About the Effects of Mesh Size and Compatibility

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Abstract: In this paper, the effects on the finite element analysis results of mesh size and mesh compatibility would be discussed based on a shear wall which has non-aligned holes. The computed results based on the compatible mesh and non-compatible mesh would be presented and compared. Similarly, the FE models with different mesh size would be analyzed and the calculated results would be compared. Through these comparison the following conclusions, which are identical with the FE theory [1-3], could be obtained that: (1) the structural stiffness of non-compatible mesh model would be less than that of compatible mesh model; (2) the structural total stiffness would decrease sequentially with the decreasing of mesh size.

Introduction

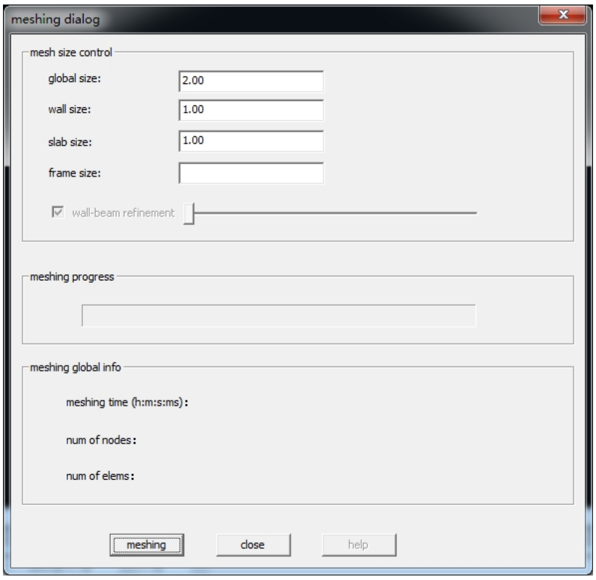

Figure 1 Dialog box of mesh size control in ISSS [5]

Generally speaking, the mesh size and mesh compatibility are very important for the finite element analysis (FEA) [1-3]. In the ISSS, which is developed by the authors in Refs. [4-7] to satisfy the increasing requirements for high performance simulation (HPS) in building structural engineering, the mesh compatibility would be automatically satisfied in the finite element (FE) model generation [5-6], while the mesh size would be controlled by the interactive dialog box, see Fig. 1.

In this paper, the effects on the finite element analysis results of mesh size and mesh compatibility would be discussed based on the following shear wall which has non-aligned holes, see Fig. 2. The computed results based on the compatible mesh and non-compatible mesh would be presented and compared. Similarly, the FE models with different mesh size would be analyzed and the calculated results would be compared. Through these comparison the following conclusions, which are identical with the FE theory [1-3], could be obtained that: (1) the structural stiffness of non-compatible mesh model would be less than that of compatible mesh model; (2) the structural total stiffness would decrease sequentially with the decreasing of mesh size.

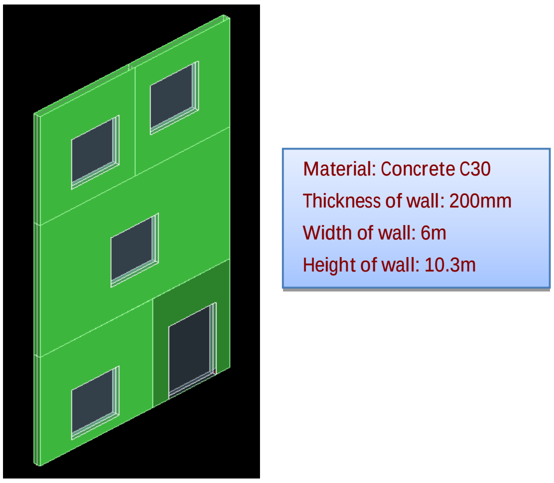

Figure 2 Illustration of a shear wall with non-aligned holes

Results comparing according to mesh compatibility

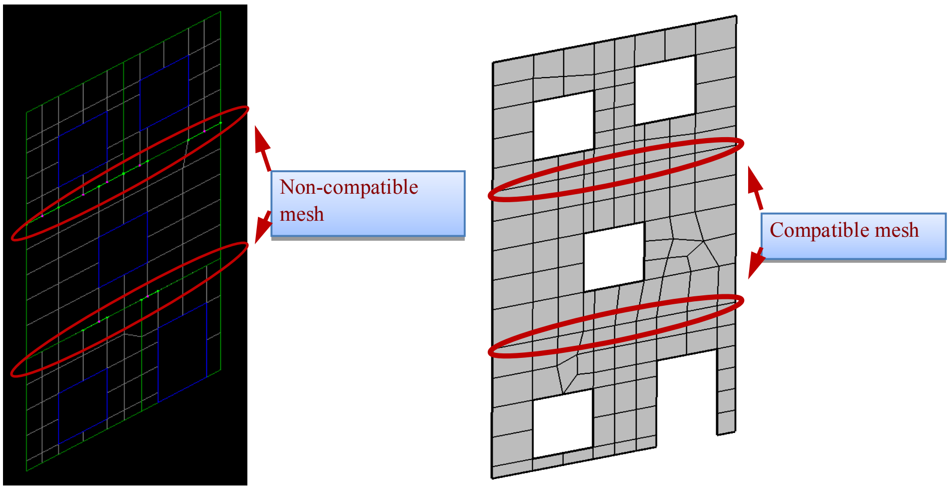

Figure 3 The non-compatible and compatible meshing

Fig. 3 presents the non-compatible mesh and compatible mesh of the shear wall structure shown in Fig. 2. To study the influence of mesh compatibility, the non-compatible and compatible finite element models are input into ANSYS and analyzed respectively. The computed results are presented in Table 1-2 and Fig. 4-5. Table 1 presents the first 5-order natural frequency results for modal analysis, from which it could be concluded that the structural stiffness of non-compatible model is less than that of compatible model, with the maximum error of 8%. In this case particularly, the mesh compatibility has much more influence on the structural bending stiffness than the torsional stiffness. Table 2 presents the maximum displacements of the structure under the action of 300KN lateral force and Fig. 4-5 presents the corresponding displacement contours. Observing these results, it is obvious that: (1) the displacement of non-compatible mesh is much higher than that of compatible mesh, with the maximum error of 8%; (2) besides the difference of displacement value, the deformation patterns of the non-compatible and compatible mesh are different, e.g. there is obvious cracks in the non-compatible mesh, leading to the degeneration of the structural stiffness.

Table 1 The effects of mesh compatibility for natural frequencies

Natural frequency	Compatible mesh	Non-compatible mesh	Calculation error
No.1 (Bending)	0.86272	0.83540	3.17%
No.2 (Torsional)	3.7042	3.7000	0.11%
No.3 (Bending)	5.6562	5.4422	3.78%
No.4 (Torsional)	11.905	11.801	0.87%
No.5 (Bending)	15.961	14.693	7.94%

Table 2 The effects of mesh compatibility for displacements

Displacement (mm)	Non-compatible mesh	Compatible mesh	Calculation error
Maximum	1.612	1.494	7.9%

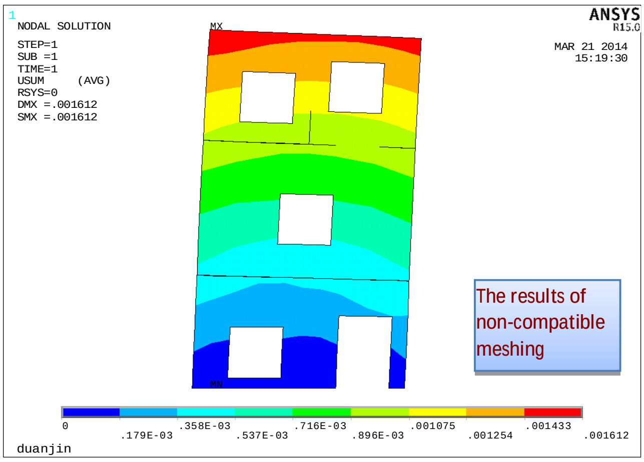

Figure 4 Displacement contour with non-compatible meshing

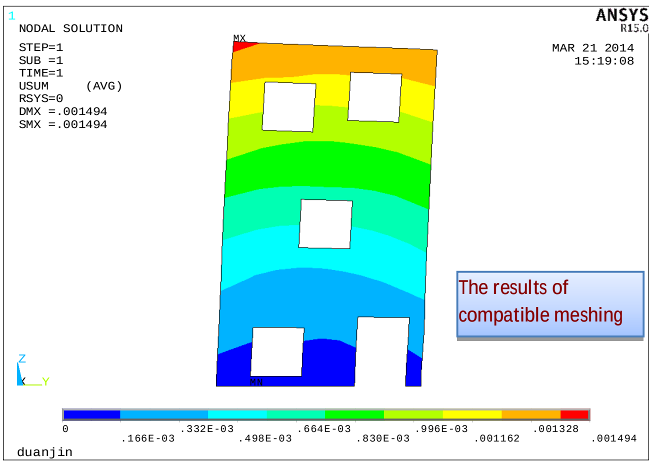

Figure 5 Displacement contour with compatible meshing

Results comparing with different mesh size

To study the influence of mesh size, the modal analysis and static analysis mentioned in above section are carried out again with different mesh size from 0.2m to 1.5m. Fig. 6-7 presents the different first order bending frequency and torsional frequency respectively, along with different mesh size. Similarly, Fig. 8-9 presents the different first maximum displacement and elemental stress respectively, along with different mesh size. From these computed results, it is obvious that the influence of mesh size is very remarkable, with the maximum displacement error of about 13%, see Table 3. In addition to the above conclusion, it is also observed from Fig. 6-8 that the structural total stiffness would decrease sequentially with the decreasing of mesh size.

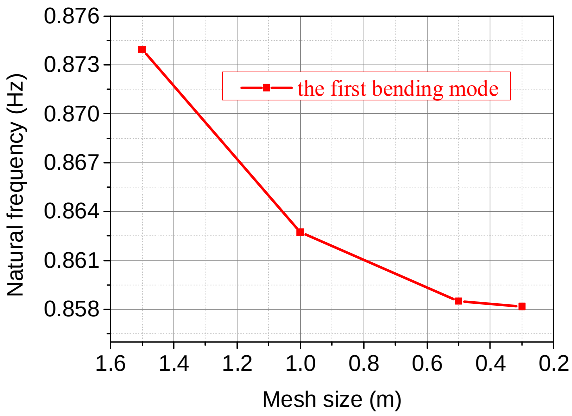

Figure 6 Convergence of the first bending frequency

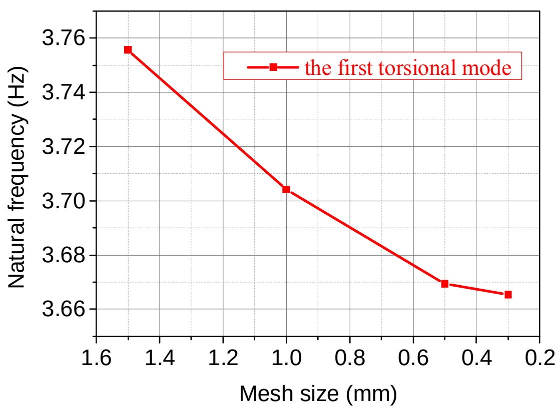

Figure 7 Convergency of the first torsional frequency

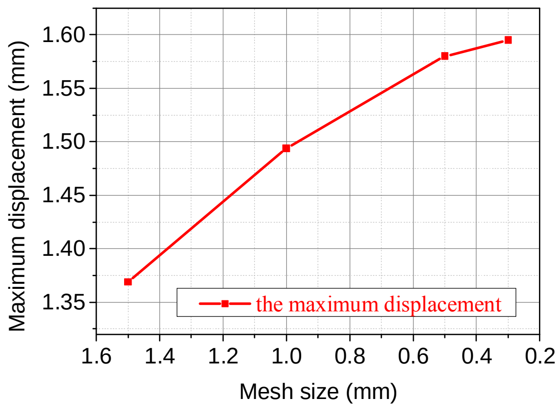

Figure 8 Convergency of the maximum displacement

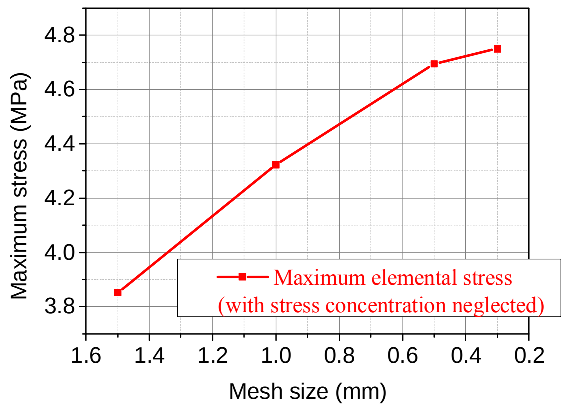

Figure 9 Convergency of the maximum elemental stress

Table 3 Results comparing with different mesh size

	1.5m	0.5m	Calculation error
1st bending natural frequency (Hz)	0.87395	0.8585	1.8%
1st torsional natural frequency (Hz)	3.7556	3.6693	2.35%
The maximum displacement (mm)	1.369	1.58	-13.35%
The maximum elemental stress (MPa)	3.852	4.694	-17.94%

Conclusions

The effects on the finite element analysis results of mesh size and mesh compatibility are discussed in this paper, based on a shear wall which has non-aligned holes. The computed results based on the compatible mesh and non-compatible mesh are presented and compared. Similarly, the FE models with different mesh size are analyzed and the calculated results are compared. Through these comparisons the following conclusions, which are identical with the FE theory [1-3], have been obtained that: (1) the structural stiffness of non-compatible mesh model would be less than that of compatible mesh model; (2) the structural total stiffness would decrease sequentially with the decreasing of mesh size.

Reference

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