Structural Health Assessment of 3D Simple Reinforced Concrete Bridge Girders Using FE-ANN procedure

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The structural deterioration of aging infrastructure systems is becoming an increasingly important issue worldwide. Over the past several decades, structural health monitoring (SHM) has proved to be a cost-effective method for detection and evaluation of damage in structures. Visual inspection and condition rating is one of the most commonly applied SHM techniques, but the effectiveness of this method suffers due to its reliance on the availability and experience of qualified personnel performing largely qualitative damage evaluations. The artificial neural network (ANN) approach presented in this study is used to train a crack-induced damage quantification model for reinforced concrete bridge girders. This ANN model requires only the results of limited field measurements to operate. Simply-supported three-dimensional reinforced concrete T-beams with varying geometric, material, and cracking properties were modeled using Abaqus finite element (FE) analysis software. Up to five cracks were considered in each beam, and the ratios of stiffness between cracked and healthy beams with the same geometric and material parameters were measured at nine equidistant nodes along the beam. Two feedforward ANNs utilizing backpropagation learning algorithms were then trained on the FE model database with beam properties serving as inputs for both neural networks. The outputs for the first network consisted of the nodal stiffness ratios. The sole output for the second ANN was a health index parameter, computed by normalizing the area under the stiffness ratio profile over the span length of the beam. The ANNs achieved excellent prediction accuracies. A touch-enabled user interface was developed to allow the ANN models to be utilized for on-site damage evaluations.

Keywords: Artificial neural networks, damage assessment, finite element analysis, reinforced concrete, structural health monitoring