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Summary of Application of Isolation Bearing in Structure

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Abstract

With the continuous improvement of building level, the research and application of earthquake insulation technology has made great progress. Building earthquake isolation technology plays an important role in dealing with earthquake disaster, disaster prevention and mitigation, which can effectively reduce the damage effect of earthquake disasters on buildings and protect the safety of people's lives and property.This paper will briefly introduce the research, development and application status of building seismic isolation technology, and summarize the current research results and existing deficiencies.The key to isolation design is to reasonably determine the isolation layer of various isolation device, isolation device selection should consider the level stiffness, deformation ability, production quality, transportation convenience, construction, installation and replacement, isolation layer, engineering cost index of the isolation device is isolation support and other devices, and isolation support needs enough bearing capacity, deformation performance and reset characteristics.

Keywords

Earthquake Isolation Support; Foundation Isolation; Structural Isolation.

1. Introduction

With the development of society, some high-tech, sophisticated and sophisticated equipment into the building, how to ensure the normal operation of these equipment during and after the earthquake, how to avoid the vibration of high-rise and super-high-rise structure caused by earthquake not exceeding the applicability of the building, and not exceeding the psychological pressure that residents can bear, and how to ensure the safety of the structure to the maximum under the strong earthquake action of super-defensive intensity, so as not to cause serious loss of people's lives and property. Fiber reinforced plastic laminated rubber, bearing with high strength, light weight, corrosion and radiation resistance and other excellent performance, has attracted extensive attention of domestic and foreign scholars. In 1999, Kelly, an American scholar, proposed to use fiber-reinforced composite material to replace the steel plate in the plate-type rubber bearing[1]. Subsequently, scholars of various countries pay close attention to and study this kind of fiber rubber bearing[2-4]. There is a great upsurge of research on fiber-reinforced composite and plate support in China. Huang Xiangyun and Zhou Fulin[5] of Guangzhou University have carried out experimental research and simulation analysis on fiber support. The mechanical properties of fibre-rubber bearings were simulated by finite element Dalian University of Technology[6]. Xu Kai[7], Guangzhou University, puts forward a new type of simple isolation bearing-engineering plastic plate rubber bearing, and analyzes and designs its mechanical properties in detail. In recent years, the theory of structural vibration control, which is

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characterized by isolation and shock absorption, has been further developed. Structural control is the abbreviation of structural vibration control, that is, in a specific part of the structure, the use of certain measures to make the dynamic response of the structure does not exceed a certain limit. Structure control can be divided into passive control, active control, semi-active control and hybrid control according to whether there is external energy input. In this paper, we mainly consider passive control, which is a kind of control method to install such devices as isolation bearing and energy dissipator in some parts of the structure in advance to make the structure difficult to resonate and to reduce the seismic response of the main structure, such as base isolation, energy dissipation, shock absorption and so on. Isolation, the design refers to the foundation of the building, or the bottom of the lower structure and the upper structure between the installation of rubber bearings and damping devices, components composed of the overall reset function of the isolation layer, in order to prolong the natural vibration period of the whole structure system, reduce the input upper, the structure of the horizontal seismic effect, to achieve the expected seismic requirements.

2. Research Status

Lu Fengyong[8] believes that the rational configuration of isolation layer isolation device is the key link in the design of isolation structure. If the isolation device is selected improperly, not only the isolation effect can not be achieved, on the contrary, it may lead to the failure of the support and the damage of the superstructure.

Li Fengyue[9] selected an existing pharmaceutical building in Shanghai as a calculation model to analyze the seismic performance of two base isolation systems (natural rubber bearing isolation system and lead rubber bearing isolation system) , the conclusions are as follows: both isolation systems can effectively prolong the basic natural vibration period of the structure, avoid the high-frequency component, reduce the seismic response, the interlayer displacement of isolation system is mainly concentrated in the isolation layer, showing a trend of approximate global translational motion. The isolation performance of the natural rubber bearing system is better than that of the lead-rubber bearing system under frequent earthquakes, and the lead-rubber bearing system has better isolation performance under rare earthquakes. The displacement resistance of lead rubber bearing is better than that of natural rubber bearing, and natural rubber bearing only has the ability to prolong the structure period, lead rubber bearing can prolong the structure period and plastic energy consumption. The concrete application of the two isolation systems should be considered in combination with the local earthquake conditions.

Yang Zhongping[10] designed and analyzed a reinforced concrete frame structure project by adopting the scheme of friction pendulum bearing isolation, and compared it with the scheme of common rubber bearing isolation, the conclusion is as follows: according to the design method of anti-gauge, the friction pendulum bearing can effectively reduce the seismic response of the building structure, and can achieve the same isolation effect as the common rubber and rubber bearing. The horizontal stiffness center of the base-isolation layer of the friction pendulum bearing has a positive correlation with the vertical force of the superstructure, compared with the laminated rubber bearings, the overall torsion of the structure has obvious advantages. According to the simplified stress analysis, the connecting bolts of the friction pendulum bearing will not be subjected to tension under the action of earthquake, and only horizontal shear should be considered in the calculation, the length of bolt embedded part can only satisfy the structure length, which greatly reduces the difficulty of mounting the bearing.

Yancheng Cai, Xiongyan Li, Suduo Xue[11] studied the application and design of three-dimensional isolation bearing in reticulated shells and structures. The results show that the isolation structure has better performance than the non-isolation system. At the same time, it is found that under the horizontal and vertical seismic conditions, the three-dimensional isolation bearing structure has good isolation. In addition, it is shown that with the increase of seismic intensity input, the maximum absolute acceleration of structural nodes and the maximum axial force of members are greatly reduced.

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The laminated rubber isolation system will magnify the long period component of seismic wave, and under the action of near-field strong earthquake, there will often be large deformation of isolation layer, and it is easy to collide with the surrounding retaining wall, the long-term stability of its own materials also has problems; the friction pendulum isolation system may produce excessive displacement during a large earthquake, and it is difficult to ensure the friction coefficient of the bearing during long-term static, how to select or optimize the friction coefficient and reset stiffness reasonably and keep the friction coefficient constant for a long time is the key to improve the isolation effect and performance. The structure of composite isolation system developed on the basis of single mode isolation system is complicated and economic, and the hybrid isolation system which depends on feedback control algorithm has complex logic and is rarely implemented in engineering. In view of the problems of weak energy dissipation capacity and poor limit performance of the traditional single-mode isolation system.

In recent years, Peng Yong bo[12] studied a kind of magnetic sliding isolation system based on eddy current energy dissipation mechanism, and developed internal magnetic sliding bearing and liquid magnetic sliding bearing considering different interface friction characteristics. Based on the magneto-electric coupling finite element simulation, theoretical deduction, derivation and quasi-static test, the force-displacement relationship of magnetic sliding bearing is established, the sliding isolation bearing is superior to the lead rubber bearing and the friction pendulum bearing. The magnetic slip in the isolation system, the isolation bearing has excellent performance in the control of the structure displacement, the structure speed, the structure acceleration under the action of the ground motion in various fields, far and near fields, among the four isolation systems investigated, the effect of shock absorption is the best, so it has excellent engineering applicability. Under the action of far-field and near-fault non-pulse ground motion, the control effect of the liquid-magnetic sliding isolation bearing is remarkable, which is comparable to that of the internal-magnetic sliding isolation bearing, but due to the shear thinning effect of the liquid-solid friction, therefore, the liquid-magnetic sliding isolation bearing is suitable for far-field, ground motion and near-fault non-pulse ground motion, and is not recommended for fault pulse ground motion. The friction pendulum bearing of the isolation system is similar to the internal magnetic sliding bearing, but the control effect is weaker than that of the internal magnetic sliding bearing, but it is better than lead rubber bearing, so friction pendulum bearing also has good engineering applicability. The damping effect of lead rubber bearing under various ground motions is generally worse than that of the first three isolation systems, so it is not recommended to use lead rubber bearing from the technical level.

3. Classification of Bearings

Sliding isolation is to set sliding materials, such as graphite, sand and talc powder, in the isolation layer, so that the foundation can only transmit limited seismic force to the superstructure, play a role in protecting the superstructure. The point is that the natural vibration period of the whole system is the same as that of the structure before sliding. Once sliding, the stiffness of the isolation layer becomes very small, and the natural vibration period of the whole system becomes very large, therefore, in theory, sliding isolation can avoid most of the seismic waves, resulting in resonance effect. In addition, the work done by the friction of the isolation layer can consume the vibration energy of the structure[13], increase the damping of the structure and reduce the seismic response of the structure.

At present, the most widely used isolator with relatively mature technology is laminated rubber bearing. In order to improve the vertical bearing capacity and vertical stiffness of the isolator, the bearings are usually made of rubber sheets and steel sheets alternately laminated by high temperature and high pressure vulcanization. Laminated rubber bearing is a large vertical stiffness, high vertical bearing capacity, small horizontal stiffness, large horizontal deformation capacity, isolation device. Rubber bearing is a kind of isolation device which has been widely studied and applied in China. Traditional rubber, rubber bearings are mainly divided into ordinary laminated rubber bearings, lead-core laminated rubber bearings and high damping laminated rubber bearing.

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4. Analysis of Structural Moment Bearing Capacity

Taking cold-formed steel structure as an example, according to the technical code for cold-formed thin-walled steel structure (GB50018-2002), the following conclusions can be obtained:

$$\frac{M_{max}}{\varphi_{bx} W_{ex}} \leq f_y$$

Where M_{max} is the maximum bending moment between spans on the spindle x-axis, φ_{bx} is the overall stability coefficient of the bending member, W_{ex} is the effective sectional modulus of the compressed edge of the cross-sectional spindle x-axis, f_y is the design value of bending strength of steel.

5. Seismic System

Because sliding friction bearings do not have self-reset capability, they may produce uncontrollable displacement during large earthquakes, while laminated rubber bearings have self-reset capability, but their damping is limited, there is no advantage in dissipating seismic energy. Therefore, the composite isolation system with both reset ability and energy dissipation characteristics is favored by most researchers and engineers. At present, the compound isolation bearings include the parallel use of rubber bearing and sliding bearing, the parallel use of rubber bearing and damper, it also includes composite isolation devices with both elastic horizontal restoring force and damping[14].

According to the different geometric structure, the friction pendulum isolation system can be divided into three types: curved surface type, groove type, hybrid curved surface groove type, friction pendulum bearings. The principle of the friction pendulum isolation system is that the slider is placed in the chassis of the concave curved surface. When the earthquake action comes, the slider will slide to the height of the concave curved surface, which will consume seismic energy, under its own gravity load, the slider will automatically slide to a lower place to realize the function of automatic reset.

6. Conclusion and Prospect

According to the basic characteristics of the installation of the isolation bearing, the application of the isolation bearing in the construction project can obviously reduce the seismic response of the building structure and play a protective role to the building, play the safety of earthquake protection, reduce the cost of buildings, improve the overall repair efficiency after the earthquake. According to the basic characteristics of construction project, through the isolation bearing, installation, when the building is damaged by the earthquake, the building maintenance personnel only need to repair the isolation device to ensure the overall repair efficiency after the earthquake. In a word, during the operation and development of the construction industry, the construction units should realize the importance of the construction of isolation and seismic bearing, and refine the project treatment scheme according to the basic needs and construction characteristics of the project, to ensure the overall effect of isolation bearing support, improve the overall quality of engineering construction. In general, in the selection of isolation bearings, construction units and owners can not determine which bearing to use simply by local seismic fortification intensity and soil quality, and must fully combine the construction cost of the structure, find the most suitable seismic isolation scheme for this structure.

With the continuous improvement of people material living standard, People investment in house decoration and use of furniture is also increasing, which also puts forward higher requirements on the effect of earthquake resistance, not only to ensure the integrity of the main building in the earthquake, as far as possible, to ensure that the interior decoration and furniture intact. Therefore, the building isolation technology still needs to make more significant progress, should be positive, summary of the technical problems and achievements in the study, accelerate the speed of research. In this paper, through consulting the data, the way of the current building isolation structure of the research progress is analyzed, hoping to play a role in some reference.

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