Analysis of Bearing Capacity of Steel Frame Structure Considering Initial Defects

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Abstract: Steel frame structure is widely used in the field of Civil Engineering. The steel structure is of light quality, good seismic performance and good structure ductility. In addition, the steel structure is convenient for large-scale industrial production. However, the steel material is due to the production process and the construction error, etc. Initial defects are inevitable. In this paper, the first four order buckling modes of the whole structure are introduced as initial defects by using the uniform defect mode method. The numerical simulation is carried out by the finite element software ABAQUS. Three analysis conditions are compared and analyzed. The impact factor of the initial defect is compared as a variable. The results of pushover analysis show that: the effect of initial defects on the bearing capacity of the overall structure is almost negligible when the impact factor of the initial defect is small.When the influence factors of the first four order initial defects are 0.5, 0.3, 0.1 and 0.5, respectively, the yield bearing capacity is reduced by 12.5%, the ultimate bearing capacity is reduced by 8.5%.
Keywords: Steel frame structure; Q235; Bearing capacity ABAQUS; Pushover analysis

1. INTRODUCTION

The structure of the house is varied, and the steel structure is a more common form of structure. By the end of 2013, the production of crude steel in China has reached 7.82 million tons, which has exceeded 50% of the total output of the world. Taking into account the demand for residential buildings at the present stage and the high industrial level of the steel structure housing, the steel structure housing will be the ideal form to replace the brick and concrete structure and the reinforced concrete structure. Steel structure housing has played the role of high strength and high elastic modulus of deformation. Compared with traditional reinforced concrete residential buildings, steel structure housing has many excellent quality characteristics. The steel structure houses not only have good building functions, but also have good seismic performance. The ductility of the steel structure is good enough to consume the energy brought by the earthquake. Besides, it can educe the risk of brittle failure. Therefore, it has good seismic performance and high structural safety, and its seismic performance is obviously superior to other structural systems. In this paper, a finite element software ABAQUS is used to establish an analytical model. The effect of initial defects on the bearing capacity of steel frame structure is discussed in three operating conditions.

2. MODEL OVERVIEW

The structure of this paper is a regular steel frame structure. One of the frames is intercepted for pushover analysis. The analysis of the steel frame in this paper is 2 layers. The height of the floor is 3 meters, and the depth of the house is 4 meters. H shaped steel is used in both frame and frame beams. The steel strength used in this paper is Q235. The yield strength of steel Q235 is eaqul to 235MPa and the limit strength of the steel is equal to 420MPa. The finite element software ABAQUS is used to set up the analysis model for numerical simulation. The rod parts are Beam element, and the steel constitutive model adopts the double fold line strengthening model. In the process of numerical simulation, the bottom of the structure is considered at the fixed end. Horizontal load is applied in the form of inverted triangle along the side of the side. Standard analysis method is used.The finite element model is set up as shown in Figure 1.

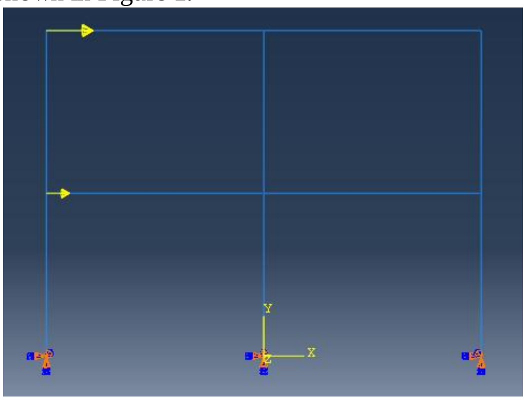

Fig.1 Finite element model of steel frame structure

3. MODAL ANALYSIS

When the initial defect is introduced according to the uniform modal defect method, firstly the buckling mode analysis of the rod is required. According to the characteristics of the critical state, the instability form can be divided into instability of branch point and instability of extreme point. The first type of instability is idealized structure, that is, the structure reaches a certain load, in addition to the original balance exists, there may be a second equilibrium. It is also known as the branch point instability or equilibrium bifurcation instability. It is also known as eigenvalue buckling. The corresponding load with structural instability can be referred to as the buckling load or the critical load. For example, the instability of the imperfect center compression column, the plate under pressure in the middle surface and the pressed cylindrical shell all belong to the first kind of instability. The second kind of instability is that when the structure is unstable, the deformation develops very large, and there is no new form of deformation. That is, the equilibrium state does not undergo qualitative change. This instability is also called the extreme point instability.The corresponding load of the destabilization is called the crushing load or the limit load. The first four order modes of the buckling mode analysis are shown in Figure2. Eigenvalues of buckling mode are shown in table1.

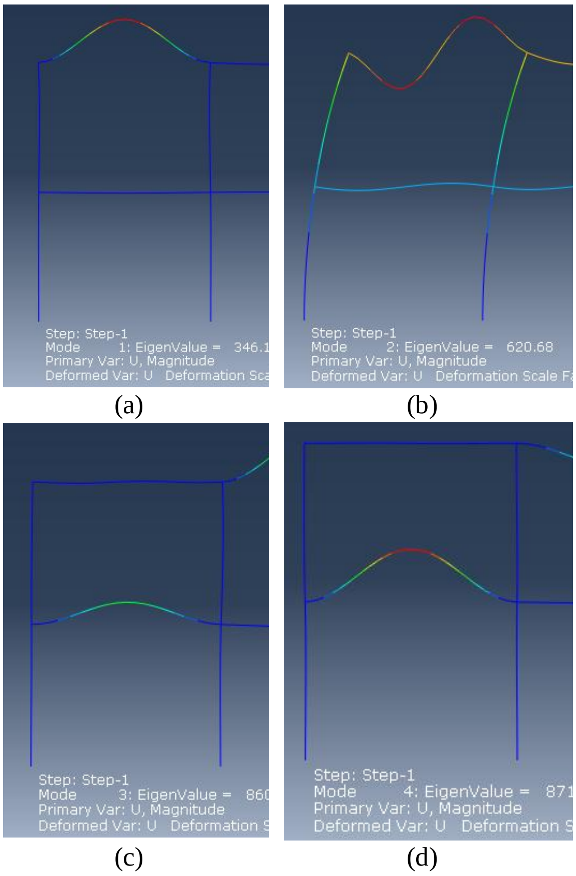

Fig.2 Buckling modes

Table 1. eigenvalues of buckling mode

Yield orders	First order eigenvalue	Second order eigenvalue	Third order eigenvalue	Fourth order eigenvalue
eigenvalue	346.17	620.68	860.03	871.81

4. PUSHOVER ANALYSIS

The static elastoplastic analysis methor (pushover analysis) is one of the most important methods to analyze the seismic performance of the existing structures. By gradually adding horizontal load or horizontal displacement along the height to the structural model, the structure will be pushed to the target displacement or collapse mechanism. In the process of nappe, the whole deformation and local plastic deformation, the failure sequence of the component and the weak parts of the structure can be clearly displayed. At the same time, the relation curve of the force and deformation of the whole structure under the action of earthquakewhich is the curve of the nonlinear reaction capacity, can be obtained. Thus, the seismic performance points of the structure can be obtained. It can be used as the basis for earthquake damage evaluation and seismic design. For slender structures, the effect of initial defects on the bearing capacity of the structure can not be ignored. In this paper, the initial defect is introduced by the uniform defect mode method. The research object is divided into three working conditions. Specific classifications are detailed in Table 2. The pushover curve is shown as shown in Figure 3.

Table 2. Working condition types

condition types	working condition1	working condition2	working condition3
Features	No consideration of initial defects	First four order buckling modes are introduced as initial defects(The defect factors are in turn 0.005,0.003,0.001and 0.0005)	First four order buckling modes are introduced as initial defects(The defect factors are in turn 0.5,0.3,0.1and 0.5)

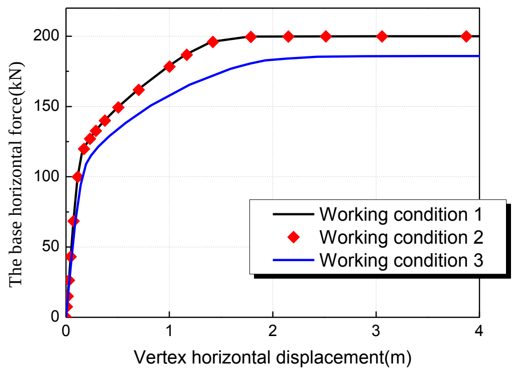

Fig.3 Vertical axial force - vertex horizontal displacement

5. CONCLUSION

A conclusion can be drawn from the pushover curve shown in Figure 3:

(1) The effect of initial defects on the bearing capacity of the overall structure is almost negligible when the impact factor of the initial defect is small.

(2) When the influence factors of the

first four order initial defects are 0.5, 0.3, 0.1 and 0.5, respectively, the yield bearing capacity is reduced by 12.5%, the ultimate bearing capacity is reduced by 8.5%.

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