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Eurocode Comparison Calculations for Storebælt Bridges

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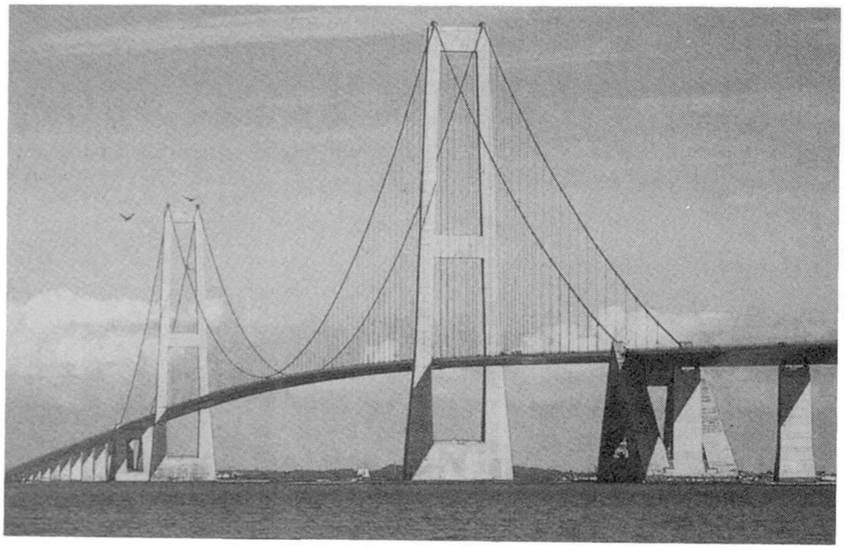
Abstract

This paper describes the main results from a desk study, where the consequences of applying the Structural Eurocodes, especially ENV 1993-2 for steel bridges, as design basis for Great Belt East Bridge, have been investigated. All main structural steel elements of the superstructures have been investigated. The bridges were originally designed according to a purpose-made design basis and the Danish national code.

The comparative study was carried out jointly by RAMBØLL and COWI, who also performed the detailed design of the bridges. The Great Belt, East Bridge consists of a suspension bridge with a main span of 1624 m and side spans of 535 m and approach bridges with 23 nearly identical spans with a span length of 193 m.

The general loads as well as the partial coefficients for loads and materials are based on the Structural Eurocodes. Project specific loads such as wind loads, ship impact, etc. are taken from the Design Basis for the Great Belt, East Bridge.



Great Belt, East Bridge

The traffic load of the Eurocode is based on Load Model 1, defined in European Pre-standard ENV 1991-3, Eurocode 1. The load corresponds to an exceedance probability of 0.1 per 100 years, whereas the traffic load on the Great Belt, East Bridge corresponds to an exceedance probability of 0.02 per year. Consequently, the Eurocode traffic loads are substantially higher. The uniformly distributed traffic load (UDL) in the Great Belt, East Bridge design basis is 18% lower than in the Eurocode, when the influence length is below 500 m. The maximal axle load is 15% higher in the Eurocode, whereas the maximum wheel pressure is about 13% larger in the Great Belt, East Bridge design basis. These differences will influence the local conditions of the deck structure.

The total load safety (TLS) factor for the dead load, which is defined as the total loads multiplied with the material partial coefficient, increases by 10 % from the Great Belt, East Bridge, design basis to the Eurocode. The TLS enhancement factor for the uniformly distributed design traffic load is identical for the two code systems. In the article all partial coefficients and TLS enhancement factors for difference loads are described.

The maximum positive and negative design bending moments are for the approach bridge girders 1.19 times larger in the Eurocode. The ratio between the material coefficients is 0.81, meaning that the TLS enhancement factor is 1.19 * 0.81 = 0.97. The conclusion of the investigation is that the area of the bridge dimensioned by the tensile stress corresponding to the global moment will remain unchanged, if designed according to the Eurocode.

In contrast to elements dimensioned for tensile stress, a further difference in the load bearing capacity for global as well as local plate stability applies. The results of the comparison are that the enhancement factor from the Great Belt, East Bridge design basis to the Eurocode ranges between 1.0 and approximate 1.35, increasing with increasing slenderness ratio.

The Eurocode does not apply to bridges with a span of more than 200 m, implying that the suspension bridge over Storebælt is not covered. The comparison is however done anyway. The TLS enhancement factor for the hangers is calculated and the results vary from 0.98 to 1.03. This means that the dimensions of the hangers in average will be the same, if dimensioned according to Eurocode. The TLS enhancement factor for the main cable is determined to 1.20, meaning that the cross section of the main cable should have been 20% larger, if calculated according to the Eurocode. This is due to the fact that the contribution of the dead load constitutes 70% of the maximum characteristic force in the main cable, and that the partial coefficient for the dead load is 1.35 according to Eurocode, and 1.1 according to the Great Belt, East Bridge design basis. The conclusion is therefore that Eurocode have too high safety level for dead load dominated structure.

The fatigue analysis has been carried out using Load Model 3 and the characteristic lifetime for the orthotropic steel deck has been determined. The results for the two most critical welds (the deck plate/trough weld and the trough splice welds) show that the SN-curves in the Eurocode and the traffic Load Model 3, in the case of the Great Belt, East Bridge, are very conservative.

In relation to this work we have found that the Eurocode does not specify how the local stresses from the axle loads shall be combined with the global stresses in the orthotropic steel deck, which is necessary for a rational design of orthotropic steel decks.

The final conclusion is that the Structural Eurocode can be used as design basis for both approach and suspension steel bridges, but has - for unique structures as the worlds 2. longest spanning suspension bridge - to be accompanied by purpose made design specifications.