Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 82 (1999)

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DOI: https://doi.org/10.5169/seals-62149

Design of Girder and Cables for Train Loads

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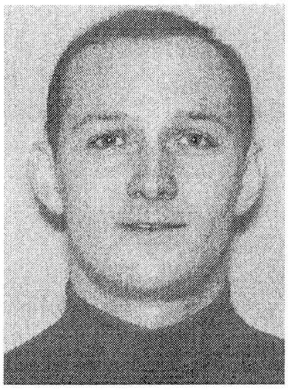

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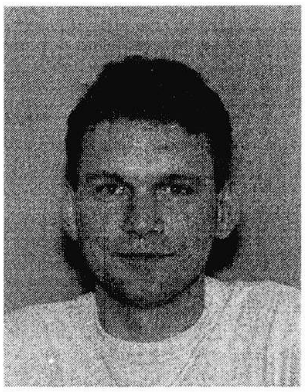

Abstract

The Cable Stayed Bridge of the Öresund Link

The High Bridge of the Öresund Link is a Cable Stayed Bridge with a Main Span of 490 m and two side spans of 160m and 141m respectively. The Pylons, with two single towers each, are constructed in reinforced concrete and the Bridge girder is a two level composite girder. The two level composite girder comprises a main carrying steel truss and a upper roadway deck slab in concrete.

The Cable Stays are arranged as a harp system with 10 Cable Stays in each cable fan. The Cable Stay inclination with horizontal is 30^{o} Deg, and the distance between the anchorages on the Girder are 20 m. For anchorage of the Cable Stays in the Pylon, a cast-in steel box has been designed. See Figure 1.

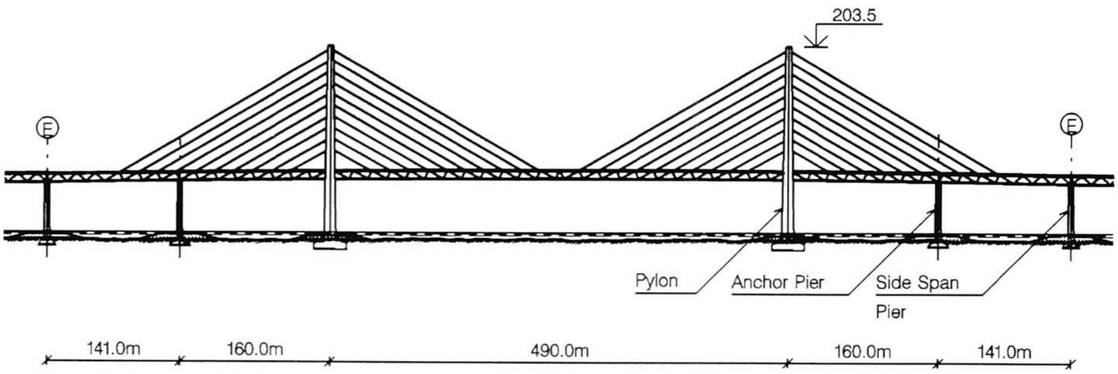

Figure 1 : Öresund Link, Cable Stayed Bridge. Side view.

The structural design was based on the Eurocodes with an associated Project Application Document and a Design Requirement document. The Design Requirement document supplemented and took precedence over the other two documents, with specific loads and other requirements covering topics which are not considered in the Eurocodes.

During detailed design computer models was established in order to perform the general verification of the Bridge, but also to perform the rather complex analyses related to the Train loads such as :

- Comfort analyses
- Dynamic Actions
- Fatigue analyses

Other complex effects with considerable design impact, but without connection to the Train loads, such as shrinkage and creep effects, shear lag and cable stay rupture, was also analysed.

Comfort Analysis

The vertical accelerations within a passenger coach was evaluated for a train with a speed of 200 km/hour, in order to verify that the comfort criteria's was fulfilled. A maximum vertical acceleration of 0,5 m/sec^2 (peak value), was found during passage of an expansion joint. Compared to the max. acceptable vertical peak acceleration of 2,0 m/sec^2, the girder is found to be well within the acceptable limits. Figure 2 gives body accelerations for one of the analysed passenger trains crossing the bridge.

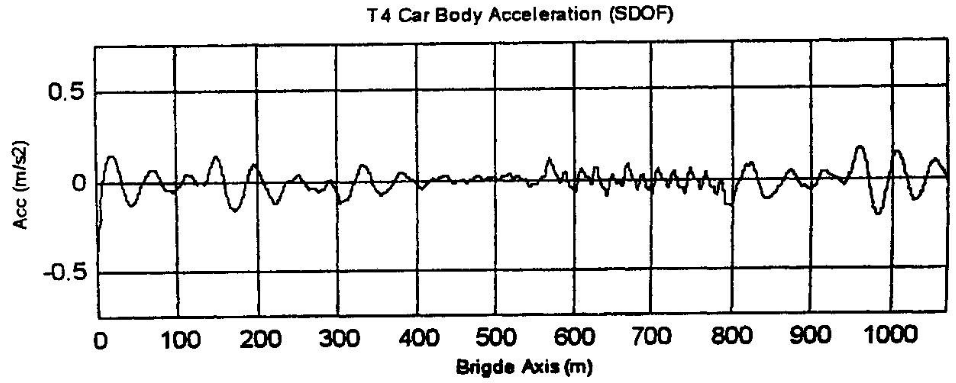

Figure 2 : Acceleration results for a passenger train crossing

Dynamic Actions

Dynamic effects from crossing of a train, was included in the design of both Girder and Cables, by introduction of a dynamic load factor. Analyses was carried out in order to determine the dynamic load factor of the global actions. The general result of the analyses, was a dynamic load factor depending on both the type of bridge element analysed, but also the element position in the bridge.

The dynamic load factors for crossing of a UIC train, was found to be in the range of 1.02 to 1.05 for the Girder, and 1.01 to 1.06 for the cable stays considering tension and 1.30 for detensioning.

Dynamic load factors was determined separately for "fatigue" trains. Here the global dynamic load factors was found to be in the range of 1.02 to 1.40 for the girder structure, and 1.02 to 1.30 in the cable stays considering tension and 1.02 to 3.60 for detensioning.

Fatigue Analysis

The Railway Tracks are supported on the lower bridge deck, a closed steel box with orthotropic deck panels, supported by transverse bulkheads with maximum 3,00 m spacing. General stress and plate buckling analyses has been performed for the steel panels and transverse bulkheads, but the major work has been related to the fatigue verification. Combination of fatigue contributions from both wind, roadway traffic and trains was made, with however the fatigue contribution from the trains as dominating. In order to perform the rather detailed fatigue verification, based on a great number of stress information's, a special computer programme was developed.