**Zeitschrift:** IABSE reports = Rapports AIPC = IVBH Berichte
**Band:** 79 (1998)

**Artikel:** The Öresund Link: bridges for rail and road traffic
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**DOI:** https://doi.org/10.5169/seals-59920

# The Öresund Link: Bridges for Rail and Road Traffic

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## Summary

The article presents the structural system, design basis and production methods for the 7800 m bridge that forms a part of the Öresund Link between Denmark and Sweden. The bridge is a composite steel-concrete superstructure, supported by reinforced concrete piers and pylons that are directly founded on a limestone substratum. Construction of the two-storey cable-stayed main bridge and the approach bridges is based on extensive prefabrication of very large elements.

## General

The Öresund Link presently under construction between Sweden and Denmark, is a 16 km long combined road and rail connection, consisting of a 3750 m immersed concrete tunnel, a 4500 m man-made island and a 7800 m long two-level bridge. The main bridge is a 1092 m long cable stayed bridge, with a 490 m main span and a free height of 57 m. The eastern and western approach bridges are 3014 m and 3739 m in length respectively.

The contract for the bridges was awarded to Sundlink Contractors in November 1995 by the owner, Öresundskonsortiet AB. Sundlink Contractors is a joint venture of Skanska AB from Sweden, Hochtief A.G. from Germany, and Højgaard and Schultz a/s and Monberg & Thorsen A/S, both from Denmark.

## Design

The contract agreement is a design and build type. The design is based on the Eurocodes in combination with a Project Application Document (PAD) and specific Design Requirements for the project. These rules define the structural and aesthetic design of the bridges, together with rather detailed contract requirements regarding e.g. statical system, use of materials, shape and

exterior dimensions. The required service lifetime is 100 years, with recognition given to the need to replace specific elements within a shorter time-limit.

The bridge girders are designed as composite steel-concrete units with the concrete roadway on top. The roadway is prestressed in the transverse direction. The railway is located at the bottom level between two steel trusses. On the cable-stayed bridge the railway will run in ballast filled troughs, resting on a closed steel box, thus forming the bottom chord of the trusses. On the approach bridges the railway will run in two parallel concrete troughs, supported at 20 m centres by steel cross girders connected to the bottom chords of the steel trusses. The concrete troughs are continuous between the expansion joints and work in composite action with the steel structure. With continuous lengths as large as 1740 m, design movements of up to 1200 mm have to be accommodated by means of special structures supporting the tracks.

The bridge foundations are formed directly on the limestone substratum and are governed by ice loads and ship impact loads.

As the production of the bridge is based on the concept of combining very large prefabricated elements, a major design task has been to optimise each unit with due regard given to the adopted construction methods, including the manufacturing, transport, handling and joining of the elements.

## Construction

The prefabricated production of the substructure elements i.e. the caissons and pier shafts, is executed at a purpose-built yard in Malmö, Sweden, close to the bridge line. The caissons are constructed in a number of steps along two production lines. There are intermediate stations where individual successive casting steps are performed. Each pier shaft on the other hand is made complete at one of ten separate positions in the pier shaft area. After prefabrication, the caissons and pier shafts are lifted, transported and placed in the bridge line by the Heavy Lift Vessel Svanen. The reinforced concrete pylons for the High Bridge are each 203 m in height and are constructed in-situ, using a traditional self-climbing formwork technique.

The foundations for the pylons were prefabricated as cellular caissons in an existing dry dock in Malmö. The 19 000 ton pieces were transported to their final position by a purpose-built catamaran. Also the superstructures of the bridges are prefabricated. The steel girders for the High Bridge are manufactured in 8 sections in Karlskrona, Sweden, some 200 km from Malmö. After painting they are brought by barge to the prefabrication yard in Malmö, where the concrete road deck is cast. Due to the shallow waters which exist in the Öresund, it is possible to erect the main span of the High Bridge in four units by utilising three temporary towers that support the 140 m long sections until the cable stays are erected.

The 49 steel girders for the Approach Bridges are fabricated in Cádiz, Spain, including the casting of the concrete road deck. The 120-140 m long girders are transported, two by two, on ocean-going barges to Malmö, where they are fitted out with the concrete troughs for the railway deck, before being transported to and erected in the bridge line.

The lifting, transporting and placing of all superstructure sections is executed by the HLV Svanen. The construction of the bridges started during late 1996 and will be finished by mid 2000.