The Hashemite University
Civil Engineering Department

EXPERIMENTAL INVESTIGATION OF SHEAR STRENGTH AND BEHAVIOR FOR RECTANGULAR CONCRETE-FILLED TUBE (RCFT) MEMBERS

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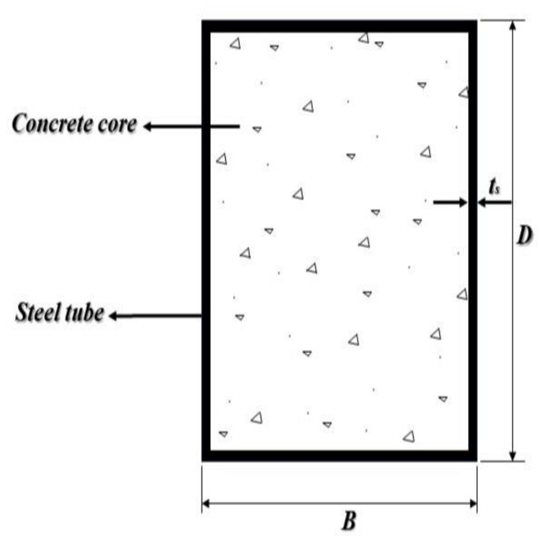
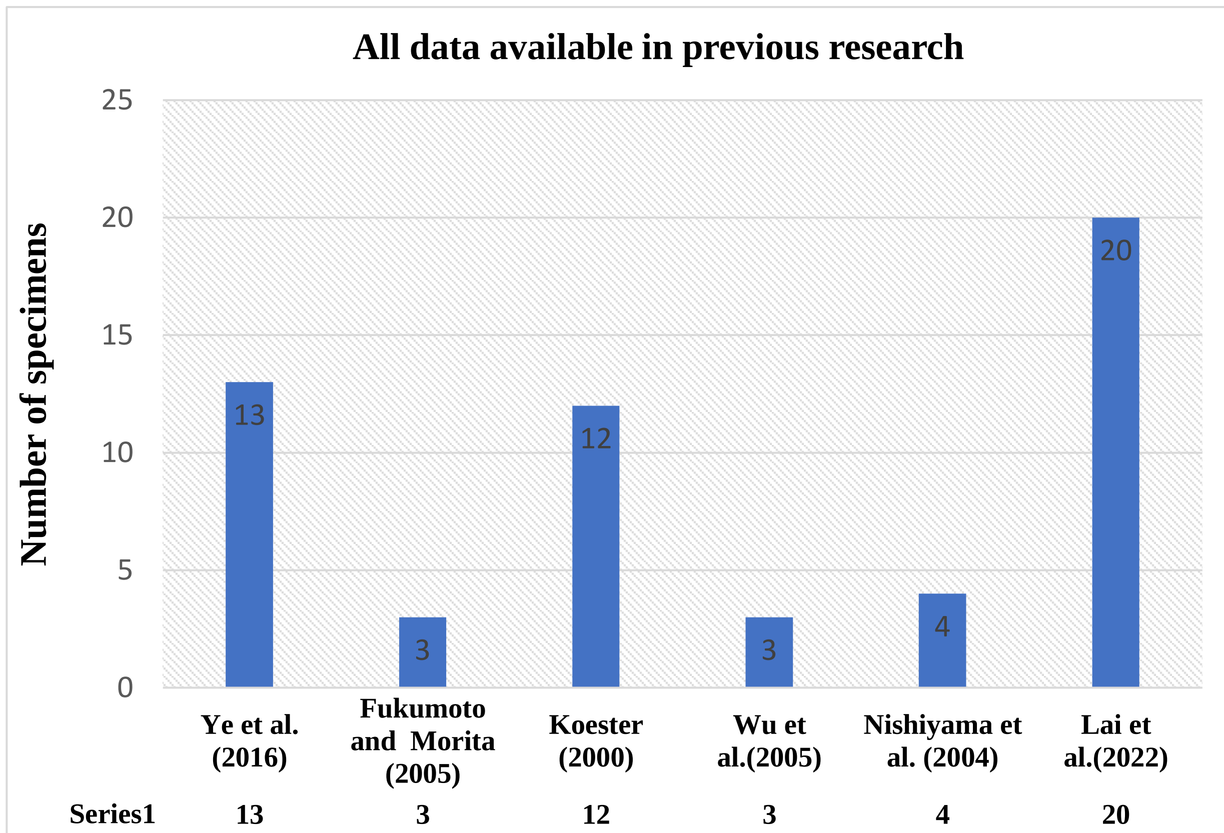
Introduction

In recent years, Concrete-Filled Steel Tubular (CFT) members, a combination of steel tubes and concrete infills, have become popular in construction due to their unique properties. CFTs offer advantages such as ductility, strength, stiffness, and energy dissipation during seismic events. Steel tubes also serve as shoring and formwork during construction, reducing labor costs and project time. CFTs come in various cross-sectional shapes, with circular configurations (CCFTs) gaining attention for their superior attributes, such as concrete confinement and resistance to buckling. Research on Rectangular Concrete-Filled Tubes (RCFTs) has primarily focused on axial and flexural behavior, with limited exploration of shear strength. This investigation aims to advance understanding by conducting new experimental tests on rectangular concrete-filled steel tubes. The study seeks to evaluate material properties' influence on shear strength, propose a design equation, record shear stiffness and strength degradation using various sensors, and compare experimental results with theoretical outcomes based on current design codes. The overarching goal is to contribute valuable data to the field and address existing gaps in the literature.



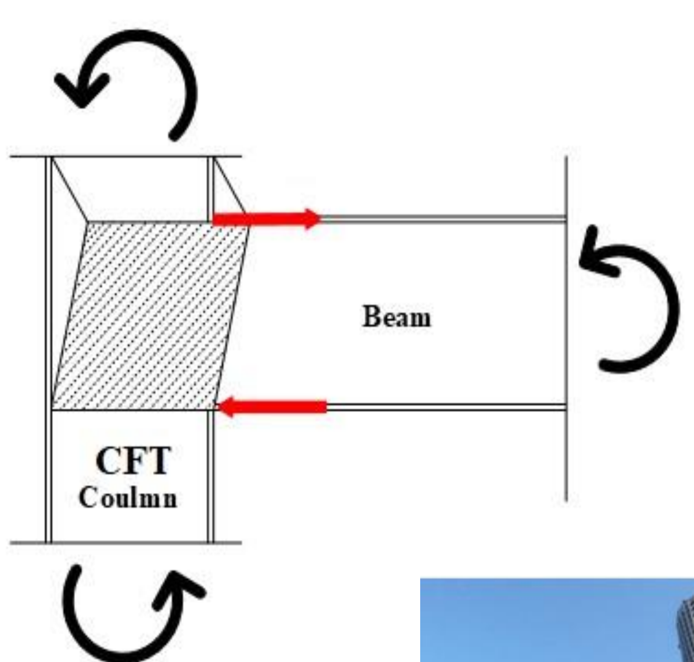
Previous Investigation

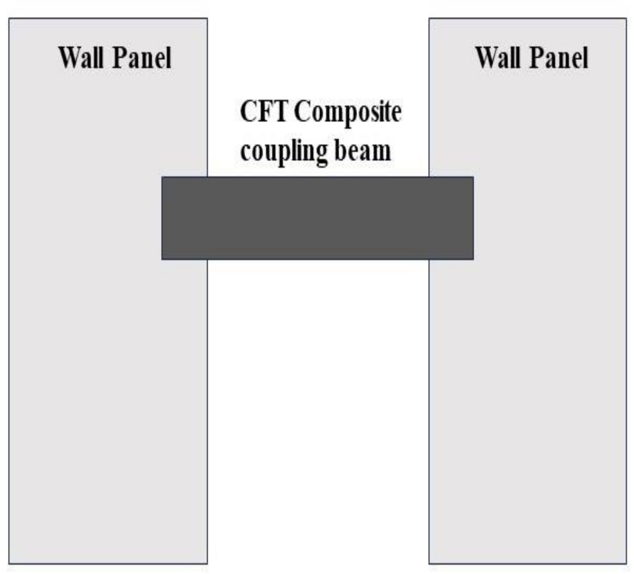
Limited research has delved into the shear strength of rectangular and square Concrete-Filled Steel Tubular (CFT) members. Koester (2000) examined split-tee through-bolted moment connections in experiments with rectangular CFTs. Nishiyama et al. (2004) investigated high material strengths' impact on subassembly behavior, testing ten beam-to-column subassemblies. Fukumoto and Morita (2005) focused on panel zones within steel beam-to-CFT columns, using eight specialized subassemblies. Wu et al. (2005) proposed an innovative bolted beam-to-column connection for CFT, testing three specimens with varying width-to-thickness ratios. Ye et al. (2016) conducted an experimental study on 38 CFTs, subjecting four specimens to pure shear loading. Lai et al. (2022) extensively explored the shear strength of steel tubes filled with high-strength concrete, specifically examining the influence of the shear span to the depth ratio on failure mode and ductility. In contrast, data on shear behavior for Rectangular Concrete-Filled Tubes (RCFT) members was sourced from 55 samples.



Significance of Study

Certainly, the investigation of shear strength in Concrete-Filled Tubes (CFT) poses a notable research challenge, particularly when considering rectangular and square members. This challenge is underscored by the limited number of studies dedicated to these specific cross-sections. Understanding shear strength is crucial in practical design codes where the ability of structural members to resist shear forces governs their performance. Examples of such scenarios include the shear-yielding locations in the panel zone of CFT columns within moment resisting frames (MRF), the use of drilled shafts spanning a thin liquefiable soil layer between two rigid strata during lateral spreading or seismic events, eccentric bracing frame (EBF) systems with shear links, and short-span coupling beams. Despite the evident importance of shear strength, it's noteworthy that the existing literature on the shear strength behavior of rectangular or square CFT members is relatively limited, resulting in a gap in understanding this aspect. The following figures illustrate applications and examples (governed by shear force) of RCFT members.





Experimental program and test setup

The testing protocol was formulated with two primary objectives: (1) to assess the shear strength of Reinforced Concrete-Filled Tubes (RCFTs) and (2) to meticulously examine parameters that have the potential to influence shear strength. This focused investigation included an in-depth exploration of the concrete strength within the core, the yield strength of the steel tube, and considerations of the span-to-depth ratio and slenderness ratio.

In addition to the above, the focus was directed toward discerning failure modes, peak load, peak strain, and the load–strain relationships, along with the experimental load-deformation response of the specimens under shear loads. The exploration of the shear behavior of concrete-filled steel tube members began with the testing of specimens designed to simulate beams constructed from RCFT members. The test setup was intricately crafted to accurately emulate the forces experienced by an RCFT beam under monotonic loading conditions.

Expected results from the investigation

The investigation aims to yield a comprehensive understanding of the shear strength behavior of Reinforced Concrete Filled Tubes (RCFTs). Anticipated outcomes include identifying and characterizing failure modes, determining peak load and peak strain values, analyzing load–strain relationships, and examining the experimental load-deformation response under shear loads. Furthermore, the study seeks to provide insights into the influence of key parameters—such as concrete core strength, steel tube yield strength, span-to-depth ratio, and slenderness ratio—on the shear strength of RCFT members. By elucidating these factors, the research is poised to contribute valuable information to enhance the design and performance assessment of RCFT structures, particularly under shear loading conditions.