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Tests Study of a 1:20 Scale Steel-concrete Hybrid Structure

Di WU [a], *Yan XIONG* [b]*

[a] *Engineering Research Center for earthquake engineering, Guangzhou University, Guangzhou 510405, China*
[b] *State Key Laboratory of Subtropical Building Science, South China University of Tech., Guangzhou 510640, China*

Abstract

The seismic resistance of a 36-storey high-rise structure with the height of 149 m is studied in this paper. The simulated earthquake shaking table tests have been performed on 1/20 scaled model of the steel-concrete hybrid structure. The steel-concrete hybrid structure is composed of the surrounding diagrid, the reinforced concrete core tube, the floor slab, the beam of floor. The dynamic properties and the seismic behaviour have been analysed by the shaking table test based on the measurement method on the natural vibration frequency and the damage of the model structure. The test results have shown that the phenomena of failure occurred in some components after undergoing the earthquakes of the different fortification levels. The buckling failures occur in the inclined column of the diagrid on the higher floors, the horizontal cracks in the core walls of the higher floors has been appeared, and also the damages occur in the connection between the concrete core tube, the inclined beam of floor and the span beam. Since these inclined column and the key joints between the concrete core tube and the beam have been damaged seriously in the shaking table test, the detailed theoretical analysis is required to avoid the local structural damage.

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* Corresponding author. Tel.: +86-15013257899; fax: +86-020-87114274.
E-mail address: xyan@scut.edu.cn, 11795234@qq.com

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1. Introduction

At present, most of the buildings built in the world are concentrated in economically developed areas, and have not yet experienced the crucible of earthquake disasters. In the absence of sufficient research and the lack of seismic disaster data, it is of great practical significance to carry out a systematic theoretical and experimental study on the seismic performance of the high-rise building structures.

In recent years, the steel-concrete hybrid Structures, such as steel diagrid-reinforced concrete core tube structure, (diagrid-core tube structure) have been widely used in the forms of high-rise buildings [1, 2].The geometric configuration of diagrid-core tube structure is similar to that of braced frame-tube structure, however there is no traditional "vertical column", and the vertical column in the conventional structure is replaced by the inclined column system. From the current research results of the aseismic performance of the structural system, the inclined column shows a strong spatial characteristic in the diagrid- core tube structure, and the shear lag effect is less than that of traditional tube structure. Various experimental methods are available to study the nonlinear behavior of high-rise buildings, such as quasi-static tests, forced-vibration tests, shaking table tests, and pseudodynamic tests [3]. The shaking table test is one of the most realistic and reliable experimental methods for evaluating the inelastic seismic performance of structures [4, 5].And this test method has been widely used to study the seismic behaviors of the typical hybrid tall building [6], the new shear wall model [7], the base-isolated structures [8], the High-rise building with a transfer plate [9], the reinforced concrete frames without and with passive control systems [10].

In this study, a series of experiments have been conducted on a 1/20 scaled model 36-storey steel-concrete hybrid structure through shaking table tests. The main objective is the evaluation of earthquake-resistant behaviours and strengthening of the hybrid structure.

2. Model shaking table test

2.1. Structure Model design and manufacture

A diagrid-reinforced concrete core tube hybrid structure consists of two parts: a huge steel rhombic diagonal grids frame and a reinforced concrete core tube. The total height of the structure is 162m with 4.5 m storey height. And it is in planar square configuration with the plane size is 45m * 45m. In order to transfer the structural gravity load from the slab to the outer wall, a steel oblique grid frame is set up about 1.5 meters from the exterior side of floor slab. The shear force between the surrounding diagrid and the shear wall is transmitted by the floor panel and the diagonal brace connecting the corner of the diagrid and the core tube.

In view of the complexity of the diagrid-frame reinforced concrete core tube structure system and the regulation of transfinite height of structural high-rise building [11], this building belongs to the tall buildings beyond the Code-Specification. Fig 1 is the structural plan layout of standard floor of the structure model.

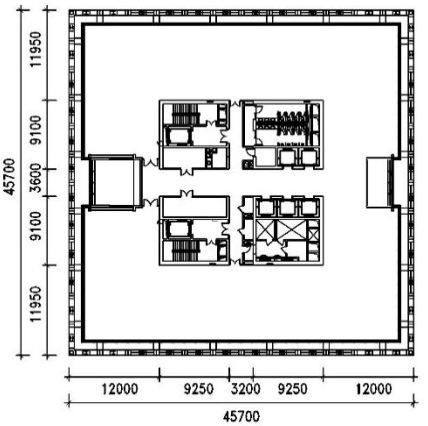

Fig.1. Structural plan layout of standard floor.

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