Buffeting and aeroelastic response analysis of a long-span suspension bridge in time-domain

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ABSTRACT

The objective of this work is the modeling and implementation of wind loads for time-domain finite element response analysis of a long-span bridge. The case studied is the Hardanger Bridge with a main span of 1310m, a suspension bridge at present under construction. The girder is a wedge shaped steel box 3.3m high and 18.3m wide.

The aeroelastic loads on the bridge girder are defined by convolution integrals implementing nine indicial functions. Indicial functions have been determined with Laplace transforms from rational function approximations of the aeroelastic loads expressed in terms of experimental determined flutter derivatives [5]. Results from time-domain aeroelastic response analyses of the bridge have been presented [4].

The buffeting loads in a quasi-steady description are defined with random wind fields generated from spectra. The method as presented by Shinozuka and Jan [6] has been applied. Single point target spectra, of the Kaimal type, in accordance with Eurocode 1, Annex B, are applied [1]. The distribution of wind gusts in a vertical plane transversal to the mean wind direction has been defined with use of the normalized co-spectrum by Krenk, see e.g. [2]:

$$\psi_m(\kappa_m, r) = \left(1 - \frac{1}{2}\kappa_m r\right)\exp(-\kappa_m r) \qquad (1)$$

In Eq. 1 r is the distance between the points in question, κ_m is a modified wave number where index m is for fluctuating component u or w.

The finite element model of the bridge incorporates 33 wind load elements along the bridge deck and 37 wind load elements along each cable plane. The equations of motion for the bridge-wind system are solved iteratively by implicit direct integration with the trapezoidal rule whereas the convolution load is calculated with Simpson's one third rule. An update of the structural stiffness matrix at each time-step accounts for non-linearity due to displacements of the bridge.

This work presents structural response due to superposed buffeting and aeroelastic loads at different mean wind speeds. Time-series of response at selected locations on bridge girder and cables are presented.

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