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# Cyclic testing of square CFST frames with ALC panel or block walls

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ABSTRACT

An experimental program was conducted to investigate seismic behavior and failure modes of square concrete-filled steel tube (CFST) frames with autoclaved lightweight aerated concrete (ALC) walls. Four specimens of square CFST frames with ALC panel or block walls and one pure specimen of square CFST frame were carried out under vertical axial loading and horizontal low-cyclic loading. The connector type, the wall connection type, the wall type and the wall thickness were considered. The failure modes, hysteretic behavior, strength and rigidity degradation, ductility and energy-dissipating performance of all specimens were analyzed and discussed. The experimental results indicated that this typed square CFST frames with ALC walls exhibited good ductility and hysteretic energy-dissipating capacity. The embedded ALC walls greatly improved the rigidity and strength of square CFST frame compared with the external ALC walls. By reasonable construction measures and reliable connectors, such as hooked bolt, rocking connector, U-typed connector and angle steel, the square CFST frame with ALC walls displayed good cooperative behavior and safety reliability. They can be applied in high-rise composite structure buildings.



## 1. Introduction

Although enclosure walls are routinely treated as nonstructural elements for infilled frames by most structural engineers during structural design process. Recent severe earthquake disaster survey reports indicated that enclosure walls damage and collapse resulted in casualties and economic losses. The reasons for the failure of panel walls, besides the quality of panel walls, irrationality of the connector type between panel walls and major structure is the other important factor. Therefore, it is need to investigate different connector type on the anti-seismic behavior of major structures with wall panels.

In recent years, with the increase of the wall material innovation and the development of building industrialization in China, a large number of autoclaved lightweight aerated concrete (ALC) walls were used as building envelope in multi-layer and high-rise buildings due to its competitive merits, such as lightweight, high strength, good fire resistance, good thermal insulation and sound insulation, ease of installation and maintainability etc. Memon et al. [1] and Ng et al. [2] reported the compressive and flexural strengths of the ALC panels. Low et al. [3] and Wakili et al. [4] investigated the thermal performance of ALC panels. Tanner et al. [5] and Costa et al. [6] studied failure modes and seismic behavior of pure autoclaved aerated concrete walls.

There has been a great number of studies on the static and hysteretic behavior of H-shaped steel frame with various types of block or panel walls. Memari et al. [7] implemented a dynamic testing of a full-scale H-shaped steel frame building with block walls. Moghadam et al. [8] presented an experimental investigation to obtain the cracking strength of masonry or concrete embedded in pin-joint H-shaped steel frames. Markulak et al. [9] reported cyclic behavior of H-shaped steel frames with three different types of masonry infills. On the basis of experimental study, Zhao et al. [10] developed a macro finite element (FE) model of H-shaped steel frame embedded with ALC block walls. Chen and Liu [11] proposed a FE model to study the seismic behavior of concrete blocks infilled H-shaped steel frame with openings. Tomaževič et al. [12] presented a shaking table program to investigate dynamic response of autoclaved aerated concrete confined masonry buildings. Fang et al. [13,14] carried out a shaking table test of H-shaped steel frame with external ALC panels. In addition, a few scholars paid attention to the interaction and connection effect between wall panels and H-shaped steel frames. Wang [15] studied the earthquake response of a six storey H-shaped steel frame with concrete panels by different types of connectors. Okazaki et al. [16] presented an experimental program to investigate the interaction mechanism between external ALC walls and H-shaped steel frame by a rotating panel installation method.

The concrete-filled steel tube (CFST) frames have been applied widely in multilayer and high-rise composite structure buildings because of their excellent earthquake resistance. For the CFST columns, local buckling of the steel tube wall is prohibited by the existence of in-filled concrete and concrete spalling is prevented by the confining

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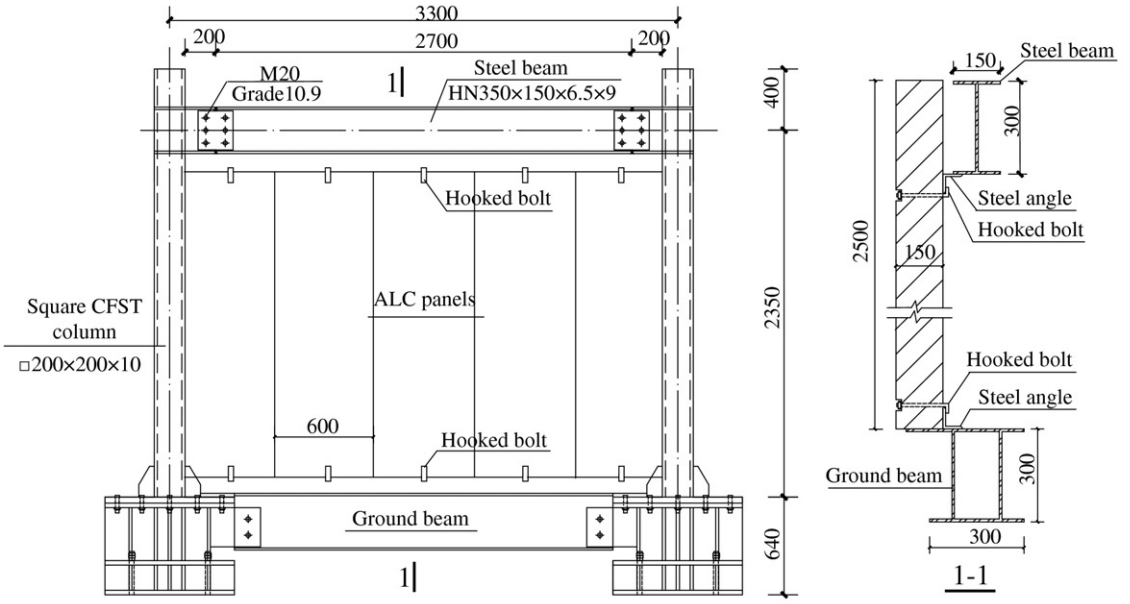
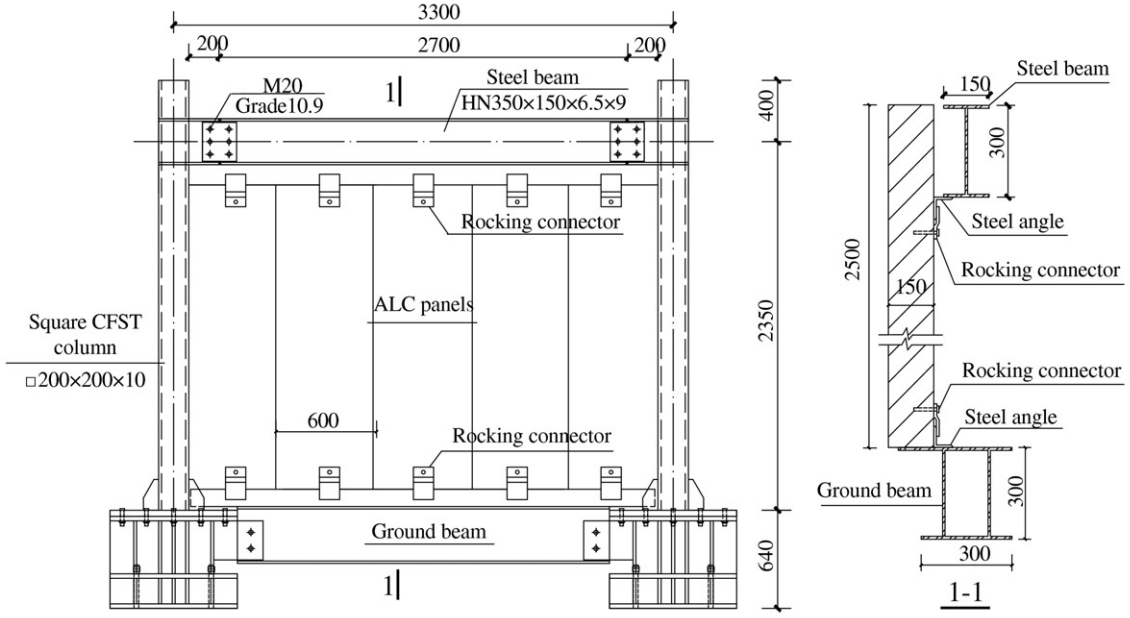



(a) Specimen SFW2-square CFST frame with external ALC panels (hooked bolt connector)




(b) Specimen SFW3-square CFST frame with external ALC panels (rocking connector)

**Fig. 1.** Detailed dimensions and configurations of specimens (unit: mm).

effect of the steel tube. Thus, the CFST columns could enhance the stiffness of the frame over steel tube columns and make the deformation between CFST frame and ALC walls more cooperative. Compared with circular cross-section of CFST column, the square cross-section of CFST column is more convenient to install and arrange connectors between frames and walls, and easier to ensure the safety and reliability of structures. However, the above-mentioned experimental studies and numerical analysis mainly focused on the seismic performance of H-shaped steel frames with different types of block or panel walls. Little research programs were conducted on the seismic behavior of composite CFST frames with ALC walls [17]. It limited the development of ALC walls in high-rise composite structure buildings.

This paper is to make a further investigation into the influence of the connector type, the wall connection type, the wall type and the wall thickness on the seismic performance of square CFST frames with ALC panel or block walls. Hereinto, four specimens of square CFST frames with ALC panel or block walls and one pure specimen of square CFST frame were tested under vertical axial loading and horizontal low-cyclic loading. The failure modes, hysteretic behavior, strength and rigidity degradation, ductility and energy-dissipating behavior of all specimens were analyzed in detail. It revealed the cooperative performance between ALC walls and main structure and connection reliability under earthquake action. It provided some useful reference for engineering practice application.