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Vibration Control of Stiffening Arch Bridge

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A variety of technical problems related to highway bridges have been point out, because an increasing number of heavy trucks are seen on nation's highway in recent years, and the method of reinforcement of bridges has become the center of wide interest. In the reinforcement of bridges, it is necessary to consider the serviceability of bridges not only in terms of statistical and dynamical problems, but also the vibration felt by pedestrians.

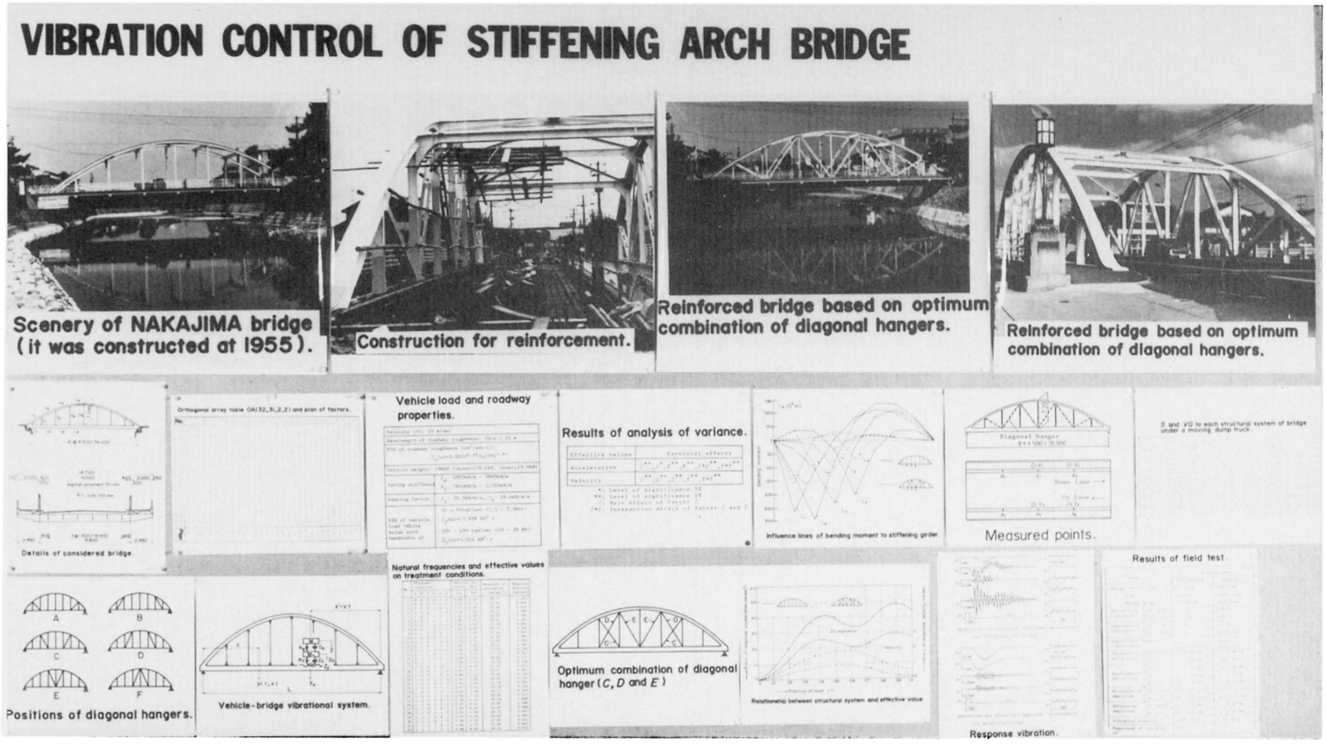
In this paper, a particular stiffening arch bridge (Lohse girder bridge), which holds these problems described above, is considered as case study. The method of reinforcement is investigated by the insertion of diagonal hangers. In order to find out the most efficient of reinforcement on this bridge, a statistical inference method (a design of experiments) is applied to this study. In this method, the evalution of vibration control is investigated. It is considered that the acceleration corresponds to the magnitude of vibration on the bridge and the velocity corresponds to the vibration felt by a pedestrian. Each effective value of the response acceleration and velocity is calculated by dynamic analysis of nonstationary response of the bridge with inserted diagonal hangers under a moving heavy vehicle, and the optimum combination of diagonal hangers is estimated from these effective values. The effect of insertion of the estimated optimum combination on the serviceability of this bridge based on the vibration sensibility of pedestrian, and the statistical and dynamic problems is investigated.

Using the calculated results described above, and taking aesthetic point into consideration, actual construction was done to reinforce the bridge. Before and after testing was done to determine the effect of the insertion of the diagonal hangers. From the measurd results of this field test, it could be seen that these results beared out the predictions of the analytical study.

The major conclusions of this study can be summarized as follows:

(1) The load carrying capacity of the stiffening girder increases because the applied load is disersed by these diagonal hangers.
(2) The excitation of the first asymmetric vibration is eliminated because the vibration mode is changed by the alteration of the bridge structure system and the natural frequency increases.
(3) The serviceability of this bridge is improved because the vibration felt by the pedestrian decreases.

Finally, from the results of this analytical study and field test, it is recognized that the method of reinforcement using diagonal hangers is a successfull way for vibration control in the stiffening arch bridge.



VIBRATION CONTROL OF STIFFENING ARCH BRIDGE

Scenery of NAKAJIMA bridge (it was constructed at 1955).

Construction for reinforcement.

Reinforced bridge based on optimum combination of diagonal hangers.

Reinforced bridge based on optimum combination of diagonal hangers.

Details of considered bridge.

Orthogonal array table: OA(32,3¹,2,2) and plan of factors.

Vehicle load and roadway properties.

Results of analysis of variance.

Influence lines of bending moment to stiffening girder.

Measured points.

S and VG to each structural system of bridge under a moving dump truck.

Positions of diagonal hangers.

Vehicle-bridge vibrational system.

Natural frequencies and effective values on treatment conditions.

Optimum combination of diagonal hanger (C, D and E)

Relationship between structural system and effective value.

Response vibration.

Results of field test.