A technique of modeling local variation of laterally loaded masonry wall panels

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The traditional analysis techniques, such as the finite element method, study structural performances all based on the constitutive condition and mechanism, which are applied to all areas of engineering. However, an issue has existed for a long time, that is, the difference between the structural response caused by the variability of the structure itself and the corresponding analytical result has not been studied fully in theory. At present, the variability is generally treated as a random factor and then connected with some physical parameters of the structure. This method on dealing with variability can only reflect the variability of structure limitedly and one-sidedly. In other words, this treatment does not present the structural variability in basis of theory and mechanism and is only based on the experience with statistical parametric analysis. Masonry is a composite material made of units (bricks, blocks, etc) and mortar. The complex mechanical behavior of masonry material is the result of the variability. Hence, it is difficult for the traditional FEA to predict the response of the masonry structure close to experimental ones. So far, there is very little research in this area, except that Zhou (2002) introduced the stiffness/strength corrector based on cellular automata to successfully predict the response of laterally loaded masonry panels. Zhou et al. (2006) proposed a novel zone similarity technique using cellular automata (CA) for masonry wall panels. He used information about panel boundaries and location of zones from similar boundary types to transfer certain information from a single base panel tested in the laboratory to a number of unseen new panels with different boundary types and panels with or without openings. Then Zhang et al. (2008) developed the CA model for predicting the cracking pattern of vertically loaded masonry wallettes. Zhang and Zhou (2009) developed the application of stiffness corrector to predicting the behavior of vertically loaded masonry wall panels. This paper presents an innovative technique of modeling the local variability of laterally loaded masonry wall panels, which can predict the response of wall panels with modified global material properties based on CA model.

This paper introduces an innovative model modified by local property coefficients, in order to make a more accurate modeling of the local variation of laterally loaded masonry wall panels. The study discovers the variation of the property of an element in the different working regions on the wall panel is closely related with the configuration of the structure. Therefore, a concept of local property on the wall panel is proposed to reflect the variation of property of element in individual regions on the wall panel. The local property coefficients, produced from the comparison between the experimental and numerical displacements at individual points on the wall panel, are taken use of quantitatively expressing the variation in masonry properties at local regions within the wall panel and the effect of panel boundaries on the regions. When the parameters based on the concept are used in the FEA of masonry wall panel, a great improvement is achieved on the prediction of response of the structure.
efficiently. Thus, the global material properties of the masonry wall panel become different for individual regions on the wall panel. For the application of local property coefficients from the base wall panel (a full-scale experimental panel) to an unseen new panel, the corresponding rule is applied to match similar zones between the base panel and the unseen panel whose configuration is different from the base panel by the cellular automata technique.

This paper presents two formulas for modifying initial value in the directions of length and height in application of cellular automata model. As the geometrical size of predicted panel different from that of the base panel, it is necessary to amend the initial values of the transition function and transition coefficients. In the case of the constant boundary initial value and the transition coefficient of the base panel, both values of the predicted panel are amended using the two formulas and then the similar zones between the two panels are matched using the proposed rule; thus, the deformation of new panel can be predicted accurately.

Finally, the finite element analysis (FEA) program specialized for masonry panels is used to predict the response of wall panels with modified global material properties. When compared with the experimental results, the application of local property coefficients in the FEA can improve the accuracy of the prediction of displacements of the wall panel by 16%. The case studies also indicate that the proposed method represents the true behavior of the masonry panels very well, as the variation in masonry properties relating to boundary effect is reflected in the FEA. Therefore, this study could lead a new way for the application of the existing experimental records in structural analysis. This would lead a new way for the application of the existing experimental data in structural analysis and an improvement on the existing FEA in some complex structural analysis.

The novel technique is presented to predict the response of masonry wall panel loaded laterally by exploiting the advantages of CA and modelling the local variation. It can not only greatly save testing expenditure but also beneficially exploit the application of experimental data and records. And it can be used not only a theoretically analytical technique but also an experimentally analytical technique.

Despite many advances, there is a need for reliable and comprehensive methods to predict the behaviour of vertically loaded masonry wall panels. The main purpose of our work is to explore one particular relation of the variation in masonry properties and to present a reliable and economic solution method.

References

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