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## Observation and Research on Seismic Response of Super High-rise Buildings

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# Observation and Research on Seismic Response of Super High-rise Buildings

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**Abstract:** With the development of social economy, the increase of urban population and the shortage of land resources, the world has set off a high-rise building construction climax. More and more population concentrated and land-saving super-high-rise buildings are put into construction and use. However, the story height of this kind of building structure is higher, the layout of flat elevation is more complex, the experience of actual earthquake damage is lacking, and the seismic design is not sufficiently based, so the damage situation of this kind of building structure under earthquake is more complex than that of ordinary regular structure. This paper mainly studies the response of super high-rise buildings under seismic force, and briefly summarizes the research methods of seismic performance of such buildings.

## 1. Introduction

Foreword: One of the main causes of casualties after earthquake disaster is the collapse of building structure. As a symbol of economic and social development, super high-rise buildings are constantly changing the economic structure and urban landscape of our cities, becoming a major mainstream of the development of modern economic and social construction industry. At present, China has become one of the centers of the development of super high-rise buildings in the world. After decades of development and construction, the development of super-high-rise buildings in China has made good achievements in both theory and practice. From the point of view of the construction of super-high-rise buildings in China, today's super-high-rise buildings are no longer simply pursuing height, but more consideration is given to space modeling, urban environment, long-term use and technology related to super-high-rise buildings. The research on earthquake damage of super high-rise buildings is still in the ascendant in China, although some predecessors have done some explorations. Especially in the world, super high-rise buildings generally lack practical experience of earthquake damage, and can not find sufficient basis for seismic design. The relevant design regulations of reasonable safety in China's seismic code have not yet been given, which belong to over-limit design. How to ensure the safety and reliability of super high-rise buildings under the action of earthquake has become an urgent problem to be solved.

The research shows that seismic design of engineering buildings based on seismic data can effectively reduce the damage of buildings caused by earthquakes; moreover, the dynamic characteristics of complex super high-rise buildings can be studied by scaling shaking table simulation test, and reasonable structural design can be carried out accordingly; at the same time, numerical simulation of super high-rise buildings can be carried out by finite element software. The collapse mechanism and seismic performance of super high-rise buildings can be simulated more intuitively.



## 2. Research methods

At present, the seismic disaster of super high-rise buildings is reduced to the greatest extent by three methods: strong earthquake observation, shaking table simulation test and numerical simulation. Strong earthquake observation is an important part of seismic observation. Its main purpose is to obtain the records of ground vibration when strong earthquakes occur, and to provide scientific basis for timely and effective organization of earthquake relief and establishment of large earthquake emergency system. Shaking table test mainly studies the dynamic response characteristics of complex super high-rise structures under frequent and rare earthquakes, and based on this, reasonable seismic design of engineering structures is carried out. In fact, it is very difficult and expensive to study the collapse resistance of super high-rise buildings by shaking table test. Therefore, the comprehensive, fast and inexpensive numerical simulation method has gradually become an important means to study the seismic performance and collapse resistance of building structures.

### 2.1 Strong Earthquake Observation

Strong earthquake observation data can be used as the basis for seismic design of urban high-rise buildings and provide reliable data support for urban seismic fortification. At present, strong motion observation has been widely used in engineering, such as installing strong motion observer in some long-span bridges and high-rise buildings, in order to record seismic data and analyze the seismic performance of the structure, and more accurately carry out seismic design and seismic reinforcement of super high-rise buildings.

At present, the strong seismograph in the world has been widely used, such as the United States, as early as 1990s, Japan has used the strong seismograph in the earthquake to obtain valuable main shock acceleration records. The cause of strong earthquake observation in China started relatively late, and it is far below the world average level both in quantity and observation technology. The earliest digital strong earthquake network in China is the Shanghai Digital Strong Earthquake Observation Network, which plays an active role in earthquake prevention, disaster reduction and disaster relief in Shanghai and even the whole country. At present, many developed regions or cities in China begin to pay attention to the construction of strong earthquake observation network and stations, and have also made a considerable number of valuable records.

The super-high-rise buildings built in our country belong to over-limit design, lack of experience in earthquake damage and insufficient basis for design. By laying out the seismic observation network of these super-high-rise buildings, the structural dynamic response under strong earthquake is obtained, in order to establish the correct structural response model and carry out reasonable seismic design for such buildings.

### 2.2 Scaled Shaking Table Test

At present, the height of many super high-rise buildings in our country has exceeded the stipulation of "Code for Structural Design and Construction of Reinforced Concrete High-rise Buildings". There is no ready-made code to follow in design. In order to ensure the safety and reliability of structural design, researchers have conducted scaled shaking table tests on some super high-rise buildings.

In the past year, a 1:25 scale model of particulate concrete was used to simulate the seismic vibration of a 120-meter super-high-rise building in China Aviation Building.

In fact, the current super high-rise building structure in the earthquake collapse resistance performance is good, there is no corresponding actual earthquake damage experience. But the construction and experimental research of super high-rise building structure has never stopped.

### 2.3 numerical simulation and finite element analysis

Usually, buildings over 100 m or 25 stories are defined as "super high-rise buildings". For such structures, it is very difficult and expensive to test their collapse resistance by shaking table. Therefore, numerical simulation has become an important means to study the collapse and seismic performance of structures and buildings. In order to study the seismic response characteristics of super

high-rise building structures, equal model can be used to calculate the seismic response of super high-rise buildings under frequent earthquakes. Finite element software concise Etabs, SAP2000 finite element software such as

It is easy to carry out structural static analysis, modal analysis, seismic acceleration response spectrum analysis and elastic dynamic time history analysis for super high-rise structures. Specific work is as follows: (1) Dynamic characteristics analysis, analysis of the structure's natural vibration characteristics and mode shapes, evaluation of the structure's torsional vibration effect and selection of the number of mode shapes in seismic calculation; (2) Elastic time history analysis under frequent earthquakes: comparison of the difference of seismic response between mode decomposition method and direct integration method; assumption of elastic floor and rigid floor for structural period and some special features The influence of internal force of special components. At the same time, the characteristics of internal force and displacement response of corner columns without slabs in super high-rise building structures under EL-Centro wave, Taft wave and artificial wave are analyzed according to the requirements of codes.

### 3. Conclusion

Since the reform and opening up, the construction of high-rise buildings in China has made rapid progress. According to statistics, up to 2010, there are 47 super-high-rise buildings under construction or built in China, which are over 300 meters. The speed and quantity of high-rise building construction are rare in the world. With the diversification of social needs, in addition to high-rise office buildings, new high-rise buildings such as high-rise residential buildings, high-rise hotels and high-rise hospitals have emerged and developed vigorously.

The development of super high-rise buildings also promotes the development of new building structure system and new large-scale structural components. At the same time, it is difficult to carry out experimental research by conventional methods, so the seismic safety of high-rise buildings, especially the research of seismic performance under earthquake action, is an important subject. Some scholars have proposed that complex structure modeling, strong non-linear analysis, super-large-scale calculation and other issues are important issues to be solved in the collapse simulation of super high-rise buildings. In recent years, the environmental and energy issues have also had a great impact on the super high-rise building industry, but people's enthusiasm for building high-rise buildings will not diminish, and the construction of super high-rise buildings will not stop.

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