Anti-Seismic Behavior of a Multi-Tower Building Model

Xiang-Yu Gao
South China Constr. Univ.
Guangzhou, China

Fu-Lin ZHOU
South China Constr. Univ.
Guangzhou, China

Wen-Xiu CHEN
Huayi Arch. Design Inst.
Shenzhen, China

Summary

This paper introduced a shaking table test research on anti-seismic behavior of a multi-tower building model. The prototype is Futian Commercial Building that use the new technique of RC transfer plate and steel tube columns. The details of the columns are specially designed and the load bearing capacity of columns-beams joint models was proved by series static tests. The anti-seismic behavior (such as dynamic characteristics, cracking procedure, etc.)of the global tructure is studied here through the test results. Some suggestions for structural design are raised.

Introduction

Futian building group on a rigid foundation has four commercial buildings (39 floors, 100m high) and one official building (39 floors, 139m high). Because a commercial market occupies its first 6 floors, the structural system is changed by means of a reinforced concrete transfer plate(at 7th floor). Frame and RC tube are used under the plate, above which, are the four independent shear wall structures. The official tower (frame-tube structure) does not connect with the plate. Fig.1 is the plane layout of 2nd floor. For increasing the market area, steel tube concrete columns are used. A specially designed beam-column details was put forward for simplifying construction. Static tests(Fig.2) conducted in EERTC indicated that the details were reliable. Considering both of the special columns and the complicated building, structural analysis is very difficult. Therefore, a shaking table test of micro concrete model is necessary for the design and analysis. Some aspects of the anti-seismic behavior are presented later according to the tested results.

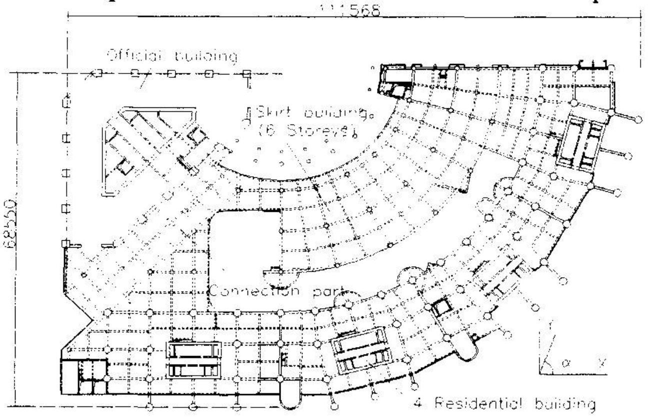


Fig.1: 2nd floor of Futian Building

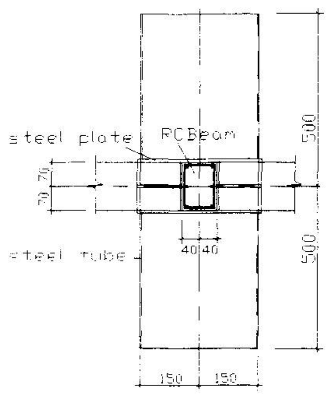


Fig.2: Beam-Column Joint Model

Design of the Model

Considering the table condition and the test requirements, the simulation coefficients are listed in table 1. Fig.3 is the testing model. Different angles are required to input earthquakes. Tree waves, thirteen different input angels and tree grades of intensity (plus white noise and biaxial tests) of total 32 tests are included.

Table1 Simulation of Futian Building

Item	*Parameter*	*Scale*	*Note*
length	C_l	38	thickness adjusted as E_c
elastic model	C_e	3.06	
strain	C_ε	1.00	
density	C_ρ	0.46	table bearing condition
acceleration	C_a	0.18	inertia force equivalence
gravity	C_g	1.00	
time	C_t	14.65	
mass	C_m	24967	

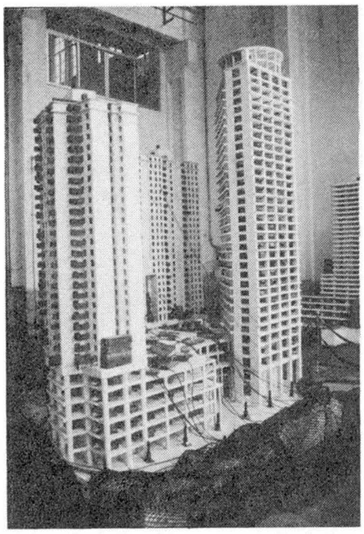


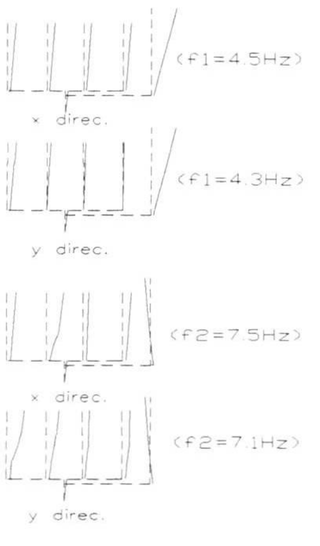
Fig.3: The Testing Model

Anti-Seismic Behavior

Table2 shows the comparison between the calculated and tested frequency. Fig.4 gives the analytic model and vibration modes. Fig.5 is the tested result. It is clear that the analytic mode is a kind of "plane vibration", while the tested one is "space vibration". All the earthquake tests (inputted from different angle) proved that the entire torsional movement was the dominant mode. Comparing the responses of different input angles, α=45° and 135° were the worst. The connection part cracked at moderate intensity. Steel tube columns and the transfer plate were reliable during the different tests.

Table 2 Comparison of frequencies (model)

Items	*Calculated*		*Tested*	
	X direc.fre.	Y direc.fre.	Frequency	Note
1st mode	4.48	4.31	6.72	entire torsion
2nd mode	7.51	7.07	8.72	move slantwise



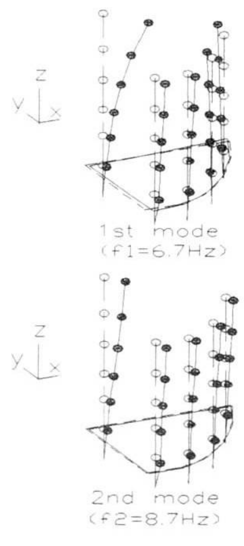


Fig.4: Analytic model and modes *Fig.5: Tested modes*

Conclusion and Suggestions

The details of steel tube concrete columns and the RC transfer plate are reliable. The dominant vibration mode is the torsional mode because of the structural layout. The response of Elcentro (ns+ew) wave is the most severe than other waves. The difference between the tested and the analytic result comes mainly from the analytical model that needs to be improved. Cracks appeared at the connection part of the official tower and the 4 residential buildings, which was the weakest part and need to be strengthened or totally separated.

Reference

[1]G.M.Sabnis,H.G.Harris,R.N.White,M.S.Mirza,Structural Modeling and Experimental Techniques, Prentice-Hall, 1983.

[2] Structural Design and Construction Standard for High-rise Buildings in Reinforced Concrete, JGJ 3-91, 1991, China.

[3]. Design Code for Earthquake Resistant Building, GBJ11-89, April,1990, China.