Sustainability and Innovation in Design of Major Bridge Substructures

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Abstract

Major bridge substructures like anchor blocks for suspension bridges and large offshore foundations for bridge towers and piers are generally exposed to very significant loads. Therefore, to achieve sustainable and resilient solutions for design of such structures, careful optimization of material consumption and adaption to the actual boundary conditions are needed. Also, accidental loads like earthquake and ship impact can be important design drivers.

This calls for adaptation and innovation to find sustainable, resilient, and durable substructure solutions which can also be constructed fast and efficiently. This is illustrated by examples from COWI's history of substructure designs comprising a variety of solutions ranging from caissons to pile foundations and open dredged foundations.

Keywords: Substructure; sustainability; caissons; piles; suspension bridge; cable stayed bridge.

1 Introduction

For major bridges and in particular when such bridges cross deep waterways very significant investment in the substructures is required. Therefore, optimization in the design to reduce quantities and construction equipment is essential. However, since the substructures are always on the critical path in the construction program also optimization in relation to fast-track, construction is essential.

The aim to reduce quantities and in particular concrete is in itself leading to improved sustainability and reduced CO_2 equivalent emissions. However, also use of existing construction facilities and local materials plays an important role. This will be demonstrated by examples from COWI's history of substructure designs in the following.

The substructure designs can generally be divided in three main categories comprising concrete caissons, pile foundations in steel or concrete and open dredged concrete foundations.

2 Caisson foundations

Concrete caisson foundations have been used for a number of major bridges designed by COWI as shown in the examples below.

2.1 Great Belt East Bridge

For the Great Belt East Bridge in Denmark, having a main suspension span of 1624m, the foundations for both the towers and the anchor blocks were based on caissons as shown in Figure 2-1 and Figure 2-2.

The soil is competent clay till or marl. Therefore, the main design issue was to achieve sufficient effective weight to transfer the large horizontal forces from ship impact of 670 MN at the towers and 540 MN from the main cable pull at the anchor blocks. As illustrated in the Figure 2-1 and Figure 2-2 the main contribution to the effective weight of the foundations is ensured by use of sand ballast and for the anchor blocks also iron ore and olivine to balance the overturning moment from the cable pull. Sand was locally available and iron ore and olivine were delivered by ship from Norway. In this

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