Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 82 (1999)

Artikel: Computer based optimising of the tensioning of cable-stayed bridges

Autor: Bruer, Arne / Pircher, Heinz / Bokan, Heinz

DOI: https://doi.org/10.5169/seals-62114

Computer Based Optimising of the Tensioning of Cable-Stayed Bridges

Arne BRUER
Civil Engineer
Teknisk Data AS
Oslo, Norway

Heinz PIRCHER
Senior Partner
TDV GesmbH
Graz, Austria

Heinz BOKAN
Partner
TDV GesmbH
Graz, Austria

Abstract

One of the most delicate issues in the design of long span cable-stayed bridges is to find an appropriate strategy for the stay cable tensioning procedure.

Commonly, the basic design concept leads to structural requirements and restrictions for the displacements, the moments and the stress distribution in both the girder and in the pylons. Both, the tensioning sequence and the tensioning forces must be optimised to meet these requirements at the end of the construction.

The method of analysis described in this paper models every construction stage in detail. The tensioning of each individual cable is considered at first as a unit loading case acting on the current structural system and influencing all the previously applied unit loading cases. All the other loading cases (e.g.: self weight of the new segment, moving the traveller etc.) which are applied during the erection procedure are also calculated step by step. All the displacements and the internal forces from each construction stage are accumulated and the values are sub-divided into one "constant" (self weight etc.) and several "variable" components. Each "variable" component is connected with one of the unit loading cases.

A system of equations is composed by comparing these accumulated values with the initial design requirements. This leads to intensity factors for all the unit loading cases. Even when creep and shrinkage is considered, this system of equations remains linear. If 2nd Order effects are considered, non-linearity occurs.

The prime benefit of the method described above is, that an optimal tensioning strategy is achieved where the number of stressing actions is minimised.

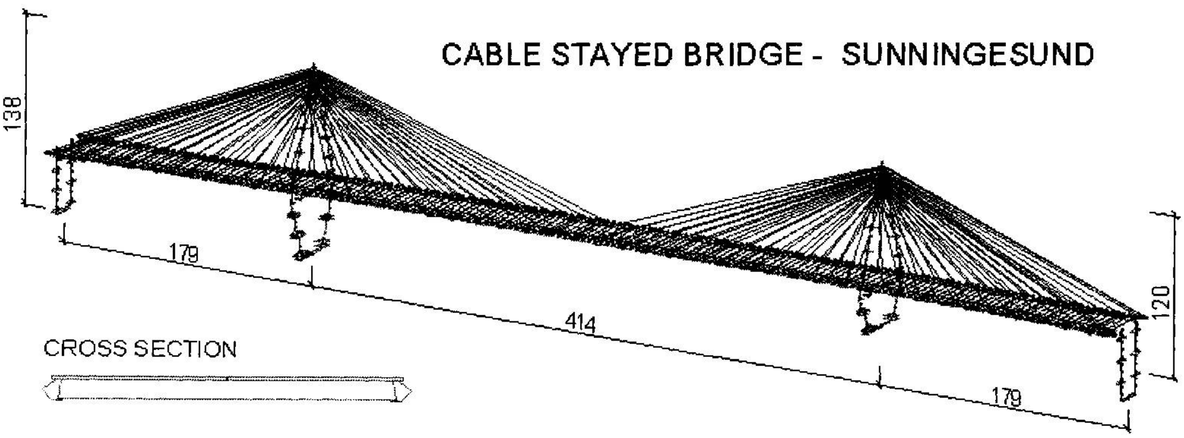

Figure 1

The concept is illustrated by the analysis of the UDDEVALLA-bridge which crosses over the Sunningesund waterway. This bridge is a long span cable-stayed structure currently under construction in Sweden. The main girder is composite, consisting of 2 steel edge beams and a concrete slab comprising pre-cast elements with cast in-situ joints, which requires a complex free cantilevering erection procedure. Approach viaducts at both ends of the main bridge are rigidly connected to the main structure. The main span is 470 m, the side spans are 179 m each and the total length of the structure including the approach viaducts is 1.712 m. Creep and shrinkage effects, which modified the force distribution to a major degree, were considered, including all the interactions between the approach viaducts and the main structure. The 2nd Order effects are also significant because of the extreme slenderness of the girder. A very strict design requirement was the limitation of the bending moment in the pylon during all construction phases. This limitation dictated the stressing approach to a large degree.

Finding the optimal tensioning strategy lead to considerable savings in costs and time.

The diagram below shows the time dependency of the cable forces during construction. The time axis is not to scale but shows a sequence of the different actions. Stages 1-16 are the cable tensioning and deck cantilevering stages. The deck construction is complete at the end of stage 16, the additional dead load is applied in stage 17 and stage 18 is for creep and shrinkage up to "time infinity".

Cable force variation in side span cables 5, 6, 7 and 8 (numbering from the pylon)

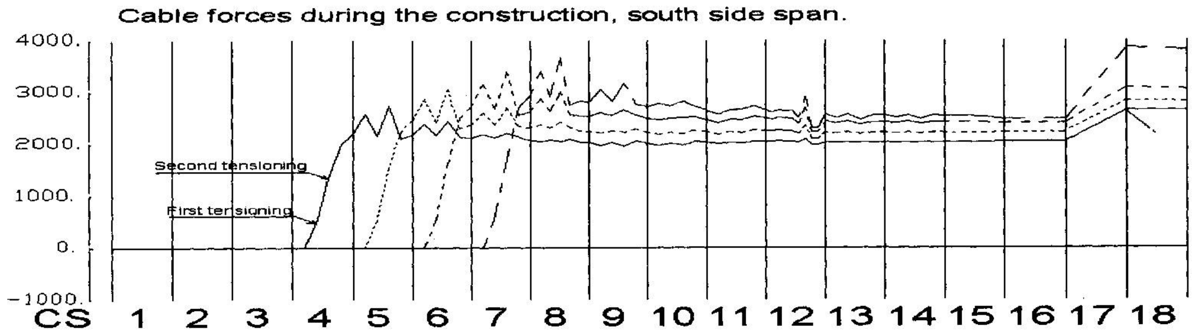

Figure 2