Effect of joint behavior on stability of single-layer grid shells

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Abstract

The mechanic behavior of bolted joints is different from a hinged joint or a rigid joint, which has a significant effect on the stability of single-layer grid shells. This paper discussed the effect of joint behavior on stability of single-layer grid shells. Based on the mechanic behavior of the bolted joint obtained from experiment[1], the finite element models of single-layer grid shells with bolted joints were established, and spring elements were used to simulate the joint behavior. The stiffness of the spring element was deduced based on the stiffness of series springs. The material nonlinearity and geometric nonlinearity were considered in FEA model. The influence of joint stiffness on the nonlinear buckling load, eigenvalue buckling mode, nonlinear failure mode, and internal stress of the structure had been studied by changing the joint stiffness over a reasonable range.

With the decrease of the joint stiffness, the wave number of the first-order mode of eigenvalue buckling increased. When the joint stiffness was small to a certain extent, the eigenvalue buckling mode showed local deformation, and the overall performance of the cable-braced grid shell was weakened.

The different joints might lead to the change of the buckling mode of grid shells. The distribution of the maximal compression stress of the tubes was similar to that of the structural displacement when the cable-braced grid shell collapsed. The deeper the concave dimple was, the higher the stress of the tube was. The distribution of the maximal compression stress of the tubes was similar to that of the structural displacement when the cable-braced grid shell collapsed. With the increase of the bolted joint stiffness, the deeper the concave dimple was, and the higher the stress of the tube was.

The bolted joint stiffness had a great influence on the nonlinear buckling load of cable-braced grid shells. With the decrease of the joint stiffness, the stiffness and nonlinear buckling load of the structure decreased. Considering the effect of the joint stiffness on the eigenvalue buckling mode, the nonlinear buckling load of the structure, and the internal forces of the tubes, the joint stiffness of the elliptic paraboloid cable-braced grid shells should be greater than 20% of the rigid joint stiffness. At this time, the buckling load would be more than 55% of the rigid grid shell buckling load.

Keywords: Stability, grid shell, buckling load, bolted joint, joint stiffness

References

[1] R. Feng, J. Ye, B. Zhu. “Behavior of Bolted Joints of Cable-Braced Grid Shells”. *Journal of Structural Engineering*, 2015.