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Finite Element Analysis of Axial Compression Performance of Lean Magnesium Ore Concrete-filled Steel Tube

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Abstract

Using lean magnesia ore as coarse aggregate inside CFST to make lean magnesia concrete to replace the original concrete can effectively reduce building pollution and ensure the sustainable utilization of resources without greatly reducing the bearing capacity of CFST columns. Rong Xiuqiang, Xie Jing established a theoretical model to study the bearing capacity of CFST filled with special aggregates under axial compression. decreased, but the strength-to-weight ratio of the column gradually increased. Chen Zongping and others conducted an experimental study on the eccentric pressure performance of circular CFST short columns, and analyzed the effects of eccentricity, coarse aggregate replacement rate, slenderness ratio and other factors on the peak load of short columns. Li Bin, Liu Wenyuan Wen Shuqing Liao Xu and others conducted experimental research and finite element analysis on the seismic performance of circular concrete-filled steel tubular columns, and analyzed the yield strength of steel tubes, compressive strength of concrete, and steel The influence of factors such as ratio and slenderness ratio on the bearing capacity, ductility, lateral stiffness and energy dissipation capacity of the column, and suggestions for the selection of relevant parameters are put forward. In this experiment, the ABAQUS finite element software was used to establish a model of CFST with poor magnesium ore, and the influence of the axial compression performance of the short column of CFST with poor magnesium ore was studied. The results show that, within a certain range, the use of lean magnesium ore as coarse aggregate to make high strength concrete with lean magnesium ore instead of the original concrete will reduce the bearing capacity of CFST. But to a certain extent, the effect of low-carbon environmental protection can be achieved.

Keywords

Concrete-filled Steel Tubular Column; Lean Magnesium Ore; Axial Pressure; Bearing Capacity; Finite Element Analysis.

1. Finite Element Method Calculation Process

The process of using ABAQUS analysis to calculate high-strength CFST with magnesium-lean ore is as follows:

1) Establish model (steel tube, concrete).

2) Define material properties (the steel tube constitutive model uses a five-line segment model that conforms to the VonMises curvature criterion; the core concrete uses a Han Linhai's constitutive relation model).

3) Define assembly parts.

4) Define mesh division (see Figure 3 and Figure 4 for mesh division diagrams).

5) Define contact (see Section 2.4 for the direct interface model between steel pipe and magnesium-poor concrete: Interaction).

6) Define the analysis step.

7) Define boundary conditions and loads (boundary conditions: one end is fixed; the load is to apply a concentrated load directly at the loading point to couple the loading point to the loading surface).

8) Post-processing.

1.1 Determination of Constitutive Relations of Concrete

The determination of the steel and core concrete constitutive models directly affects the post-processing analysis results. At present, the existing structural models have not been fully proved in practice, and their constitutive relations are not universal. Therefore, further research is needed to find a constitutive model suitable for the steel-tube lean magnesia high-strength concrete in this paper. The constitutive model of the lean magnesium ore concrete is mainly used by Han Linhai [8-9]. After the calculation, analysis and inspection of a large number of concrete-filled steel tubular cases, the constitutive relationship model applied in the ABAQUS finite element software is determined as follows:

$$y=\begin{cases} 2x-x^2 & (x\le 1) \\ \dfrac{x}{\beta_0(x-1)^{\vartheta}+x} & (x>1) \end{cases}$$

in the formula:$x=\frac{\varepsilon}{\varepsilon_0}$ $y=\frac{\sigma}{\sigma_0}$;

$$\sigma_0=f_c',\ \varepsilon_0=\varepsilon_c+800\xi^{0.2}10^{-6},\ \varepsilon_c=(1300+12.5f_c')10^{-6},\ \vartheta=2,\ \beta_0=(2.36\times 10^{-5})^{[0.25+(\xi-0.5)^7]}(f_c')^{0.5}0.5\ge 0.12$$

In the above formula, the compressive strength of the concrete cylinder (f_c') is in N/mm. ξis the constraint effect coefficient, and the Poisson's ratio of the magnesium-lean high-strength concrete is taken as 0.3. is the compressive strength of concrete cylinders.

1.2 Determination of Steel Constitutive Relation

In the finite element calculation model, the 30mm steel pipe and the 3mm Q235 type ordinary mild steel thin-walled steel pipe are certified by the quality certificate of Tianjin Youfa Company Tangshan Youfa Steel Pipe Production Company, and the result data is consistent with this.

2. Finite Element Modeling

Using ABAQUS finite element software to simulate the experimental system, and by debugging different material parameters and their simulation parameters, to obtain relevant data, changes and simulation results after damage.

2.1 Build the Model

As shown in Figure 1, a model of lean magnesium ore CFST was established for axial compression test. The specimen was subjected to axial compression test with a length of 300 mm, a cross-sectional diameter of 100 mm, and a 3 mm rear wall of the tube. Figure 2 shows. The test piece selected Q235 steel pipe and concrete with poor magnesium ore as coarse aggregate as the raw materials for making concrete filled with poor magnesium ore concrete.

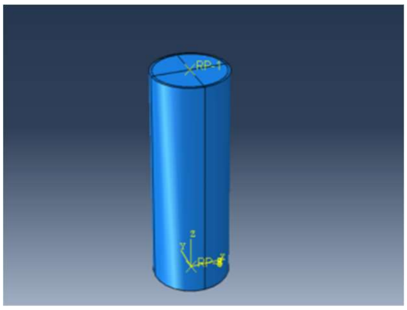

Figure 1. CFST model

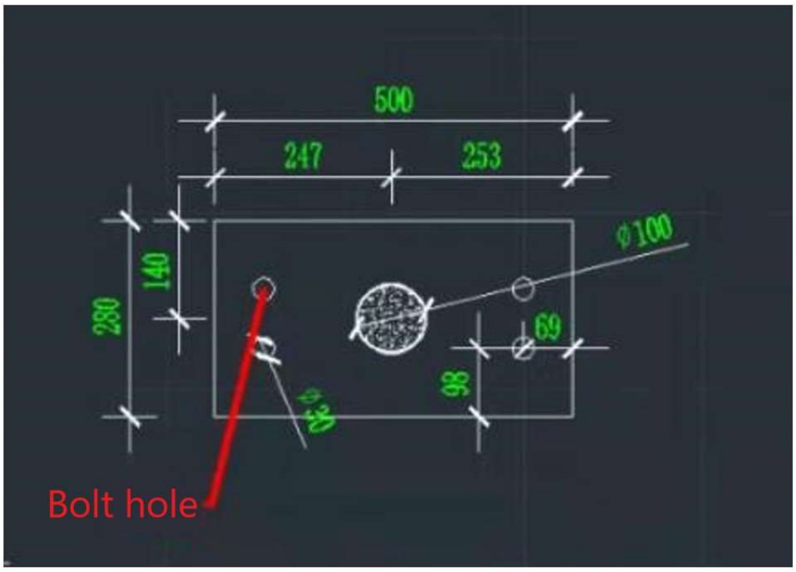

Figure 2. Sectional top view of prefabricated member

2.2 Element Selection and Meshing

The simulated magnesia-depleted concrete and the external steel pipe are all performed using an eight-node hexahedral reduced-integration element (C3D8R). The experimental models are all solid elements, and the elastic modulus is adjusted to 206000Pa and the Poisson's ratio to 0.3 in the material property setting of the steel pipe. The material properties of ore concrete are selected with reference to the actual data in the experiment. The degree of meshing directly affects the accuracy of the conclusion and the calculation speed. We use hexahedral meshes for meshing this time, and the density of the meshes is distributed according to the overall size, as shown in Figure 3 and Figure 3. 4 shown.

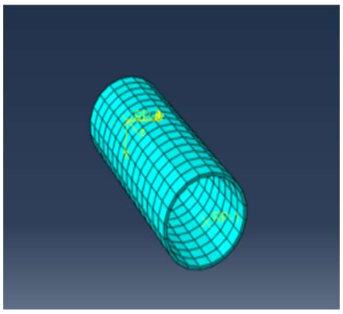

Figure 3. Mesh division diagram of steel pipe model

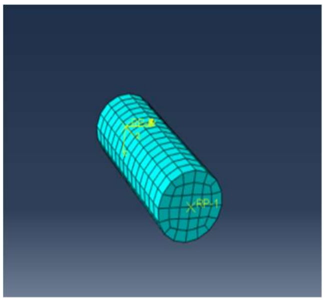

Figure 4. Meshing diagram of concrete model

2.3 Analysis Part Setting

Preliminary models were generated using static conventional analysis, but this did not yield accurate results compared to the samples. This is due to the type of analysis section, which is difficult to converge due to contact or material complexity, resulting in a large number of iterations. Conversely, if the analysis step used in each finite element model is a dynamic display, by using this step, the computation time is obviously shorter than the static general step, because the new system of equations is computed without iteration, and the system matrix The update of is performed at the end of each time section.

2.4 Interaction

The interface model between the steel pipe and concrete is not easy to determine. After checking the data and synthesizing the research results of various scholars, and considering the interface bonding force and the friction between the core concrete, the friction coefficient μ is in the range of 0.2-0.6. In the simulation process, the surface-to-surface contact is adopted between the two. After the calculation, the normal direction is determined to be hard contact, and the tangential friction coefficient is taken as 0.4.

3. Analysis of Simulation Results

3.1 Analysis of Failure Form

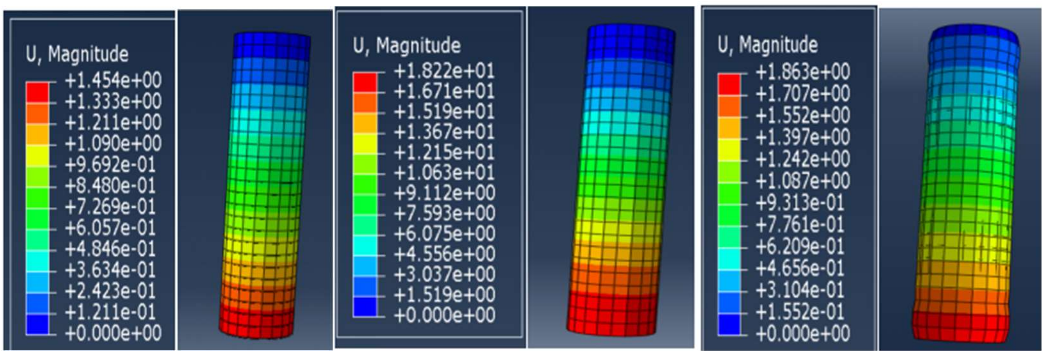

Figure 5. Analysis of failure mode of concrete filled steel tube with lean magnesium ore

Figure 5 is the stress cloud diagram of the final failure shape of the specimen simulated by the above finite element. According to the theoretical analysis, the damage mechanism is: the yield of the outer steel pipe under the stress state, and the damage of the lean magnesia concrete under the three-way force. constitutes strength damage.

4. Conclusion

In this paper, the ABAQUS finite element analysis software is used as the platform, and the appropriate material constitutive model is selected to successfully simulate the axial pressure and force analysis of the circular magnesia-poor CFST. Through finite element simulation, it is confirmed that using lean magnesium ore as coarse aggregate to make lean magnesium ore high-strength concrete to replace the original concrete in a certain range will reduce the bearing capacity of concrete-filled steel tubes, but to a certain extent, it can achieve the effect of low-carbon and environmental protection.

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