones in less exposed parts of the breakwater.

OUR LONG HISTORY IN THE FAROE ISLANDS

More than 50 years ago we carried out our first project with Tórshavn Harbour – the beginning of our long track record working with them. Since the harbour expansion in 1984, we have completed several other major projects, including:

- Tórshavn Harbour, Physical model testing of reclamation in front of existing breakwater and reinforcement of breakwater, 1984
- Marina Tórshavn, Model testing of harbour disturbance, 1987
- Tórshavn New container harbour, Model testing of harbour disturbance and stability tests, 1988
- Tórshavn Harbour, Model testing of new marina, 2006
- Influence on Sandagerði Beach by expansion of Argir Harbour, Wave modelling and beach stability, 2012

In addition, we have completed several projects for other harbours on the Faroe Islands, including:

- Porkeri Harbour, Analysis of wave conditions, 1976
- Argir Harbour, Physical model testing, 1977
- Skalavik Harbour, Analysis of wave conditions, 1991
- Sydralur, Physical model testing of ferry landing, 2002
- Klaksvík Harbour, Assessment of harbour disturbance for proposed expansion, 2004
- Skuvoyar Harbour, Physical model testing of new harbour, 2005
- Leirvík Harbour, Wave agitation study for new harbour layout, 2006
- Svinoy Harbour, Physical model testing of new harbour, 2009

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