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Scour Damaged Detection of Bridge Piers Using Vibration Analysis - Numerical Study of a Bridge

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Abstract : The brutal collapse of bridges is mainly due to scour. Indeed, the soil erosion in the riverbed around a pier modifies the embedding conditions of the structure, reduces its overall stiffness and threatens its stability. Hence, finding an efficient technique that allows early scour detection becomes mandatory. Vibration analysis is an indirect method for scour detection that relies on real-time monitoring of the bridge. It tends to indicate the presence of a scour based on its consequences on the stability of the structure and its dynamic response. Most of the research in this field has focused on the dynamic behavior of a single pile and has examined the depth of the scour. In this paper, a bridge is fully modeled with all piles and spans and the scour is represented by a reduction in the foundation's stiffnesses. This work aims to identify the vibration modes sensitive to the rigidity's loss in the foundations so that their variations can be considered as a scour indicator: the decrease in soil-structure interaction rigidity leads to a decrease in the natural frequencies' values. By using the first-order perturbation method, the expression of sensitivity, which depends only on the selected vibration modes, is established to determine the deficiency of foundations stiffnesses. The solutions are obtained by using the singular value decomposition method for the regularization of the inverse problem. The propagation of uncertainties is also calculated to verify the efficiency of the inverse problem method. Numerical simulations describing different scenarios of scour are investigated on a simplified model of a real composite steel-concrete bridge located in France. The results of the modal analysis show that the modes corresponding to in-plane and out-of-plane piers vibrations are sensitive to the loss of foundation stiffness. While the deck bending modes are not affected by this damage.

Keywords : bridge's piers, inverse problems, modal sensitivity, scour detection, vibration analysis
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