Aeroelastic Analysis of a Bridge Deck Section with the Total Form of Flutter Derivatives

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Since the flutter instability is an extremely important issue for the design of long-span bridges, numerous analytical methods have been proposed. The unsteady aerodynamic forces are usually expressed as the form of a mixed frequency and time domain formulation and, as a result, the flutter problem consists of a nonlinear eigenvalue problem in frequency domain. The conventional approach to solve this problem is based on an iterative calculation of each eigenvalue until the assumed frequency for the evaluation of the aeroelastic forces comes into allowable limit of differences with the imaginary part of the calculated eigenvalue. However, for the long-span bridges, the natural frequencies are closely distributed with some complicated and coupled properties in three dimensional mode shapes. In case, the aerodynamic coupling among modes is not negligible. To overcome this problem, the rational function approximation (RFA) is utilized to transform the equation of motion defined in a frequency-time-domain into a frequency independent state-space model. Although the RFA method has been successfully applied for many cases, it is found that the RFA method may yield erroneous results for bluff sections in authors' recent research works. To discuss the limitation of the RFA method and to develop an approach for the multi mode flutter analysis, this paper proposes a method based on the least square method for evaluating the flutter derivatives in a total form. For the verification of the proposed method, the free vibration response of a two dimensional section model is analyzed for the two types of representative section of bridge decks; a thin rectangular plate with width-to-depth (B/D) ratio of 20 and a bluff H-type section.

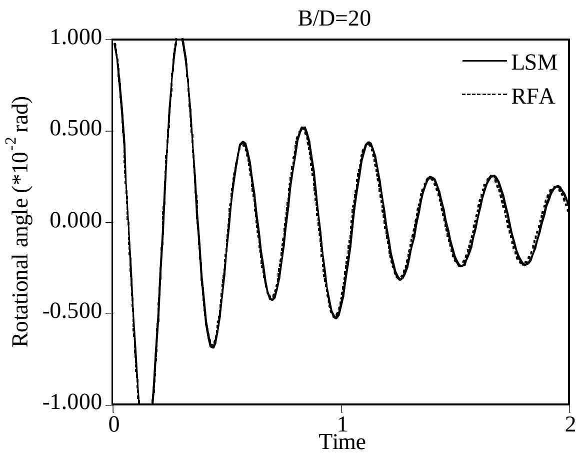

Fig. 1: Rotational angle of B/D=20 (U=12m/s)

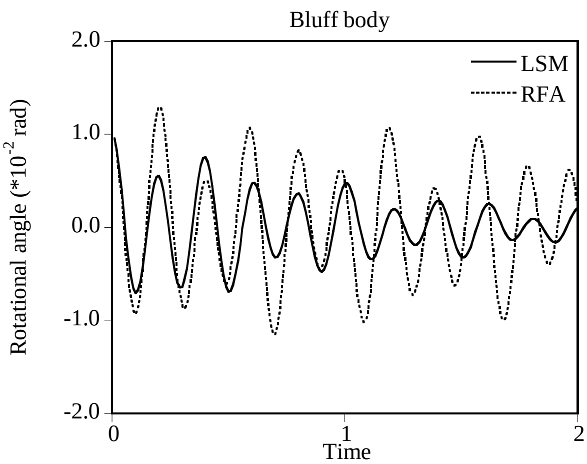

Fig. 2: Rotational angle of H-type section (U=6m/s)