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Vibration Control Realizations On A Lightweight Frp Footbridge

Iván M DÍAZ, Christian GALLEGOS-CALDERÓN, José RAMÍREZ-SENENT, Christian A. BARRERA-VARGAS

Fiber Reinforced Polymer (FRP) pedestrian structures have been found to be feasible, offering numerous advantages, such as high strength-to-weight ra-tio, low maintenance cost, corrosion resistance, fast installation, amongst others. The authors have followed a motion-based design approach to design and build a 10 m-span simply supported full-scale FRP footbridge, in such a way that the structure fulfils all the static requirements. However, compliance at the Vibration Serviceability Limit State (VSLS) is not reached. As this criterion is critical since the bridge is extremely lightweight (only 80 kg/m), the vibration comfort is met through the installation of inertial controllers. This allows to complete the adopt-ed structural design, leading to a feasible footbridge project. When dealing with lightweight pedestrian structures, human-structure-controller interaction phenomenon plays an important role and cannot be ne-glected in the VSLS assessment and the design of vibration controllers. Addition-ally, when designing active and semi-active vibration controllers, the actuator dy-namics are usually considered to be independent of the structural response, how-ever, this assumption may not be held in lively responsive pedestrian bridges since the structure movement may not be negligible. Accounting for a frequency-domain approach, which has been developed by the authors, the aforementioned issues can be properly addressed to design and implement a vibration control strategy. Thus, this paper presents the vibration control strategies explored by the au-thors to meet vertical vibration limits on the FRP footbridge. Concretely, three realizations are described. First, the design, installation and experimental assess-ment of a passive inertial vibration controller (Tuned Mass Damper, TMD) is ex-plained. The controller is designed using the mentioned frequency-domain ap-proach, which considers the total closed-loop transfer function of stochastic cou-pled human-structure systems. Second, the passive device is upgraded through the substitution of the passive damper with a magnetorheological damper, which is controlled in real time employing an on-off phase control law. Hence, a semi-active TMD is obtained. Third, an active TMD is designed through the classical Direct Velocity Feedback, but a state-of-the-art actuator dynamic inversion to widen the frequency-band of effectiveness is considered. This is an important is-sue when dealing with lightweight structures that may show non-negligible non-resonant harmonic responses. For all the cases, the experimental campaign in-volves walking and bouncing excitations, and the results are evaluated in terms maximum transient vibration values calculated from the 1-s running RMS. The pros and cons of the three vibration control realizations have been critically com-pared. Keywords: Active vibration control, Inertial vibration controllers, Lightweight structures, Human-Structure-Controller interaction