ENHANCING STRUCTURAL ASSESSMENT: AN INTEGRATED APPROACH USING 3D APPLIED ELEMENT METHOD AND SENSITIVITY-BASED MODEL UPDATING

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1. INTRODUCTION

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)[1], 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 [2],[3] built inside the 3D AEM framework.

2. METHODOLOGY

Our method's key component is the capacity to obtain precise information on a building's materials, particularly its stiffness (Young's modulus (E)). 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 objective function for the optimization is:

$$Minimize\, f(x)=\sum_{i=1}^{n_{modes}} ¿¿¿$$

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. In order to find the value of updating parameters (x) and subsequently the material properties (Young's modulus (E)) of the structure for the (j+1)-th iteration, the Levenberg-Marquardt algorithm [4] is used.

$$x_{j+1}=x_j-\left(\nabla ¿¿ 2 f\left(x_j\right)+\Lambda I\right)^{-1}\nabla f\left(x_j\right)¿$$

Using a four-story building frame typical of those in Nepal as the testbed, our methodology was evaluated (Figure 1). 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.

3. RESULTS

The updated parameters (Young's Modulus) values after the model updating using the developed method are shown in Table 1. The frequency of the updated structure is obtained to be 3.89 hz and 16.55 hz for first and second mode respectively, within the error margin of 1.83%. On the other hand, the updated mode shape vectors are obtained within the error margin of 3.45% in comparison with the experimental mode shape of the structure as shown in Figure 2.

4. CONCLUSIONS

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.

Table 1. Young's Modulus of the updated structure

SN	Youngs' Modulus *10^5 (KN/m^2) Experiment	Updated	Error %
Column	223	229.60	2.95%
Beam/Slab	194	196.87	1.48%
Wall	158	160.41	1.52%

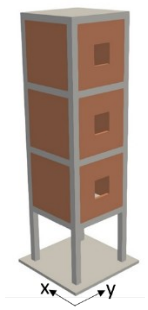

Figure 1. Case study building

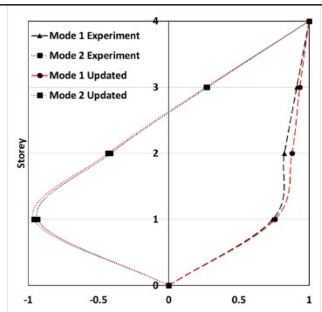

Figure 2. Mode shape comparison of the case study building

5. REFERENCE

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