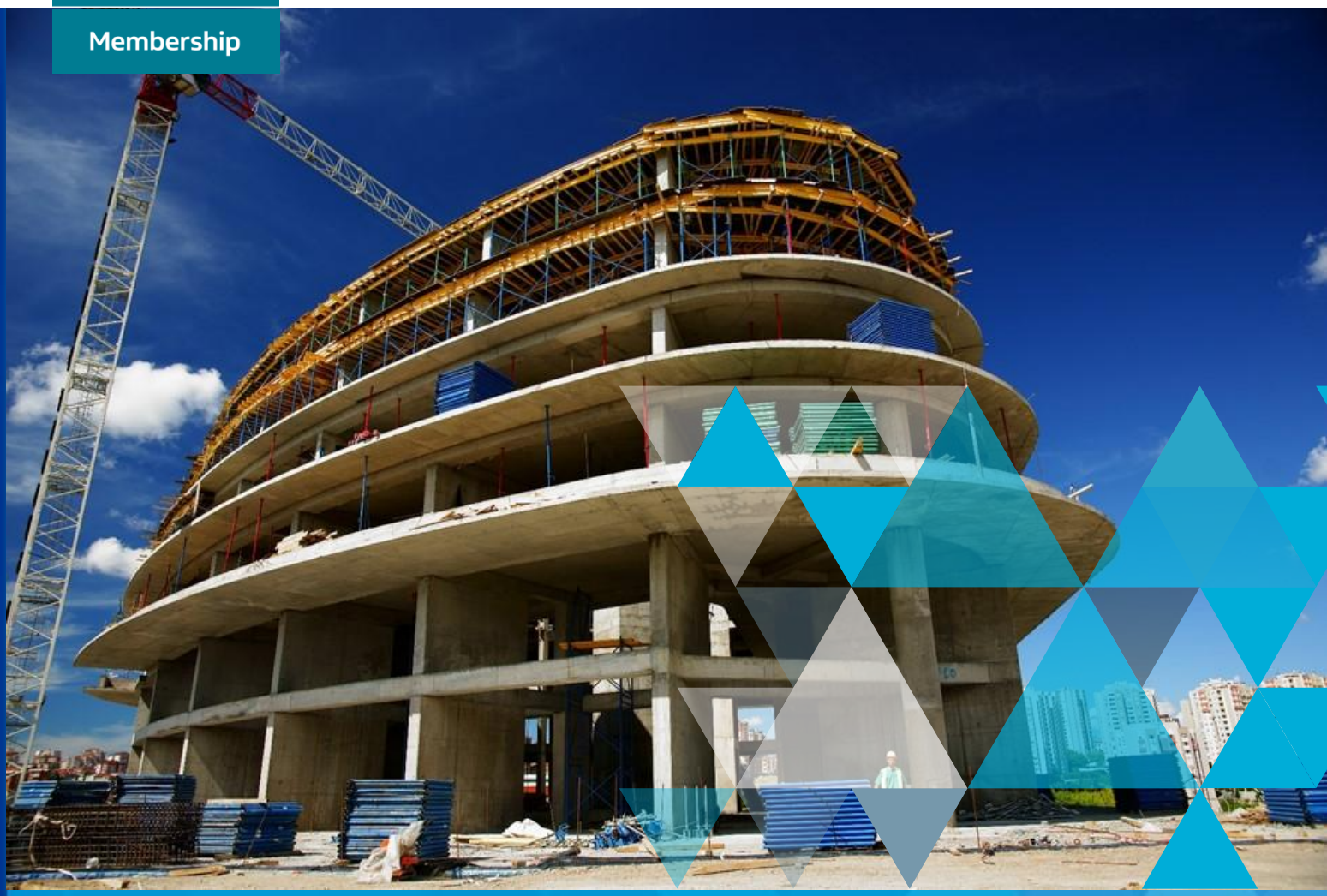
Institution of Civil Engineers

Membership



ICE Further Learning Exam Case Study:

Telfjordholme Port Expansion

Telfjordholme Port Expansion

The port of Telfjordholme, on the exposed Scandinavian coast is to be expanded. The Port Authority is working closely with the Local Council on its economic growth and jobs strategy. A new quay will include offshore-wind servicing. Inward investment to a new industrial site for logistics and windfarm maintenance will complement the redevelopment of Local Council land within the port hinterland.

Construction of a new western breakwater is key to port expansion. Construction is challenged by coastal morphology, strong littoral currents and an estimated sediment transport in the order of 0.7 million cubic metres per year. The coast is subject to several storms every year with wave heights exceeding 5m. Even between April and September, wave heights can reach 3.5–4.0m.

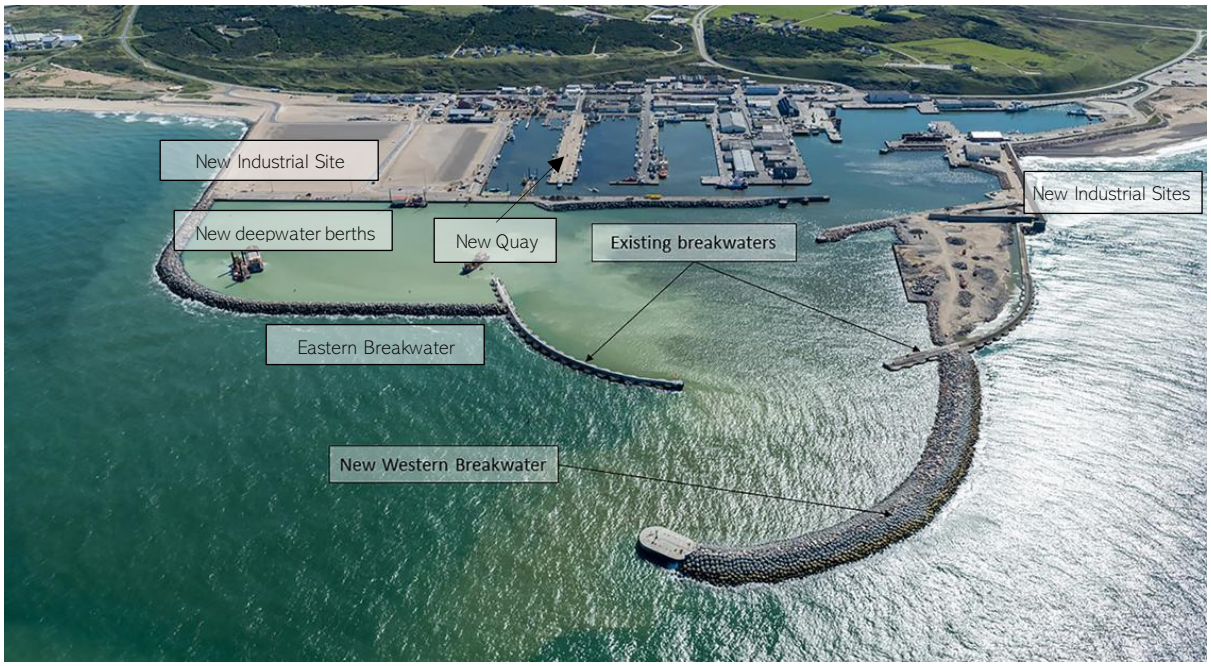


Figure 1. Port Expansion Project

The port expansion (Figure 1) comprises

- 400m western breakwater
- 40 × 22 ×17m caisson breakwater roundhead
- 1000m eastern breakwater/revetment
- 350m quay
- 50ha industrial sites
- Increased water depths to 10.5m and deep-water berths.

Water depths along the new western breakwater vary from −9 to −12.5 m with bed slopes of up to 1:30 north-west of the most exposed outer part. The seabed consists of a surficial layer of limestone covered by post-glacial marine sand. The sand layer is very mobile with varying thicknesses of 0 to 4m along the breakwater.

Construction of the 350m quay, dredging for deepwater berths and the development of the industrial

site are less weather dependent than the caisson and breakwater works.

Part 1: Development of breakwater concept

The new western breakwater is the key element of the port extension and poses a number of design and construction challenges.

12.5m diameter caissons with a low and sloping wave wall were used for the existing breakwater completed in 1967. Caissons have certain advantages due to the shallow and competent limestone at the site, which provides a robust, non-deformable and erosion-resistant base unsusceptible to scour and liquefaction.

Modern breakwaters along this coastline are rock-armoured rubble mounds. This is possible because high-quality rock is available in large quantities from quarries in Sweden and Norway. However, due to the severe design wave conditions at Telfjordholme, the rock armour would need to consist of substantial quantities of high-density basalt or norite in gradations of 20–30t and the breakwater would need a very mild slope of 1:2.75 to be hydraulically stable.

An alternative is to use concrete armour units (CAUs) as the primary armour on the seaward side and partly on the rear side. CAU options (figure 2) need to be evaluated.
Construction options include both marine based operations and progressive extension of the breakwater using land-based construction.

Figure 2. Concrete Armour Unit options

Part 1 Questions

1. As Project Manager for preliminary design, how will you lead a team to identify the most cost effective, constructable and sustainable solution for the Port Authority client?
2. As leader of a Design & Construct consortium tender, how will you assure the client re quality & sustainability, and negotiate contract cost/KPI targets? (Assume a form of contract)

Part 2: Design and Construction

A Cubipod armoured rubble mound solution is adopted for the new breakwater but requires extensive modelling and design, including 3-dimensional physical model tests at the coastal engineering basin at a local University. Accurate placement will require a quite smooth underlayer. A cross section (Figure 3) illustrates complexity.

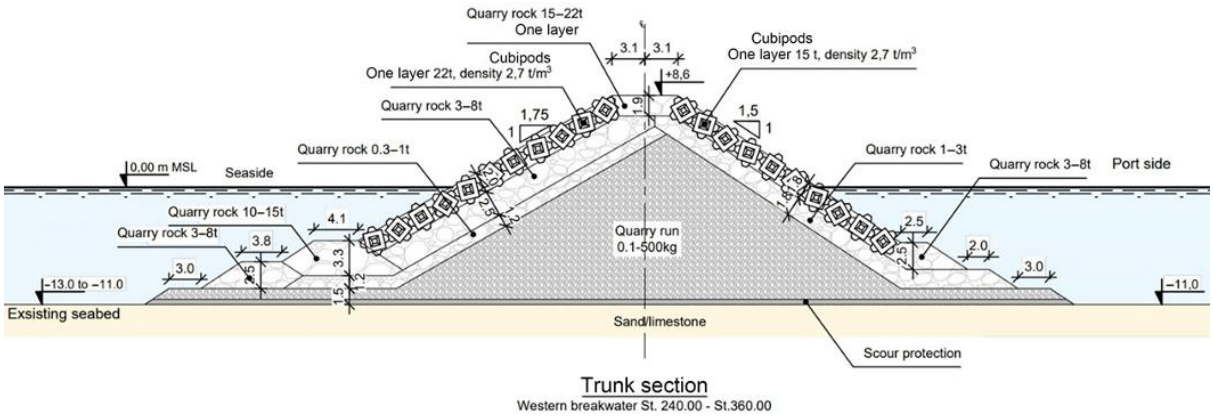


Figure 3. Breakwater cross-section

Breakwater construction will be limited to the summer season to avoid winter storms. It will be built over two summers within an overall 3 year period that includes construction of the caisson breakwater roundhead, revetments on the eastern breakwater, the new quay and landside facilities. Construction includes pre-casting of the Cubipods to a patented design.

A grab and lifting tool designed for hydraulic excavators can handle 15t and 22t Cubipods (Figure 4) for the largest units, lifting loops can be cast in for placement by crane. During fair weather conditions, an average of 85 units per 10 h shift can be expected.

Figure 4 Lifting and placing Cubipods

Part 2 Questions

3. As Contract Manager, how will you contribute to design to ensure constructability and make the most of design expertise for sustainable, affordable outcomes?
4. What are the key hazards and associated risks, and through your leadership, how will you deliver industry leading safety outcomes?

Part 3: Weather Disruption

In the late summer of the first season, the western breakwater is struck by the summer storm 'Knud', with less than 24h prior warning in weather forecasts. The storm warning is issued while the contractor is installing the armour layer (Cubipods) along the outer part of the partly constructed breakwater. There is no time to protect and cover the exposed lengths of the filter layer and exposed core before the storm hits and consequently the filter and core suffer quite significant damage requiring repair and delaying the programme.

Part 3 Question

5. As Contract Manager, what should you do as Storm Knud approaches, and once it has passed how will you assure the client regarding cost, time and quality impacts?

Our vision

Civil engineers at the heart of society, delivering sustainable development through knowledge, skills, and professional expertise.

Core purpose.

- **To develop and qualify professionals engaged in civil engineering**
- **To exchange knowledge and best practice for the creation of a sustainable and built environment.**
- **To promote our contribution to society worldwide**

Diversity statement

As a membership organisation and an employer, we value diversity and inclusion - a foundation for great engineering achievement

Institution of Civil Engineers
One Great George Street
Westminster
London SW1P 3AA
UK

T: +44 (0) 20 7665 2012
E: membership@ice.org.uk
W: ice.org.uk