Overview of the Current Status of Research on Seismic Isolation Bearings

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Abstract

Seismic isolation technology refers to the addition of seismic isolation layer in the middle of the substructure and superstructure, or the addition of seismic isolation bearing to the foundation part of the building, seismic isolation bearing to impede the propagation of earthquakes. The seismic isolation structure can extend the structural cycle, reduce the transmission of seismic energy in the building structure, and improve the seismic performance and safety performance of the building structure. Seismic isolation bearings are widely used in actual projects, how to better play its performance has become an inevitable problem. This paper briefly describes the research status of seismic isolation bearings at home and abroad.

Keywords

Seismic Isolation Bearing; Earthquake;Safety Performance.

1. Introductory

Earthquakes are one of the largest natural disasters, releasing enormous amounts of energy when they occur. Every year, about 20 destructive earthquakes occur in the world, causing more than hundreds of billions of dollars in damage.Many studies have shown [1-3] that the collapse and localized damage of buildings are the direct cause of casualties and property damage. After an earthquake, it is likely to cause many secondary disasters, such as fires, landslides, tsunamis, sewage, etc., which will have a great impact on people and cause damage to the ecological environment [4]. Research on seismic isolation bearings is of great importance.

2. Three Types of Seismic Isolation Bearings

2.1 High Damping Rubber Isolation Bearing

High damping rubber isolation bearing is composed of steel plate and high damping rubber layer, although the structure is the same with the natural rubber bearing, but the high damping rubber energy consumption ability is better, high damping rubber bearing has the advantages of natural rubber bearing and the advantages of energy-consuming devices, the damping ratio can reach more than 20%. High damping rubber bearing does not need external dampers to obtain strong damping characteristics, the better the rubber mixing ratio, the higher the energy dissipation capacity of high damping rubber bearing.

2.2 Lead Core Rubber Bearing

Lead core rubber bearing consists of natural rubber bearing and lead core, which is located in the center of natural rubber bearing. The lead core has good energy dissipation ability, and the plastic deformation of the lead core can consume energy, which is a good damping material. As mentioned above, natural rubber bearing has great vertical bearing capacity and vertical stiffness, so lead core rubber bearing has the advantages of natural rubber bearing and lead core at the same time. Lead core rubber bearings have good energy dissipation capacity and can be used alone, and are widely used in seismic isolation structures today. Chen Yuming [5] established a structural integrated multi-scale model of lead-core rubber seismic isolation bearings, analyzed the effects of horizontal and inclined installation deviations on the building, and put forward recommendations on the control of bearing installation deviations.

2.3 Friction Pendulum Bearing

Friction pendulum bearing have strong self-resetting ability and stable energy consumption performance, and they are widely used in reduced-aperture buildings. Early friction pendulum bearing consists of slider, upper seat plate and lower seat plate. The sliding surface of the bearing is on the lower seat plate, and when the external force on the building is greater than the static friction between the slider and the lower seat plate, the slider starts to slide, cutting down the upward transmission of seismic effects, thus achieving the purpose of friction energy consumption. At this stage, the research on friction pendulum bearing has made great progress, and the new friction pendulum seismic isolation bearing researched by Duan Zhongzhe [6] has good seismic isolation effect on the structure.

3. Research Status of Domestic Seismic Isolation Bearing

Li Wujie et al [7] developed a new type of seismic isolation bearing, the study of vertical support and horizontal reset elements for each other separate, for independent individuals, friction dissipation is by the rigid slider to complete the work, the self-resetting function for the elastic rubber part to complete the work. The article describes the basic principles of the study. Seismic isolation bearing of the comparison is good, each bearing from the beginning to the end of the play a very good vertical stability, in the earthquake after the reset of the bearing is very good.

Dang Yu et al [8] used artificial neural networks to model the machine learning for predicting the complex relationship between seismic isolation structural design parameters and structural response, which has high prediction accuracy and fast computational efficiency.

Wang Meng et al [9] proposed a new type of seismic isolation bearing based on the advantages of SMA and NSD. The new seismic isolation bearing in this study significantly controls the bottom shear force of SMA bearing and significantly reduces the residual deformation of NSD bearing.

Chenxi Zhang et al [10] combined with an example of an elementary school in Xiong'an, analyzed and got the conclusion that the complementarity of dampers and seismic isolation bearings will greatly improve the safety factor of the building.

To improve the seismic capacity of large-span structures in terms of bridges, Li Shouwen et al [11] proposed a new type of friction pendulum seismic isolation bearing, and it was found that the cable-stayed-friction pendulum bearing had good results in terms of continuous girder bridges.

Reducing the risk of damage to people and property caused by earthquakes, Yang Shaoheng et al [12] proposed a construction and installation method of seismic isolation bearings for buildings, and introduced examples to show that the rubber seismic isolation bearing construction methods and techniques can reduce the cost of the building, can shorten the construction time and have a very good safety, for the future seismic isolation bearing construction technology to provide a new way of thinking and new methods.

After the earthquake, the seismic isolation bearing undergoes a large deformation to ensure the structural safety performance, and there are some seismic isolation bearings that are difficult to be restored to their original state after the earthquake, and the residual deformation affects the normal use of the main structure of the building, and it is difficult to ensure the safety of the building under the subsequent seismic effects. Wang Bin et al [13] showed that seismic isolation bearings have poor resetting ability after the earthquake, and proposed a new idea, SMA-LRB seismic isolation bearings have good resetting ability.

Zheng Wenzhi et al [14] proposed a new type of lead-core rubber bearing, firstly established the model of seismic isolation bearing and shape memory alloy cable, explored the hysteresis curve of the bearing, and then subsequently did the experiments to get the data to increase the accuracy and credibility of the comparison, the study provides a reference for the design of the seismic system of beam bridges under the near-field seismic action.

Rubber seismic isolation bearings are widely used in modern bridges and buildings, but most of the construction process is relatively complex and difficult, if the construction is not appropriate, it is easy to affect the safety performance of the upper building. Zhao Wengang [15] proposed a new construction method, the use of pier inserts on the alignment bolt group to indirectly seismic isolation bearing under the embedded steel plate, this method uses high-strength anchor bolts so that the bridge superstructure, bridge substructure, seismic isolation bearing stable connection, no longer use the traditional grouting process, greatly reducing the construction process.

Thick-layer rubber bearings have very small vertical stiffness and high vertical resistance to earthquakes, but the oscillating effect of the superstructure will increase. Liu Xuhong et al [16] developed a new type of seismic isolation bearing, prestressed thick-layer rubber seismic isolation bearing. This study concluded that PRB has a good ability to limit the swing angle of the superstructure than TRB, and the more intense the earthquake, the more obvious the limiting function.

Museums can display historical relics, so that more people can recognize the charm and essence of history and culture, so that more people can understand history. Earthquakes often produce more or less harm to cultural relics, in order to reduce and avoid the harm of earthquakes to cultural relics, Zou et al [17] developed a sliding seismic isolation bearing. This study proved the effect of seismic isolation bearing through experiments, analyzed with finite element model, and compared with the test data to show the reliability and feasibility of the finite element model. This study shows that the sliding seismic isolation bearing for cultural relics can effectively reduce the impact of earthquakes on cultural relics.

Yin Peng et al [18] showed that the difference in the calculated values between the single tower model and the multi-tower link model is very small, so after setting the lead-core rubber seismic isolation bearing, the link corridor has little influence on the main building, and the main building is designed using the single tower model. At the same time, finite element analysis is done on the key parts to verify the safety performance of the corridor and the main building.

Yu Zhongyang et al [19] studied the placement and design of seismic isolation bearings in subway stations, the study effectively improved the force transfer mechanism of the station structure, the side walls of the station resisted the earthquake more, after optimization, the side walls bear more seismic loads, significantly reducing the damage of the center column, the results of this study provide seismic ideas for the building of the approximate station.

Seismic resistance and isolation technology of large bridges is a key difficulty in bridge design. Zheng Guohua et al [20] used the finite element program Midas/civil 2020 to study the seismic isolation design of a bridge in Sichuan, analyze its seismic response, and examine its seismic performance. The study shows that the seismic isolation effect of high damping seismic isolation rubber bearing is very good.

The performance of common seismic isolation bearings in tension is generally low, which is not easy to be utilized on buildings with large aspect ratios, Li Shiyao et al [21] developed a tensile isolation rubber bearing. In terms of yield tensile stress, the bearing is greatly improved over ordinary rubber bearings, with ultimate tensile stress exceeding 5.96 MPa and ultimate shear strain greater than or equal to five times the thickness of the rubber layer; there is a very small change in the mechanical properties of this bearing after stretching. The new type of bearing has no increase in cost but the tensile capacity has been greatly improved compared with the ordinary bearing.

Yu Bin [22] found that the improved seismic isolation bearing can significantly reduce the building maintenance costs, maintenance time and casualties, in the seismic isolation system layout, the building corner columns and side columns in the position of the improved seismic isolation bearing priority arrangement.

Song Rui-Qing et al [23] established a cultural relics display cabinet-vertical constant stiffness (variable stiffness) seismic isolation bearing model, using the vertical acceleration response as an indicator of the time course analysis, verified the effect of vertical variable stiffness seismic isolation bearing, which has a very good seismic isolation effect.

4. Current Status of Foreign Research on Seismic Isolation Bearings

Gauron et al [24] conducted compression shear tests on natural rubber bearings and showed that under actual axial loads, the bearings will suffer compression shear damage when the deformation of the bearings is large, and that the length-to-finish ratio is an important factor in controlling the ultimate state of the rubber bearings.

Katsamakas Antonios A et al [25] proposed a new type of seismic isolation bearing which can be used for seismic isolation of lightweight structures, this study describes the axial response. Combined compression tests with horizontal cyclic loading tests were done using seismic isolation bearings.

Miranda Sebastián et al [26] proposed a new method for two-dimensional modeling of seismic isolation bearings using three springs in parallel, which is versatile in that a single model is able to represent different seismic isolation bearings; the process of applying it is simple, requires fewer parameters, and is easier to calibrate in the test cycle and in the test results.

Ishii K et al [27] proposed a mechanical model. Static bending tests were performed under various combinations of vertical loads and shear deformations. Simulation analysis was performed to validate the new mechanical model. The analytical results using the new model showed a very good agreement with the experimental observations.

5. Conclusion

Seismic isolation bearing can improve the structural safety performance, can protect the structure of internal components and facilities, effectively reduce property damage and casualties, reduce the cost of maintenance after the earthquake. With the development and popularization of seismic isolation technology, scholars in various countries have developed many new seismic isolation technologies, and are looking forward to the introduction of new bearings with better seismic performance.

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