Finite Element Analysis of Concrete Filled Steel Tube Flexural Model

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Abstract

In this paper, the finite element analysis of 4 different steels is analyzed. The flexural capacity, deformation capacity, failure mode, failure mode, key position strain distribution and development of concrete filled steel tube with circular cross section are studied. So as to deepen the understanding of concrete filled steel tubular flexural members.

Keywords

Concrete Filled Steel Tube; Flexural Properties; Bending Bearing Capacity.

1. Preface

Concrete filled steel tube is made of steel and concrete composite made of materials, in the loading process, due to the constraint of core concrete filled steel tube, the failure mode from brittle to plastic, the material properties change, significantly increased the strength, plasticity and toughness properties are obviously improved; the core concrete block and delay the premature pipe effectively the occurrence of local buckling, the failure mode from stable control into control of steel strength, improve the stability and ductility, stiffness degradation mitigation, seismic strengthening. The concrete filled steel tube can give full play to the mechanical properties of the two materials, and effectively make up for their respective defects.

At present, many domestic and foreign research on the concrete filled steel tubular compressive members on the bending of circular CFST are relatively less, but in the space truss beam, an upper chord and a lower chord respectively by the axial force of the brace, thereby bending deformation in steel pipe; eccentrically loaded concrete, concrete filled steel tube is also prone to bending deformation. In order to meet the needs of practical engineering, of circular cross-section steel tube concrete flexural bending bearing capacity, bending deformation, and the overall performance of node failure mode, failure mode, strain distribution and the key parts of the development process, to ensure the rationality of steel pipe concrete truss structure safety and technology, study on the mechanical behavior of circular concrete filled steel tubes is very necessary therefore, this paper conducted a series of analyzed and calculated by the finite element model of concrete filled steel tubular flexural members.

2. Finite element model analysis

2.1 Model building

In order to verify the reliability of the test results, the finite element software ABAQUS is used to establish the spatial analysis model of the concrete filled steel tube. The material parameters of concrete and steel ABAQUS in the selection of materials is consistent with the experimental results, the constitutive model of concrete with plastic damage constitutive model, as shown in Figure 1, the model for uniaxial loading, cyclic loading and dynamic loading, and has a better convergence; using the elastic linear hardening steel the constitutive model, as shown in figure 2.

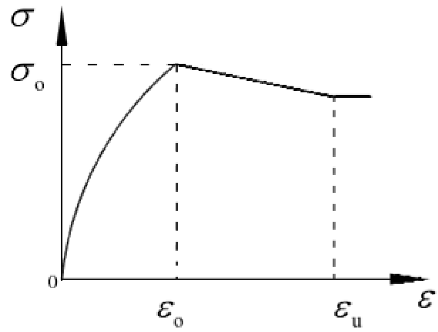


Figure 1: Plastic damage model of concrete

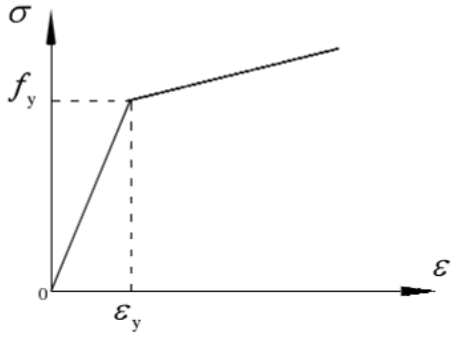


Figure 2: Steel elastic linear constitutive model

Cross model using single point loading method, in order to prevent stress concentration appears in the process of loading pipe, steel sheet set in the branch end plate load simulation, in order to increase the contact area, loading plate is made of rigid analytic (Analytical rigid) simulation, between the loading plate and pipe contact surface through the load transfer, loading mode for the displacement loading, and between steel pipe and concrete pipe head and pipe (including pipe steel and concrete), charge between steel tube and concrete through binding constraints (Tie) connection. The bearing constraint of transverse and vertical translational displacement, vertical translational and rotational restraint all release. In solving the nonlinear equations, considering the material nonlinearity of steel and concrete, boundary conditions of nonlinear problem of geometric nonlinearity and the interface between steel and concrete in the process of stress caused by the change of contact conditions, the incremental iterative hybrid method for solving.

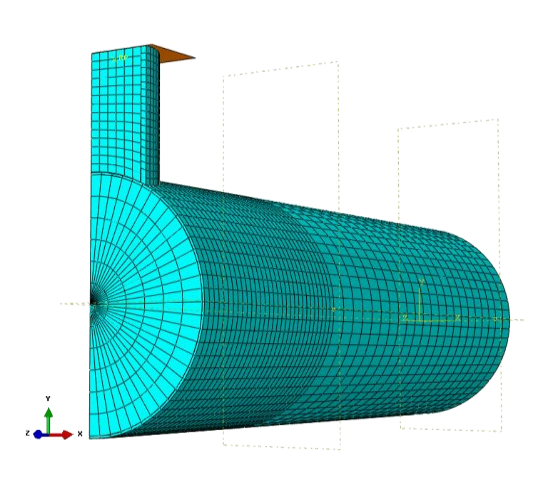
In the selection of unit type, steel and concrete are made of 8 hexahedron intetgrated unit C3D8R, the unit has the following advantages: 1, to solve the displacement results more accurate; 2, mesh distortion, the analysis precision will not be greatly affected; 3, under bending load is not prone to shear locking. The unit can be used to simulate the generation of large mesh distortions and is suitable for large strain analysis.

According to the parameters of the above model, the mechanical properties of concrete filled steel tube with different steel ratio are calculated. based on four kinds of different steel ratio to do the comparative calculation.

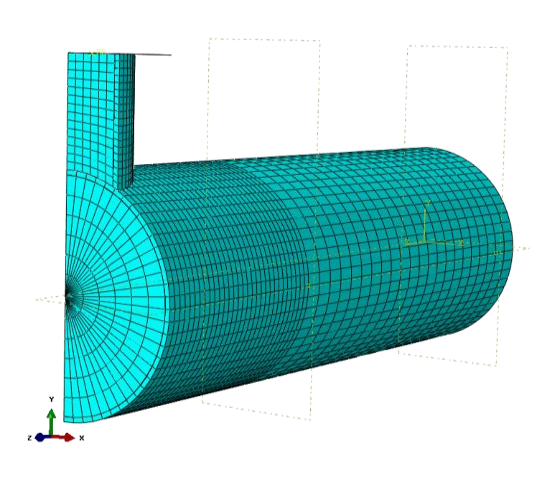
Table1: The thickness of steel tubes with different steel ratio

Steel ratio	0.04	0.09	0.15	0.21
Corresponding thickness of steel tube（mm）	2.14	4.64	7.42	10

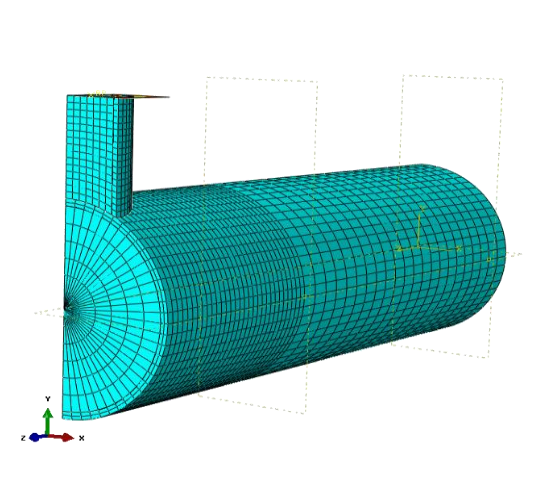
Because the concrete nonvoid tube no slip or slip is negligible, so with no slip model of concrete filled steel tube with different steel ratio. In order to improve the calculation speed, the geometry model of the bending element and the symmetry of the load boundary condition are used to simulate the 1/4 model, and the mesh of the finite element model is shown in Figure 3.



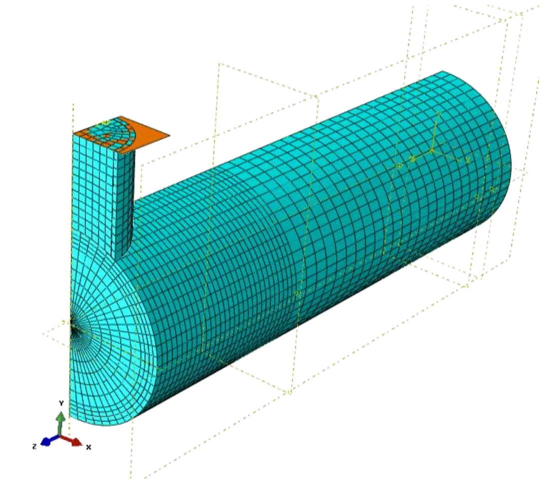
a. 2.14mm thick steel tube concrete



b. 2.14mm thick steel tube concrete



c. 2.14mm thick steel tube concrete

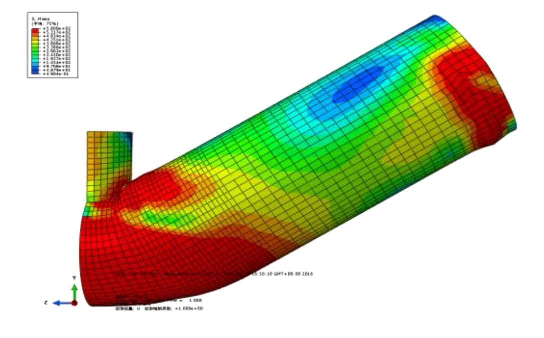


d. 2.14mm thick steel tube concrete

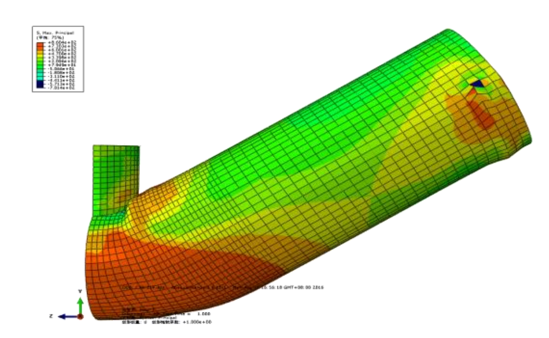
Figure3: Finite element model of concrete filled steel tube with different steel ratio

2.2 Finite element model results analysis

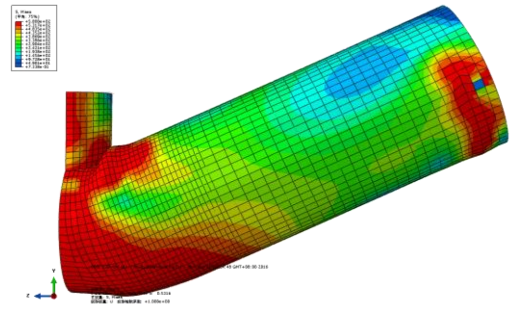
The finite element model is shown in Figure 4.



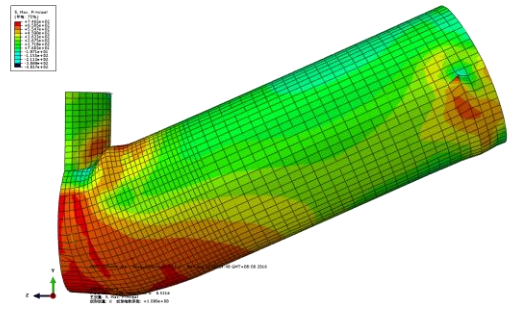
a1. Stress cloud image of 2.14mm thick steel tube



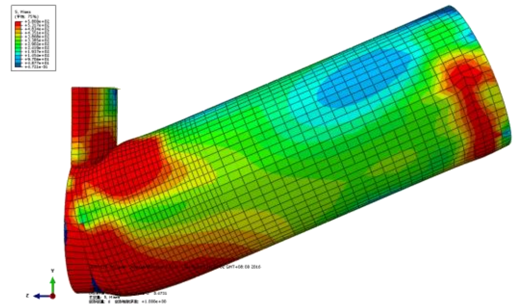
a2. Maximum tensile stress of 2.14mm thick steel tube concrete



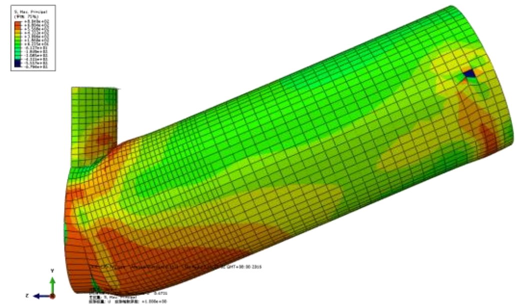
b1. Stress cloud image of 4.64mm thick steel tube



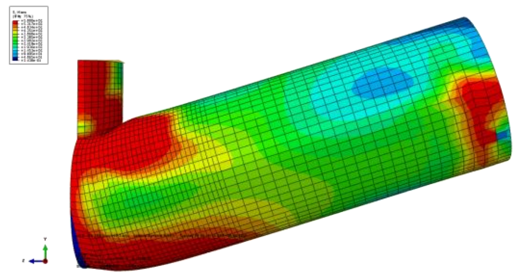
b2. Maximum tensile stress of 4.64mm thick steel tube concrete



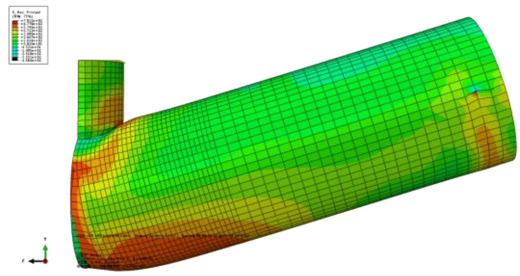
c1. Stress cloud image of7.42mm thick steel tube



c2. Maximum tensile stress of 7.42mm thick steel tube concrete



d1. Stress cloud image of 10mm thick steel tube



d2. Maximum tensile stress of 10mm thick steel tube concrete

Figure4: Deformation diagram and part of the finite element model of concrete filled steel tube with different steel tube thickness

Finite element peak load, deflection of the specimen of the comparison of calculated results are shown in Table 2, table P_y said steel pipe concrete yield load, P_u limit bearing capacity of concrete filled steel tube, δ_y said calculated value of the corresponding span deflection of P_y, δ_u said Calculated value of the corresponding span deflection of P_u.

Table 2: Comparison of the results of finite element analysis of concrete filled steel tube with finite element method

Steel ratio	0.04	0.09	0.15	0.21
P_y (t)	20.28	35.69	50.83	62.93
δ_y(mm)	2.72	2.64	2.58	2.54
P_u (t)	33.47	64.89	96.70	124.44
δ_u(mm)	39.79	50.00	31.65	32.04

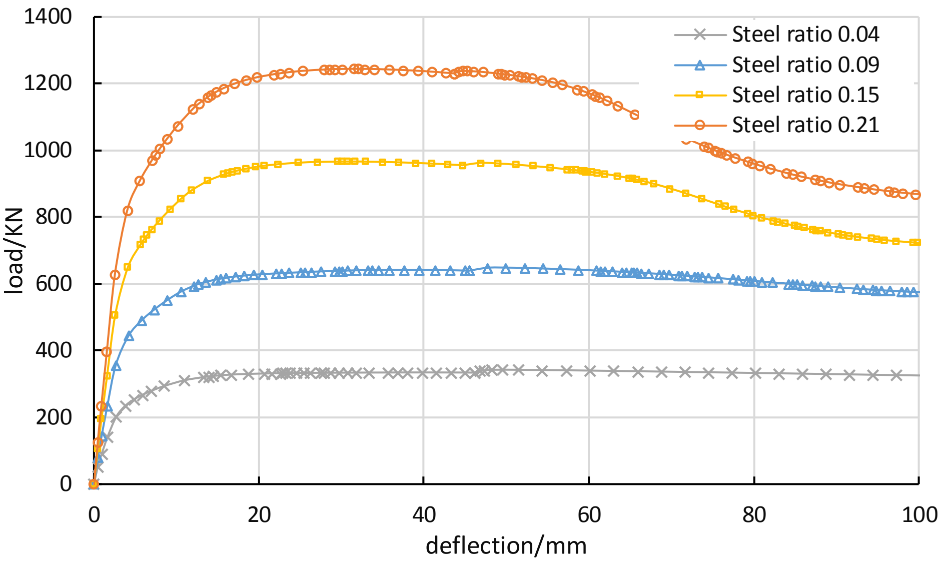


Figure 5:Load deflection curves of concrete filled steel tubes with different steel ratio

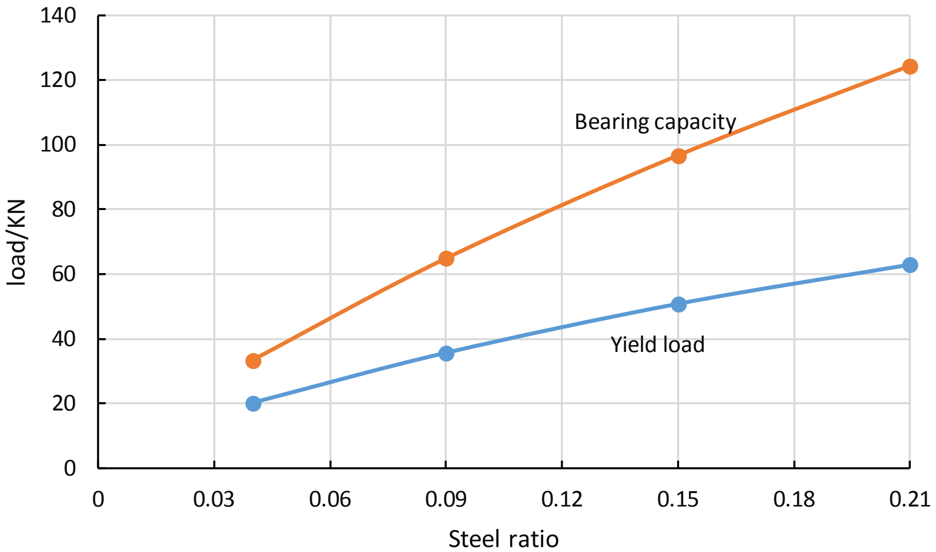


Figure 6: Comparison of yield load and bearing capacity of concrete filled steel tube with different steel ratio

By the above analysis results, it is known that the higher the steel ratio, the higher the bearing capacity and bending rigidity of the steel tube with a certain diameter. As can be seen from figure two, the bearing capacity and yield load of the 4 straight lines are not parallel, which shows that with the increase of the steel ratio, the bearing capacity increases faster than the yield load.

3. Conclusion

According to the above research and analysis, we can draw the following conclusion in the range of the parameters studied:

(1) Under the condition that the outer diameter of the steel tube is certain, the higher the steel ratio, the higher the bearing capacity and bending rigidity are.

(2) Under the above 4 kinds of steel ratio, With the steel ratio of 0.21 as the benchmark, the bearing capacity of concrete filled steel tubes with 0.04. 0.09 and 0.15 has reduced 73.1%. 47.9% and 22.3%.

(3) The flexural stiffness of the specimens has a great influence on the bending stiffness, the higher the steel ratio, the greater the flexural rigidity.

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