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Studies on Seismic Identification and Reinforcement Design of Building Structures

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Abstract

China is a country with many earthquakes. Seismic safety monitoring and building earthquake-proofing technique are important means to protect the safety of people's property in China. However, up to now, China's seismic reinforcement and identification technology is still not mature enough. In particular, the 2008 Wenchuan earthquake caused great loss of life and safety to the Chinese people. This paper, takes seismic identification and reinforcement technology of building structures as the research object and summarizes the main methods of building structure seismic resistance in China. This paper is based on an in-depth analysis of the main seismic reinforcement and identification techniques in China, deeply analyzes the crux of anti-seismic and reinforcement of building structure combining with the current building seismic reinforcement typical cases, and puts forward some reasonable suggestions and improvement methods for the future development of building seismic identification and reinforcement design.

Keywords

Building Structure, Earthquake Proof, Identification, Reinforcement Design

1. Introduction

In recent years, the development of seismic technology and design of building structures in China is getting more and more rapid. People's requirements for building seismic reinforcement are also increasing. At the same time, China's seismic design standards are higher and higher. But because of the reality of the national conditions, many old neighborhoods of the last century are still widespread. Their earthquake resistance and safety are important hidden dangers to people's property and safety. Once the earthquake occurs, the former community seismic resistance cannot meet the current requirements, so the safety of people's lives and property cannot be guaranteed. Therefore, it is necessary to

carry out seismic identification of the old communities, which also meets safety requirements. The following is the author's elaboration of the building structure seismic reinforcement and design, hoping to contribute to the development of building seismic technology through author's analysis and demonstration.

2. History of Seismic Identification and Reinforcement Design of Building Structures

Throughout the history of seismic identification and reinforcement design in China's construction industry, the process is divided into three stages. The first stage was during the Xingtai and Tangshan earthquakes of the last century. At that time, China did not formulate strict seismic standards. Most of the construction houses in China were distributed by enterprises and the state, and there is no concept of commercial housing. At the same time, China's construction industry has not formed a scale. As a result, the Tangshan earthquake has caused serious damage to the safety of Chinese people's lives and property. It also improved Chinese people's understanding of seismic identification and reinforcement, and sounded the alarm bell for the development of building seismic resistance in China. This stage is the initial stage of building seismic reinforcement and identification in China. With the introduction of building seismic codes and formulation of seismic labeling, the 1990s was a period of rapid development of building seismic resistance in China, and it was also the second period of seismic identification and reinforcement design in China. The period is the foundation period for the development of China's building seismic industry, which has laid a foundation for the reinforcement and development of subsequent seismic standards. At this stage, China's housing construction issued special seismic standards. In 1978, China promulgated the codes for seismic design of industrial and civil buildings. The code provided technical support for building seismic design in China. At the same time, the standards for aseismic identification of industrial and civil buildings were also issued. The introduction of these two standards has promoted the development of building seismic engineering reinforcement and design in China, which also provides technical support for the reinforcement of a large number of houses in China. The third stage was after 1989. China successively revised the codes for seismic design of industrial and civil buildings of the 1978 edition. In 1995, China's ministry of housing and construction also revised the standards for aseismic identification of industrial and civil buildings. In this stage, the combination of seismic design codes and identification standards pushed the building seismic to a new development stage [1].

3. An Overview on Seismic Identification and Reinforcement Design of Building Structures

3.1. The Concept of Seismic Resistance Is an Extension of the Theory of Identification and Reinforcement

The seismic design concept of building structure is to improve the seismic safety

according to building structures, and form new design concept and new design model according to all kinds of experiences obtained in the process of various earthquake—resistant disasters. The design and construction of this method avoids complicated numerical calculation, and is also a significant difference from the traditional seismic design checking calculation. This kind of concrete seismic design has the following points: 1) The principle that houses do not fall down during large earthquakes, can be repaired after medium earthquakes and cannot be shaken by small earthquakes. 2) In the process of design, the replacement of reinforcement should be carried out in strict accordance with the construction procedure. 3) In the process of design and reinforcement, prevention first and prevention and treatment integration should be given priority to throughout the design idea. 4) In the process of design, we should understand the design concept and path of building seismic resistance and have clear design ideas for building seismic resistance. 5) Make specific analysis of different buildings and formulate appropriate seismic design and reinforcement plan according to the local conditions [2].

The load of the building structure is mainly transmitted through the upper structure and the lower structure's direct support. This kind of load transfer must be affected by the overall building stiffness. In order to ensure the building in the small earthquake has strong resistance under the role of the structure, and the stability of buildings under the action of large and medium-sized earthquakes, large earthquake buildings must be kept from collapsing. Therefore, we must choose the scientific and reasonable support mode according to the stiffness and strength, the layout of the support, and ways to balance the internal stress of the structure reasonably. The support of the building is generated in this environment. Rubber support (as shown in **Figure 1**) appeared in the late 1960s. With the improvement of rubber refining technology, the high damping rubber support has also been improved. In the subsequent process, various kinds of rubber support styles also emerge endlessly, such as basin rubber support, lead-zinc rubber support, high damping rubber support and friction rubber support.

Figure 1. Rubber support.

At present, the research on seismic support has been more extensive and in-depth, from single damping to comprehensive damping technology, and from single support damping to compound support damping. Support damping technology has been greatly improved and widely used. It is found that the lead-zinc rubber bearing is more effective in shock—reducing and anti-seismic in the past researches and analysis, which has obvious effect on reducing seismic stiffness of buildings. Therefore, the advantages of lead-zinc rubber support are more significant in the process of constructing longitudinal seismic system.

3.2. An Overview of Seismic Identification Methods for Building Structures

In the process of identifying existing buildings, we can adopt the comprehensive method of aseismic design identification to identify and describe it and analyze the types of the building to be debugged according to the specific identification technologies. Then, the seismic effect of the whole building is judged by all its debugging factors. GB50023-2009 specified the types of divisions required, debug and integrate according to different usage characteristics. The distinction between distant and near earthquakes is also made during this process. According to the actual situation analysis, there are the following aspects of performance [3]:

1) There are some differences between the existing building structure and the new building structure aseismic identification.

Currently, the seismic design of the existing building structure is reformed by combining 78 structural designs. The design is mainly for old houses and unreconstructed houses and has some differences with the new structural design. When the working life of seismic identification is not considered, the design requirement of seismic capability of new project should be higher than that of existing project.

2) The main methods for seismic identification of building structures.

The identification standard and method issued by the state often lack a clear judgment on the overall seismic capability. This makes it impossible to make clear that whether it meets the requirements of the actual standards, so we can only judge by experience. This often causes many cases that do not meet the actual situation and standards. In practice, the reinforcement of the whole building can only be improved according to specific parts. The process creates new areas for reinforcement and prevention, which will cause certain aseismic defects to the whole building. According to GB50023-2009 standard, the main measure is to make full use of the seismic capacity, which is also the main identification method of this measure. There are two main aspects of this analysis. On the one hand, the seismic structure is analyzed. On the other hand, the bearing capacity of buildings is analyzed. These two aspects affect the safety and stability of the whole building. Other requirements are not necessarily strict. However, when the bearing capacity of foundation decreases, other requirements must be raised [4].

3) Seismic identification of building structures.

According to the comprehensive seismic capacity of the building structure and the process to identify it, the identification part is mainly divided into the main part and other parts (as shown in Figure 2). The main parts need to be carefully examined, and then examine the other parts. Only in this way can the seismic safety and integrity of the building structure be determined. The seismic parts, types and structures of different buildings are different, and the intensity also varies. Give examples according to the corresponding framework: at 6 and 7 degrees, the emphasis is on node construction and frame span, while at 8 and 9 degrees, check and measure the columns thoroughly, and construct sections.

4) Identification of building structure foundation.

It is necessary to study and analyze the earthquake disaster according to the actual investigation results. In the process of actual research, it is only necessary to test and identify the seriously defective sections and the disadvantageous sections with 8 or 9 degrees. In the process of verification, I class site, box foundation, basement, pile foundation, etc. should be inspected, and superstructure identification can also be weakened appropriately. In the process of verification for IV class site, the upper identification of the building structure can also be appropriately elevated due to the unevenness of the soil layer and the complex terrain.

5) Seismic testing of existing building structures.

One of the important concepts of new seismic design is the requirement of regularity and rationality. The existence of existing buildings also conforms to the content of regularity and feasibility. But new building structures need to be used to measure and update them. Although the performance and detection methods of each building structure are different, still can be handled and tested by common means, so as to improve the identification requirements [5].

6) The structural members meet the minimum requirement of material grade strength.

Figure 2. Seismic identification of building structures.

First is to judge the actual bearing capacity of the structure. The second is to narrow the scope of identification in seismic measurement. If the existing building structure no longer meets the specific criteria for identification, we should use the reinforcement principle to reinforce it. Current processing identification standards in China mainly include GB50023-2009 and GB50367-2006.

In addition, there are certain construction requirements. The seismic index of the existing building structure should be the same or similar with that of the new building structure. Therefore, the following concepts and principles should be grasped in the process of actual processing: 1) The principles of seismic reinforcement vary. If existing structures need seismic reinforcement, they are safe and reliable even when they are not required. But if it can't be put into normal use, they are not safe when they need reinforcement. This is very different from the nature of repair and reinforcement. The seismic reinforcement of building structure mainly includes the poor recovery ability after damage, which needs reinforcement, the partial restoration of the seismic capability of structure or the comprehensive reinforcement. 2) The reinforcement target and basis is the conclusion of seismic identification. Seismic identification and seismic reinforcement is a continuation of work. 3) Improve comprehensive seismic capability (as shown in Figure 3). If an existing building or a new building does not meet the relevant regulations, we can choose to start from the two aspects of bearing capacity and deformation capacity in order to improve the deformation capacity as well as its bearing capacity. The damage can only be minimized when different building defects are addressed, so as to improve its overall seismic capacity. 4) Improve the performance of reinforcement. The main purpose of building structure reinforcement is to improve the comprehensive ability of earthquake resistance and always keep the old and new components connected smoothly. In the whole process of detection, the degree of collaboration between the old and new parts is affected. In particular, new injuries should be prevented. 5) Fully increase the carrying capacity. As the foundation of building structure is in vertical action for a long time, the soil structure is relatively strong. Therefore, the strong soil structure needs to improve the bearing capacity. When the weight of

Figure 3. Comprehensive seismic method.

the building structure is too much, there is no need to deal with its foundation. Direct reinforcement is enough. 6) Choose proper reinforcement materials. The selection of reinforcement materials should be strictly screened. Choose safe materials with good quality and high reinforcement grade. And before the reinforcement construction, the actual size of the building structure needs to be measured twice. Once the material structure inclines, a set of scientific and reasonable plans should be made to repair it.

4. Analysis on the Status of Seismic Capability Identification of Building Structures in China

The aseismic capability of building structure is mainly evaluated by analyzing and judging the current building aseismic capability. The current seismic standard GB50023-2009 in China points out the current important methods. That is the zonal screening method. The method reuses the whole Angle from the seismic macroscopic analysis, and carries on bearing capacity calculation jointly and severally. Structural tests are also carried out on buildings that do not meet the requirements. Reinforcement and design must be carried out in strict accordance with the national standard GB50023-2009. The identification ability of reinforcement is taken as an important measure to test in order to comprehensively identify the seismic capacity of buildings and structures [6].

The macroscopic seismic identification of the current building structure is mainly divided into the following aspects: quality identification of buildings, elevation identification of buildings, bearing capacity identification of buildings' foundation, etc. Only in this way can the inspection quality and work efficiency of the building be improved. In the process of aseismic identification of concrete buildings, buildings should be tested in a relatively simple way. When the magnitude intensity does not exceed 6 degrees, it is not necessary to carry out specific monitoring, but specific precautions should also be taken. Only in this way can the inspection quality and work efficiency of the building be improved. As an important component of seismic identification of building structures, seismic capability index plays an important role. Only by combining various big data for analysis and comparison, and summarizing the same part of it, can the overall quality and level of seismic identification of building structures be improved and can develop towards quantitative direction.

5. Analysis on the Practice of Seismic Strengthening of Building Structures

In the late 1990s in China, safety and stability can only be considered, the overall area of use can only be increased, and the purpose of reinforcement can only be achieved after unified planning for some projects of old urban renewal, and to optimize the exterior structure of the building beautification. China's current national standard GB50369-2006 provides it with abundant concrete measures for seismic reinforcement: 1) In the process of seismic strengthening of building

structure, it is necessary to improve the rigidity ability of building and its bearing capacity. The main method is to enlarge the cross section of building components. For example, Jiujiang old intermediate court reform just added a row of columns to the original single-span frame and transformed it into a two-span frame. It improved the bearing capacity and ductility, reduced the height of the layer. To improve the shear capacity of the components, two methods of connection construction and enveloping steel structure are used. 2) Once obvious defects are found in the building structure system, we can solve it by the method of disconnecting or adding structures. In this way, the bearing capacity and deformation capacity of the building structure can be improved so that the comprehensive seismic capacity of the building structure meets the specified requirements. For example, the renovation of an office building breaks the L-shaped structure into two regular rectangular structures. The original single span frame forms frame shear structure by adding concrete shear wall. 3) Ensure the integrity and safety of building structure by improving the deformation ability of building structure. 4) In the case of unreasonable building structure, especially in the case of low seismic capability, we can only protect the local components when deal with weak links first. If the stirrup of beam is insufficient, high strength carbon fiber is usually added. It not only meets the actual requirements of the overall building structure, but also needs to achieve beautiful effect. 5) For non-building structures that do not meet the specified standards, it is necessary to carry out key inspections and rectification of potentially dangerous areas [7].

6. Conclusion

From the above analysis, we can draw the following conclusions: 1) In the process of building reinforcement design, the feasibility and economy of the reinforcement plan should be strictly controlled, and the life cycle of the building should be increased reasonably. 2) When strengthening the main body of the building structure, a complete and specific construction plan should be formulated according to the actual situation to minimize the disturbance to the foundation. 3) Many methods can be used to reinforce buildings. In the process of reinforcement, many kinds of composite materials can be used to reinforce walls to improve the overall seismic level. At the same time, avoid strengthening the original frame column as much as possible. 4) Consider building structure load and stiffness changes and other factors comprehensively to avoid uncontrollable factors in the construction process. 5) Use the new reinforcing technology of viscose steel and chemical anchor. If sufficient funds are available, seismic research can be carried out and scientific methods such as seismic dissipation technology should be widely used.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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