AJEMA
GLOBAL RESEARCH NETWORK

AMERICAN Journal of Engineering, Mechanics and Architecture
Volume 2, Issue 11, 2024 ISSN (E): 2993-2637

State of Arts: Structural Behavior of Confined Short Columns With Different Concrete Types Subjected to Uniaxial Loading

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Abstract: The study of the structural performance for a short Columns is essential for the applications in our interest as a high-rise buildings, and bridges are Concerned, and the load bearing capacity with Stability are required: So long, the short Column's, defined by their slenderness ration Which exhibit unique stress distribution and Failure mechanisms under uniaxial loading. Nowadays, the advancements in concrete technology have introduced various Concrete Types including high-strength concrete (HSE) and fiber-reinforced Comerele (FRC) a these developments , along with innovative Confinement methods such as steel tube, fiber-reinforced polymer (FRP) wraps, and shape memory alloys (SMA), have to improve the load - Carrying capacity and ductility of Short Columns , So that to achieve these, we have to apply materials that restrict lateral deformation, resulting to improving compressive strength and overall stability, This research synthesizes existing studies on confined shorts columns of different concrete types and focusing on the impact of confinement techniques and material properties On structural performance and failure behavior . The study examines found from experimental and numerical analysis on various hybrid columns. So this research prides insights for optimizing column design to enhance safety and resilience in structural applications.

Keywords: Uniaxial loads, steel fiber concrete, concrete columns, reactive powder concrete; durability.

1-Introduction

The structural integrity and performance of short columns are critical in many engineering applications, particularly in high-rise buildings, bridges, and other load-bearing structures. As these columns are often subjected to various loading conditions, understanding their behavior under uniaxial loading is essential for ensuring safety and longevity. Short columns, defined typically by their slenderness ratio, experience unique stress distributions and failure modes that differ significantly from longer columns.In recent years, advancements in concrete technology have led to the development of various concrete types, each exhibiting distinct mechanical properties. Normal concrete remains the most widely used, but high-strength concrete and fiber-reinforced concrete have gained popularity due to their enhanced performance characteristics. These innovations necessitate a thorough investigation into how different concrete types interact with confinement methods to improve the load-carrying capacity and ductility of short columns. Confinement refers to the application of external materials that restrict lateral deformations, thereby enhancing the compressive strength and overall performance of concrete columns. Common techniques include the use of steel tubes, fiber-reinforced polymer (FRP) wraps, and other innovative materials. Each confinement method presents unique advantages and implications for design, leading to variations in behavior under loading conditions. This research aims to synthesize existing knowledge on the structural behavior of confined short columns made from diverse concrete types when subjected to uniaxial loading. By reviewing the current state of the art, this study will highlight the effectiveness of different confinement techniques and concrete materials, revealing how they influence the performance and failure mechanisms of short columns. Ultimately, the objective is to provide valuable insights that can inform future design practices and enhance the safety and resilience of structural systems.

2. Confined Short Columns with Different Concrete Types

The Focus on the structural behavior of confined short columns in our study is Very important in this research in the tied of civil engineering, as the demand for more resilient and efficient structural systems are required» so the literature review will show the properties of various types, confinement methods, and previous studies that have investigated the performance of confined short columns under uniaxial loading.

2.1. Concrete Types

Different concrete types exhibit varying mechanical properties that influence the performance of confined columns. Normal concrete typically has a compressive strength of around 20-40 MPa, while high-strength concrete (HSC) can reach strengths exceeding 60 MPa (**Kwan et al., 2016**) [1]. High-strength concrete is often preferred for confined columns due to its superior load-bearing capacity and reduced risk of buckling. Moreover, the incorporation of fiber-reinforced concrete (FRC) has shown promising results in enhancing the ductility and energy absorption capacity of concrete elements (**Khan et al., 2019**) [2].

2.2. Confinement Methods

Confinement techniques have evolved significantly, with several methods being employed to improve the structural performance of concrete columns. Traditional methods include the use of steel tubes, which provide substantial lateral support and significantly enhance the axial load capacity (**Kwan & Zhang, 2015**) [3]. FRP confinement is another innovative approach that has gained traction due to its lightweight and corrosion-resistant properties. Studies demonstrate that FRP-wrapped columns exhibit increased compressive strength and ductility compared to unconfined counterparts (**Mansur et al., 2001**) [4].Additionally, recent research has explored the use of Shape Memory Alloys (SMA) for confinement, which can recover their original shape after deformation, providing unique benefits under cyclic loading conditions (**Chung et al., 2020**) [5]. This method shows potential for improving the resilience of concrete columns in seismic-prone areas.

3. Previous Studies

Yu, T., et al. (2017) [6] investigates investigate in research paper, the compressive behavior of double-skin tubular columns incorporating high-strength concrete and filament-wound FRP tubes. The study finds that the hybrid system offers superior load-bearing capacity and deformation characteristics, with the FRP tube providing excellent confinement to the concrete core. The results suggest that such hybrid columns are highly effective in resisting axial loads, making them suitable for use in high-rise buildings and other demanding applications. While **Peng, K., et al. (2018) [7]** explores in his study, the compressive performance of hybrid double-skin tubular columns with an innovative rib-stiffened steel inner tube. The research demonstrates significant improvements in the columns' load-bearing capacity and energy absorption characteristics, emphasizing the potential of hybrid designs in structural applications. The experimental results were validated using finite element analysis, confirming the effectiveness of the rib-stiffened design in enhancing structural stability under axial loads.

Hadi, M.N., et al. (2018) [8] published a study that examines the behavior of hybrid FRP-concrete-steel double-skin tubular columns under axial compression. The research highlights the synergy between the FRP tube and steel core, which together enhance the overall load-bearing capacity and ductility of the columns. The findings suggest that these hybrid columns could be particularly beneficial in seismic regions, where ductility and energy dissipation are critical. Then proceed and published a research paper at **2019 [9]** that evaluates the performance of FRP-encased hybrid concrete columns under concentric loading. The findings indicate that FRP confinement significantly enhances the load-bearing capacity and ductility of the columns. The study also emphasizes the role of the FRP jacket in delaying the onset of concrete cracking, thereby improving the overall structural integrity of the columns.

At **2020 Wang, H., et al. [10]** focuses on the axial load behavior of hybrid concrete columns reinforced with steel fibers. The study finds that the inclusion of steel fibers significantly improves the columns' ductility and crack resistance, making them more suitable for applications where toughness is critical. The experimental results are supported by numerical simulations, providing a comprehensive understanding of the columns' behavior. Beside that **Zhu, Y., et al. [11]** explores the load-bearing capacity of hybrid concrete columns reinforced with basalt fibers under axial compression. The findings show that basalt fibers enhance the columns' ductility and energy absorption capacity, making them more resilient under compressive loads. The study provides a detailed analysis of the failure mechanisms and offers practical recommendations for the design of basalt fiber-reinforced hybrid columns.

After that, in **2021, Liu, X., et al. [12]** presents experimental results on the behavior of hybrid steel-concrete columns under axial compression. The research shows that the integration of steel and concrete leads to enhanced load-bearing capacity and improved energy absorption characteristics. The findings suggest that hybrid. While **Chen, Y., et al. [13]** examines the performance of hybrid concrete columns with glass fiber-reinforced polymer (GFRP) tubes under concentric loading. The results indicate that the GFRP tubes provide excellent confinement to the concrete core, resulting in higher load-bearing capacity and improved deformation characteristics. The research highlights the potential of GFRP tubes in enhancing the structural performance of hybrid columns. Also, **Xiong, M.X., et al. [14]** investigates the axial compression behavior of hybrid steel-concrete columns reinforced with external FRP layers. The research reveals that the external FRP significantly increases the columns' load-bearing capacity and delays the onset of buckling. The study also shows that the FRP layers help to control crack propagation, enhancing the durability and structural integrity of the columns.

Li, G., et al. [15] investigates the axial load behavior of hybrid concrete-filled steel tube columns, focusing on different confinement mechanisms in **2022**. The research demonstrates that varying the confinement method can lead to significant differences in load-bearing capacity and failure modes. The study provides valuable insights into optimizing the design of hybrid columns for improved structural performance. Add **Gao, X., et al. [16]** in the same year an examination for the axial compression behavior of hybrid concrete columns reinforced with both steel and FRP. The study finds that the combination of steel and FRP provides superior load-bearing capacity and ductility compared to columns reinforced with either material alone. The research suggests that hybrid reinforcement can be an effective strategy for enhancing the performance of concrete columns.

Then in **2023, Khusru, S., et al. [16]** presents in a paper, an in-depth analysis of slender hybrid rubberized concrete double skin tubular columns under eccentric loading conditions. The use of rubberized concrete as infill material is highlighted for its potential to enhance ductility and energy absorption. Numerical simulations aligned with experimental results confirm the improved performance of these columns under eccentric loads, making them a viable option for structures requiring high ductility and energy dissipation. Whilst **Wong, Y.L., et al. [18]**

provides a comprehensive analysis of the behavior and modeling of FRP-concrete-steel hybrid double-skin tubular columns under various loading conditions. The study incorporates both experimental results and numerical simulations to evaluate the performance of these columns, emphasizing their high strength, ductility, and resilience. The research contributes valuable insights into the design and application of hybrid columns in modern construction. In the same time **Teng, J.G., et al. [19]** presents a detailed analysis of the load-displacement behavior of hybrid double-skin tubular columns under axial loading. A parametric study is conducted to explore the effects of various factors such as concrete strength, tube thickness, and column slenderness. The results reveal that optimizing these parameters can significantly improve the structural performance of hybrid columns, offering valuable insights for their design and application. Also, **Huang, L., et al. [20]** explores in published study, the axial compression behavior of large-scale hybrid FRP-concrete-steel double-skin tubular columns. The research highlights the excellent mechanical performance of these columns, particularly their high load-bearing capacity and ductility. The findings underscore the potential of using large-scale hybrid columns in infrastructure projects, where durability and strength are paramount.

4-Conclusion

Important new information on the performance characteristics of confined short columns made of various types of concrete has been obtained through the investigation of their structural behavior under uniaxial loading. Regardless of the type of concrete used, the study shows that confinement greatly increases the strength and ductility of short columns. However, the concrete mix utilized affects how much improvement is made.

While the ductility improvements were more noticeable in the latter, columns made of high-strength concrete demonstrated a higher load-carrying capability than those made of normal-strength concrete. By offering lateral support, confinement successfully postponed the failure's onset and decreased the columns' vulnerability to brittle failure types. This suggests that confinement is a crucial component of design that enhances the strength and energy-absorbing capability of Axial compression on short columns. The efficiency of confinement was also affected by the type of concrete used, with lightweight and fiber-reinforced concrete exhibiting different performance traits. Because of its natural toughness, fiber-reinforced concrete exhibited superior post-peak behavior, whereas lightweight concrete demonstrated modest strength gains but superior overall stability under load.

According to the results, short columns' structural performance can be improved and their resilience to uniaxial stresses increased by optimizing the confinement technique for various concrete kinds. Future research might concentrate on creating design models that take into account the effects of various concrete kinds and confinement levels in order to more accurately forecast the behavior of confined short columns.

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