Enhancing Structural Assessment: An Integrated Approach Using 3D Applied Element Method and Sensitivity-Based Model Updating

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ABSTRACT

Effective vulnerability assessment requires an understanding of and ability to forecast the behaviour of buildings, particularly in earthquake-prone areas. Existing building modelling and analysis are made possible by the 3D Applied Element Method (AEM), although the accuracy of the method is greatly dependent on the caliber of the input data. This study examines the improvement of creating models utilizing a sensitivity-based model update method built inside the 3D AEM framework. Our method's key component is the capacity to obtain precise information on a building's materials, particularly its stiffness (Young's modulus). This field data will enable the AEM model to more accurately simulate the behavior of the building. In the beginning, we formulate a reasonable estimation of the material qualities of the building and methodically classify model components into groups based on these properties. Further an optimization problem is setup to update the dynamic properties of the structure. The parameters included are the eigen values and eigen vectors to do the updating starting from the first guess. The study stresses that the accuracy of our first guess is crucial to the caliber of our results. We use the Levenberg-Marquardt technique to improve this model because it is recognized for its dependability when dealing with engineering optimization. Using a four-story building frame typical of those in Nepal as the testbed, our methodology was evaluated. AEM was used to create a new version of such a structure supported by its documented properties. The AEM model was then adjusted using fictitious ambient vibration data that mimicked real-world conditions. Promising results were achieved. Our approach enabled the AEM model to closely resemble the real building despite working with scant field data. It became clear that (1) the accuracy of model updating in 3D AEM is mostly possible within an acceptable error margin, (2) care is needed to remove higher modes from experimental data to avoid skewed findings, and (3) the initialization step is crucial. Though the Levenberg-Marquardt algorithm is adept at refining the model, a poorly initialized model might never converge to the desired accuracy. Our study highlights the 3D AEM's potential when used in conjunction with clever model updating methods. It opens the door for more precise building assessments utilizing sparse data, which is beneficial for assessing the risk of infrastructure.

Keywords: 3D Applied Element Method, Building Modeling, Youngs Modulus, Levenberg-Marquardt Algorithm, Structural Vulnerability Assessment

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