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Vibration Based Damage Detection and Stiffness Reduction of Bridges: Experimental Study on a Small Scale Concrete Bridge

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Abstract : Structural systems are often subjected to degradation processes due to different kind of phenomena like unexpected loadings, ageing of the materials and fatigue cycles. This is true especially for bridges, in which their safety evaluation is crucial for the purpose of a design of planning maintenance. This paper discusses the experimental evaluation of the stiffness reduction from frequency changes due to uniform damage scenario. For this purpose, a 1:4 scaled bridge has been built in the laboratory of the University of Bologna. It is made of concrete and its cross section is composed by a slab linked to four beams. This concrete deck is 6 m long and 3 m wide, and its natural frequencies have been identified dynamically by exciting it with an impact hammer, a dropping weight, or by walking on it randomly. After that, a set of loading cycles has been applied to this bridge in order to produce a uniformly distributed crack pattern. During the loading phase, either cracking moment and yielding moment has been reached. In order to define the relationship between frequency variation and loss in stiffness, the identification of the natural frequencies of the bridge has been performed, before and after the occurrence of the damage, corresponding to each load step. The behavior of breathing cracks and its effect on the natural frequencies has been taken into account in the analytical calculations. By using a sort of exponential function given from the study of lot of experimental tests in the literature, it has been possible to predict the stiffness reduction through the frequency variation measurements. During the load test also crack opening and middle span vertical displacement has been monitored.

Keywords : concrete bridge, damage detection, dynamic test, frequency shifts, operational modal analysis
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