Study on axial behaviour of concrete filled steel tubular columns

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Abstract

Concrete-filled steel tube (CFST) columns have gained wide acceptance in the construction of high-rise buildings due to their exceptional ability to withstand axial load. They are commonly employed as columns in large-span high-rise buildings, bridges, and piers. This research aims to investigate the performance of concrete-filled steel tube (CFST) columns when subjected to axial load. One key advantage is that the steel tube serves as a permanent confinement for the concrete. The concrete filling inside the tube prevents local buckling high-rise buildings, bridges, and piers. This research aims to investigate the performance of concrete-filled steel tube (CFST) columns when subjected to axial load. One key advantage is that the steel tube serves as a permanent confinement for the concrete. The concrete filling inside the tube prevents local buckling and enhances the lateral stability of the member. Moreover, the external steel tube acts as a formwork. Eight composite columns were constructed, comprising four CFST columns and four CFDST (Concrete-filled Double Skin Tubular) columns, and were subjected to axial loading for evaluation. The experimental study was conducted to determine the relationship between load, axial displacement, and lateral displacement, as well as the ultimate load-carrying capacity. Furthermore, finite element analysis using Abaqus was performed to investigate the composite columns analytically. A parametric study was also carried out, considering the diameter-to-thickness ratio and grade of concrete. Confinement significantly enhances the load-carrying capacity, and the presence of concrete infill reduces the lateral deflection of long columns.

Introduction

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Introduction

CFST columns, which stand for Concrete-Filled Steel Tube columns, are a type of composite structural element that consists of a steel tube filled with concrete. These columns have gained popularity in the construction industry for high-rise buildings, bridges, and other structures due to their numerous advantages over traditional steel or concrete columns[1] These advantages can be summarized as follows: High Strength-to-Weight Ratio: CFST columns exhibit a high strength-to-weight ratio, enabling them to support heavy loads while using less material. This results in lighter structures and reduced construction costs. Ductility: The combination of steel and concrete in CFST columns provides excellent ductility, allowing them to endure significant deformations without failure. This characteristic makes CFST columns suitable for regions prone to earthquakes. Fire Resistance: CFST columns offer exceptional fire resistance due to the presence of the concrete filling. This ensures that the steel tube remains intact and does not buckle or collapse under high temperatures. Corrosion Resistance: The concrete filling in CFST columns acts as a protective layer, shielding the steel tube from

Ductility: The combination of steel and concrete in CFST columns provides excellent ductility, allowing them to endure significant deformations without failure. This characteristic makes CFST columns suitable for regions prone to earthquakes. Fire Resistance: CFST columns offer exceptional fire resistance due to the presence of the concrete filling. This ensures that the steel tube remains intact and does not buckle or collapse under high temperatures. Corrosion Resistance: The concrete filling in CFST columns acts as a protective layer, shielding the steel tube from corrosion. This feature reduces maintenance costs and prolongs the lifespan of the structure. Design Flexibility: CFST columns can be designed in various shapes and sizes to meet specific structural requirements. The design process involves determining the appropriate thickness, diameter, and length of the steel tube and concrete to ensure the column can withstand the required loads and resist buckling and other failure modes. Despite the many advantages of CFST columns, their extensive adoption in building construction has been limited. This can be attributed to factors such as limited construction experience, inadequate understanding of design requirements, and the complexities associated with connection detailing. As a result, there is a lack of readily constructible joints that can fully

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and concrete to ensure the column can withstand the required loads and resist buckling and other failure modes. Despite the many advantages of CFST columns, their extensive adoption in building construction has been limited. This can be attributed to factors such as limited construction experience, inadequate understanding of design requirements, and the complexities associated with connection detailing. As a result, there is a lack of readily constructible joints that can fully utilize the favourable strength and stiffness properties of concrete-filled tube columns. Additionally, the use of circular hollow sections in structural steelwork is constrained due to the intricate connections required with steel beams, making standard bolting impractical[[3], [5]]. Consequently, costly, and less popular welded connections are often employed as a solution. [23]Zhang et al (2017) concluded that the annular region in CFDST columns improves confinement and enhances the axial load carrying capacity. The cyclic loading [7] is conducted and found that it exhibits significant behaviour for cyclic loading and it's a good alternative in seismic resistance design. [[4], [8]] Numerical Model with the relationship of sandwich concrete and confinement effects were considered by numerical formulations and design formula is relationship of sandwich concrete and confinement effects were considered by numerical formulations and design formula is proposed that matches with the previous experimental results.

The aim of this research is to assess the load-bearing capacity and behaviour of slender composite columns. The study seeks to establish a connection between the Euro Code equation and the findings derived from experimental analysis. Previous studies have predominantly concentrated on short columns that exhibit failure caused by phenomena such as elephant foot buckling or local deformation. However, this study aims to investigate the behaviour of long columns and their bending characteristics[4]

Section snippets

Finite element analysis

In this study, the finite element modeling was carried out using Abaqus software to create and analyze CFST and CFDST specimens. The results obtained from the analysis were then compared to the experimental findings. The dimensions and properties of the specimens are provided in carried out using Abaqus software to create and analyze CFST and CFDST specimens. The results obtained from the analysis were then compared to the experimental findings. The dimensions and properties of the specimens are provided in Table 1.[[5], [7], [23]]…

Results and discussion

The load carrying capacity obtained from the analysis results and experimental results are similar for CFST and CFDST samples and the results are shown in graph All of the specimens underwent buckling, and their load carrying capacity ceased at a certain point[22], [23], [24].seeTable 3

Where
A Load carrying capacity computed with unconfined compressive strength in kN…

B Load carrying capacity computed as per EC4 in kN…

C Load carrying capacity computed as per equation proposed by patel et al in kN…

D…

…

...

Conclusion

1. The experimental load capacity varied not more than 10% with the theoretical equation proposed by Patel et al and not more than 5% for Analytical results.…
2. The experimental Results and EC 4 varied by 15–20% as the EC4 takes additional safety factor.…
3. All CFST columns displayed substantial deformation after reaching a specific load, indicating a lack of sudden failure commonly observed in traditional RCC structures.…
4. Confining the concrete allows for a maximum ultimate strain exceeding 0.0035, thereby …

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Future works

1. Additional investigation is required to examine the bond between the steel tube and concrete for the purpose of evaluating the bond stress.…

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1. Additional investigation is required to examine the bond between the steel tube and concrete for the purpose of evaluating the bond stress.…
2. Incorporating shear studs within the steel tube can bolster bonding and facilitate enhanced interaction between the steel and concrete components.…
3. Future research endeavours can focus on investigating the Effective Moment of Inertia for the composite columns…

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CRediT authorship contribution statement

J.R. Srihari: Conceptualization, Methodology. **S. Sharmila:** . **S. Praveen Kumar:** Writing – review & editing.…

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

J.R. Srihari: Conceptualization, Methodology. **S. Sharmila:** . **S. Praveen Kumar:** Writing – review & editing.…

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References (21)

L.-H. Han *et al.*

Concrete-filled double skin steel tubular (CFDST) beam-columns subjected to cyclic bending

Eng. Struct. (October 2006)