ISSN: 0974-5823 Vol. 7 No. 3 March, 2022

International Journal of Mechanical Engineering

Behavior assessment of concrete filled slender steel tube columns under axial compression

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ABSTRACT

In recent years, the use of slender steel tube columns filled with concrete (SCFST) has been developed due to their good performance. This study evaluates the ultimate strength of slender steel tube columns filled with concrete under axial compression using the three-dimensional finite element method. The effect of some parameters on the ultimate strength, such as the compressive strength of concrete, the yield stress of steel, and the slenderness ratio on circular cross-section, was studied. Concrete's damage plasticity was adopted, while steel elastic-plastic was considered perfectly. The study showed that increasing the strength of concrete leads to an increase in the bearing capacity of the column, but at the same time, it causes a decrease in ductility. From the results obtained, increasing the yield stress leads to an increase in the ultimate strength of the column while causing a decrease in ductility. When the slenderness ratio is increased, (which means an increase in the length) leads to a decrease in the ultimate capacity of the column and decreasing this percentage causes an increase in the ultimate capacity of the column.

Key words; slender columns SCFST, 3D analysis, ABAQUS.

1. INTRODUCTION

One of the important things in making engineering decisions is how to choose materials that can been used in engineering facilities. The controlling side in this matter is the type of facility and the economic aspect with achieving the best performance for the facility. The two main structural material used in the world are steel and concrete, as the benefits of using both materials are well known. Concrete is stiff, cheap and good for fire-resistant while steel is strong, ductile and lightweight. The intelligent combination of these two materials results in a structural system that is more efficient than the use of the component individually. The composite system of these two materials has been successful in the works of columns, bridges and slabs. In recent years, concrete-filled slender steel tubes (SCFST) has been increasingly used in high-rise buildings and other types of structures such as bridges because of their advantages compared to ordinary steel or reinforced concrete columns. Due to the positive influence of the composite, and compensate for defects of the use of two different materials.

A number of researchers carried out experimental and analytical studies to investigate the response of CFST columns under different loading conditions. These studies provided extensive data for some design codes in order to develop design approaches and applications of composite columns such as the EC4[1] and the AIC code[2]. The finite element method has the ability to effectively simulate the behavior of the columns, making the results close to reality. However, the finite element method is greatly affected by the modeling method for each of the materials used in the column composition, such as steel and concrete.

Schneider [3] in 1998 investigated the effect the shape (circular, square and rectangular) on the behavior of the short concrete filled steel tube columns CFST under concentric load in compression to failure. The results obtained showed that the composite circular columns provide better confinement, stiffness and ductility compared to square and rectangular columns. Giakoumelis and Lam (2004) [4] presented an experimental study on the behavior of steel columns filled with concrete with different concrete resistance under axial load taking into account the bonding strength between concrete and steel as well as the confinement that steel tube provides on concrete. The study concluded that the effect of increasing the strength of concrete makes the bond strength between concrete and steel tube more critical. Gupta et al. [5] (2007) presented an experimental and analytical study on behavior of the Center-loaded Circular CFST Columns. They produced a nonlinear FEM to estimate the ultimate capacity of such columns. They found that when the diameter to thickness (D/t) ratio is small, the steel tube provides good confinement on the concrete and the bearing capacity of the column decreases with the increase of the D/t ratio. In addition the CFST columns that fail mainly with local buckling, the increase in the strength of the concrete lead to a decrease in the impact of confinement on the concrete core. Dundu [8] in 2013 study the behavior of 24 specimens of concrete filled steel tubes CFST columns experimentally loaded concentrically under compression to failure. He compared his experimental results with those was predicted by the South African Code (SANS10162-1) and EC4, shows that the Codes are conservative by 8.4% and 13.6% respectively . Tao et al. [9] 2013 using a wide range of experimental data to develop refined FE models to simulate CFST stub column under axial compression by using ABAQUS program version 6.12. The simulation system is based on the damaged plasticity material for concrete found in the ABAQUS program. The ultimate strength obtained by previous researchers was compared with that obtained using the finite element program. Whereas conservative predictions were obtained from the finite element model but with reasonable accuracy. Bahrami and Kouhi [12] 2020 studied the compressive behavior of steel tubes filled with concrete with circular, rectangular and square cross-sections. Where they used nonlinear three-dimensional analysis of finite elements to simulate the behavior of columns with the help of the ABAQUS program. They found that the axial-strain-load curves of the columns obtained from finite element analysis are remarkably