EFFECT OF CROSS-FRAME SPACING ON THE MODAL PROPERTIES OF CURVED BRIDGES

Saeed Reza MASSAH
Assistant Professor, Structural Engineering, Iran University of Science and Technology, Tehran, Iran
massah@iust.ac.ir

Abbas GHADAMI
PhD Student, Structural Engineering, Iran University of Science and Technology, Tehran, Iran
ghadami@civileng.iust.ac.ir

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ABSTRACT

Parametric studies have been conducted to investigate the effect of variation in the number of cross-frames on the free vibration response of curved steel bridges such as natural frequencies and mode shapes. The numerical simulations were performed using the general-purpose finite element software package ABAQUS and validity of the results verified comparing them with experimental results of other researchers.According to the results, when cross-frame spacingisselected in a certain range, the number of cross-frames, especially in low modes, has negligible effect on the free vibration frequencies of a curved bridge. Nevertheless, in the higher modes, this effect is considerable.

INTRODUCTION

The need to have a smooth traffic flow, restrictions that exist on the use of straight routes, economic and environmental considerations and an emphasis on aesthetics have all led to the increased use of curved bridges (Ziemian, 2010). The geometry of a curved bridge structure has made its design and construction a bit difficult. In this system, the girders, as the main superstructure elements, have a large tendency for deformation and out-of-plane rotation. This aspect of the structure's'behavior becomes particularly important during the construction phase, due to the lack of a hardened concrete deck and non-composite behavior of the system. Therefore, to prevent large deformations and to provide stability for the structure, the first option for the bridge engineer would be to increase the number of cross-frames in the design. Straight girders that are braced by sufficient lateral bracings only undergo vertical deflection under gravity loads. On this basis, in straight bridges, the main function of the cross-frame is to prevent the premature lateral-torsional buckling of the beams before they reach the maximum anticipated bending strength; therefore, these cross-frames are deemed as the secondary load-carrying members. In curved bridges, because of the structures' geometry, the gravity loading causes an out-of-plane rotation of the girder sections in addition to the vertical deflection. In this way, the cross-frames not only limit the extent of the lateral-torsional deformations but also play an important role in distributing and transferring the applied load between the girders, which in this case, they are recognized as the primary members (Davidson et al., 1996; Maneetes and Linzell, 2003; Linzell et al., 2004).

The tendency of the bridge designers to reduce the number of cross-frames in order to cut down the construction time and cost, and also the solving of structural fatigue problems on one hand and the importance of having sufficient lateral braces to provide stability for curved girder on the other hand, have made it necessary to conduct more exact researchon the performance of cross-frames. In 1978, Nishida et al. investigated the lateral-torsional buckling of curved beams (Nishida et al., 1978). Then in 1996, Yoo et al. explored the difference in the lateral-torsional buckling of curved girders relative to straight girders (Yoo et al., 1996). The effects of the cross-frame spacing, span length, depth and number of girders and the distance