Finite Element Analysis of Deformation Effect of Concrete Filled Steel Tubular Composite Frame under High Temperature

Yucheng LI1, Wei WANG2, Xing WANG3
(School of mechanical engineering, anhui sanlian university, hefei 230601, China)
*Corresponding author’s e-mail: kyc@slu.edu.cn

Abstract. The research on the mechanical characteristics of concrete-filled steel tubular composite frame under high temperature is one of the hot topics. In this paper, through the finite element simulation software, the failure characteristics of the deformation of concrete-filled steel tubular composite frame and the simulation results of the deformation effect of concrete-filled steel tubular composite frame structure are analyzed, including the effect of each component in different temperature fields, different structural fields and various coupling fields, the redistribution and change of the local plastic region of the component under high temperature, and the change of the local plastic region of the component under high temperature. The comparative analysis of the flexural effect of two-story two span concrete-filled steel tubular composite frame under different fire positions shows that: with the rising of fire time, the vertical displacement is also increasing, the scope of local plastic area is expanding, the deflection redistribution is obvious, and finally the mechanism is formed, and the failure occurs. The deformation effect of condition 1 changes more than that of condition 2, which indicates that the two-story two span steel tubular composite frame has a large deformation effect. The fire resistance of concrete-filled tubular composite frame is better under the condition of full section fire. The research results can provide reference value for strengthening and repairing of concrete-filled steel tubular composite frame under high temperature.

1. Introduction
The steel tube concrete composite frame is widely used in contemporary buildings[1]. The unique shape gives people a beautiful appearance. At the same time, with the increase of building types, new building materials and technologies appear, which has accelerated the development of modern buildings. Incidents frequently occur, and the concrete-filled steel tube composite frame is poor in fire resistance. Experts [2-6] have also realized the importance of the concrete-filled steel tube composite frame in fire resistance research, and thus invested a lot of time and money in the concrete-filled steel tube composite frame. The research not only analyzed the mechanical characteristics of the concrete-filled steel tube composite frame under a single factor, but also analyzed the mechanical performance of the multi-factor coupling. Especially, Li Guoqiang and Xu Lei made relevant research on the concrete-filled steel tube composite frame [7-8]. The comparative analysis of the deflection effect of the two-story, two-span concrete-filled steel tube composite frame under different fire positions has reference value for further research on the concrete-filled steel tube composite frame under high temperature fire environment.
2. Numerical calculation of flexural deformation of steel tube concrete composite frame under high temperature fire environment

2.1. Model working conditions
The two-story, two-span concrete-filled steel tube composite frame structure has a frame beam of 12m in length and a column height of 8m in each story. The steel tube concrete composite frame is Q235, the beam section is HN700×500, the column section is HW600×600, and the steel tube in the column is HW500×500. A uniform load is applied to the steel tube concrete composite frame beam. The calculation process is as follows:
Condition: Two-story, two-span concrete-filled steel tube composite frame structure with frame beams of 12m in length and 8m height of each column. Thermal-mechanical coupling finite element analysis of the whole steel tube concrete composite frame is carried out, and the deflection deformation effect of the concrete-filled steel tube composite frame is obtained.

![Figure.1 Calculation model of a two-story, two-span concrete-filled steel tube composite frame](image)

2.2. Model analysis
Through the finite element numerical simulation, the deflection cloud diagrams of the two-story, two-span concrete-filled steel tube composite frame under working conditions at different temperature moments are obtained:
Figure 2. Vertical displacement cloud diagram of concrete-filled steel tube composite frame at 3600s in working condition

As the temperature continues to rise, first, the horizontal plastic strain at the concentrated load continues to increase, the vertical displacement also continues to increase, the local plastic area continues to expand, and the deflection and deformation are redistributed significantly. The redistribution of the deformation is more obvious, and the mechanism is finally formed, and the damage occurs. The deflection effect of the working condition one is greater than that of the working condition two, indicating that the two-story, two-span steel tube concrete composite frame has a better deflection effect under the full-section fire.

3. Conclusion
In this paper, through the analysis of the finite element simulation results of the deflection deformation of the single-story single-span and two-story two-span concrete-filled steel tube composite frame under a high temperature fire environment, the following conclusions are obtained:

(1) The redistribution of the displacement of each beam and column is obvious, and the deflection effect of working condition one is larger than that of working condition two, which shows that the deflection effect of the two-story, two-span concrete-filled steel tube composite frame is better under the full-section fire.

(2) Through the thermal-mechanical coupling numerical simulation of the single-story single-span and two-story two-span concrete-filled steel tube composite frame under different fire positions, the flexural deformation effect of the concrete-filled steel tube composite frame under the thermal-mechanical coupling analysis is obtained. The reinforcement and repair of the steel tube concrete composite frame under the fire environment provides reference value.

Acknowledgment
Fund projects: Natural science research projects in Anhui Universities (KJ2020A0805), provincial natural science research project of anhui universities (KJ2014ZD06), anhui natural science fund (1408085QE96), academic support project of top academic talents of anhui universities (gxbjZD56).
About the author: li yucheng (1994 -), male, born in suzhou, anhui province, master's degree, teaching assistant, mainly engaged in research on fire resistance theory and safety assessment of steel structure, Email:947080764@qq.com.

References
[1] Xia Yunchun, Xu Zhengchao. The effect of rapid cooling of fire extinguishing spray water on the failure behavior of high-temperature steel tube concrete composite frame structure in fire[J]. Steel Structure, 2017, 32(09): 115-123.
[2] Lei Min, Shen Zuyan, Li Yuanqi, Luo Jinhui. Research status of special-shaped concrete-filled steel tube columns[J]. Structural Engineer, 2013, (03): 155-163.
[3] Ding Rui, Liu Haowu, Hou Jing, Shen Guoqing. Research on Nondestructive Testing Technology of Concrete Filled Steel Tubes for Arch Bridges[J]. Piezoelectricity and Sound and Light, 2004, (06): 447-450.
[4] Jing Yatao. Research on the fire resistance of concrete-filled steel tube frame with special-shaped columns[D]. South China University of Technology, 2009.
[5] Wang Jin. Study on the fire resistance of eccentrically compressed thin-walled concrete-filled steel tube columns [D]. Huaqiao University, 2009.
[6] Feng Chengyuan, Li Guoqiang, Jiang Binhui. Research on the influence of steel high temperature material properties model on the collapse simulation of concrete-filled steel tube composite frame structure under fire[J]. Engineering Mechanics, 2019, 36(12): 24-36+78.
[7] Zhang Xuan. Experimental study on fire resistance of full-scale reinforced concrete portal frame structure [D]. Central South University of Forestry and Technology, 2015.
[8] Hu Renxi, Kang Shiting, etc. ANSYS 13.0 civil engineering finite element analysis [M]. Beijing: Mechanical Industry Press, 2012.