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UAV Based Multi-Hazard Vulnerability Assessment System for Bridges Exposed to Scour

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Evaluating the multi-hazard performance of river crossing bridges under probable earthquake, flood, and scouring scenarios is a cumbersome task in performance-based engineering. The loss of lateral load capacity at bridge foundations may induce bridges to become highly vulnerable to failure when the effects of scour and floods are combined. Besides, the assessment of local scouring mechanism around bridge piers provides information for decisionâ€making regarding the pile footing design and for predicting the safety of bridges under critical scoured conditions. Thereby, accurate high-resolution Digital Elevation Models (DEMs) are critical for many hydraulic applications such as erosion, hydraulic modelling, sediment transport, and morphodynamics. In the present study, an automated unmanned aerial vehicle (UAV) based multi-hazard performance assessment system was developed to respond to rapid performance evaluation and performance prediction needs for river crossing reinforced concrete (RC) bridges. The Bogacay Bridge constructed over Bogacay in Antalya, Turkey was selected as the case study. In the developed system, firstly the seasonally acquired UAV measurements were used to obtain the DEMs of the river bed from 2016 to 2019. The transverse cross sections of the river bed that were taken close to the inspected bridge were used to measure the depth of the scoured regions along the bridge piles under the present conditions. Separately, in conjunction with the flood simulation and validation with 2003 flood event (corresponds to Q_{50}=1940 m^3/s), the scour depth after maximum probable flood load according to the return period of 500 years (Q_{500}=2560 m^3/s) were predicted by HEC-RAS software. Afterwards, the 3D finite element model (FEM) of the bridge was constituted automatically with the developed code considering the scoured piles. The flood loads were exerted on the modeled bridge with regard to the HEC-RAS flood inundation map and relevant water depth estimations around the bridge piers. For the seismic evaluation, nonlinear time history analyses (THA) were conducted by using scaled eleven scaled earthquake acceleration records that were acting in both principal axes of the bridge simultaneously by considering maximum direction spectra (SaRotD100) as compatible with the region seismicity. In the analyses; as the scour depth increased, the fundamental periods, shear forces and the bending moments were observed to increase while the pile lateral load capacities diminished. Therefore, the applicability of the proposed system was verified using the case study bridge.