Lateral impact behavior of Concrete-filled prefabricated UHPC tubular composite pier

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Extended Abstract

The rapid pace of global urbanization demand for large-scale infrastructure, including high-rise buildings, long-span bridges, and critical offshore facilities, have necessitated the development of advanced structural systems. For the past decades, Concrete-Filled Steel Tubular (CFST) has been the predominant construction material due to its high carrying capacity and ductility. Despite these advantages, CFST members face critical vulnerabilities, most notably their susceptibility to corrosion in chloride-rich marine environments and a rapid loss of structural integrity during fire events due to the poor thermal resistance of exposed steel. These limitations necessitate expensive protective coatings and frequent maintenance, increasing the total life-cycle cost of the infrastructure.

To address these multi-material challenges, a novel structural member has been developed: the Concrete-Filled Ultra-High-Performance Concrete Tubular (CFUT) column. This hybrid system comprises a prefabricated UHPC external tube, an ordinary normal-strength concrete (NC) core, and a continuous internal steel reinforcement cage spanning both the tube and the core. The CFUT system is engineered to utilize the exceptional mechanical and durability properties of UHPC, characterized by its dense microstructure, super-high compressive strength, and strain-hardening behavior, to create a more resilient structural component. The prefabricated UHPC tube plays a dual role in the mechanical performance of the CFUT system. Mechanically, the UHPC tube acts as a high-stiffness confining medium for the inner NC core, while simultaneously contributing directly to the axial and flexural capacity of the section

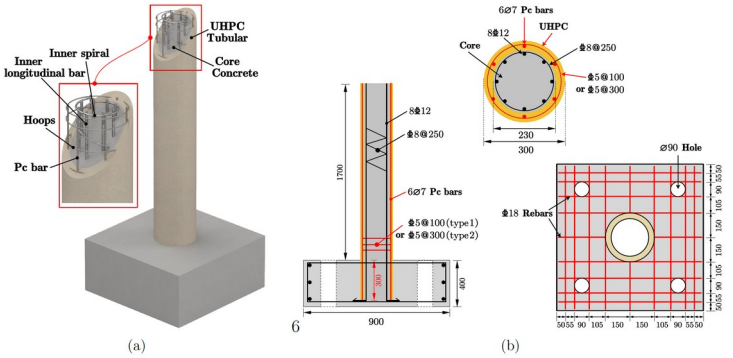

Fig. 1. Schematic of the Concrete-filled prefabricated UHPC tubular composite column (a), and the reinforcement details of the composite column (b). (units:mm)

The CFUT is distinguished by its damage-tolerant UHPC tube, which offers superior confinement and enhanced impact resilience. Lateral impact tests were conducted on six 1/3 scale specimens using a horizontal collision facility, with key parameters including steel fiber volume fraction and transverse reinforcement spacing, under impact velocities ranging from 2.56 to 5.03 m/s. The experimental results reveal a transition from flexural-shear to brittle shear-dominated failure modes with increasing impact energy. Critically, the incorporation of steel fibers within the UHPC tube proved more effective for preserving structural integrity than RC columns. Although reduced stirrup spacing was effective in mitigating localized shear damage, the initial peak impact force was governed primarily by local contact stiffness and inertial effects rather than by the transverse reinforcement. A simplified design framework was developed, establishing a reliable correlation between quasi-static lateral capacity and dynamic displacement demands. The results demonstrate that CFUT columns exhibit exceptional energy dissipation and impact resistance, offering a robust solution for the protection of critical infrastructure against accidental vehicular or vessel collisions.

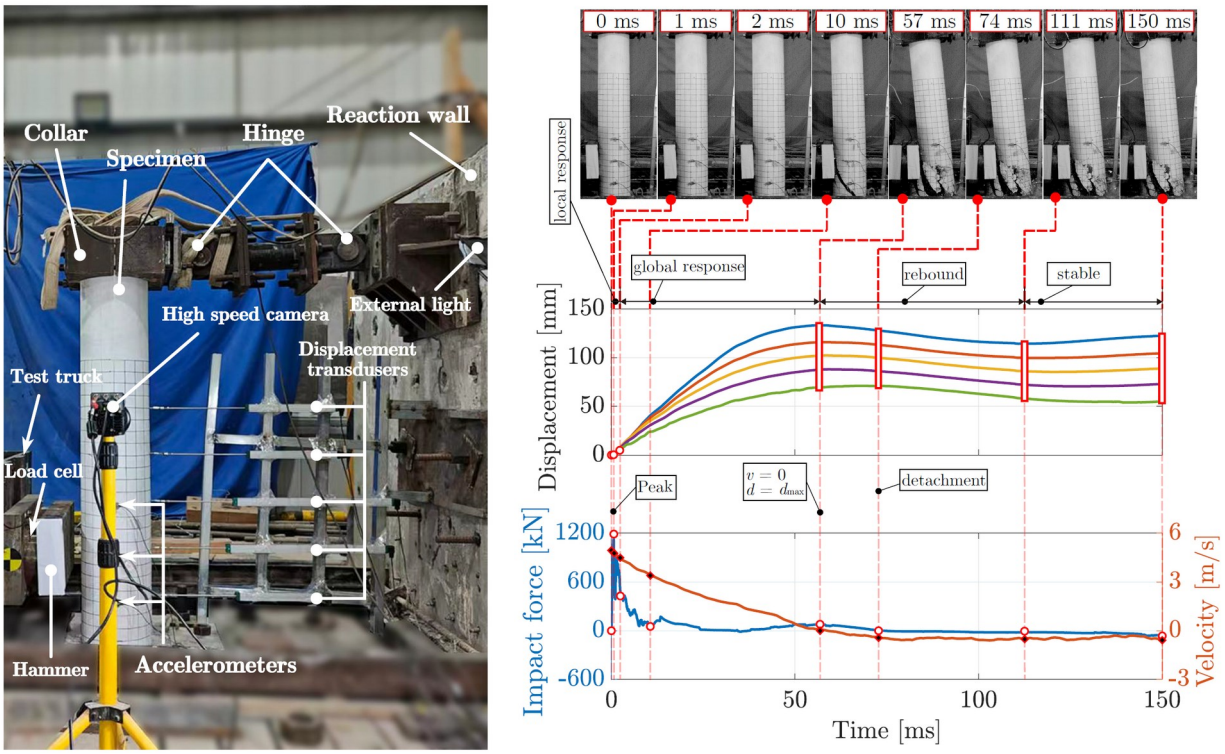

Fig. 2. photo of the column installed inthe horizontal impact facility (a), the force, displacement and velocity responses and the corresponding high-speed camera frames of the column under impact at characteristic points (b).

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