Research and Application of Energy Dissipation and Shock Absorption Technology

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Abstract

According to the research status at home and abroad, the mechanism of energy dissipation structure is clear and the effect of vibration reduction is obvious. It is safe and reliable and easy to be used in engineering. In this paper, several typical dampers are classified and summarized, such as viscous dampers, viscoelastic dampers, metal dampers and friction dampers. The future development trend is also prospected, and some problems to be solved in the study of dampers are put forward.

Keywords

Earthquake; Energy Dissipation; Damper; Application and Prospect.

1. Introduction

Earthquake is one of the most unavoidable and unpredictable disasters for human beings, which has caused great harm to human life and property[1]. At present, the seismic method adopted in our country is "ductile structure system". Under the action of earthquake, the damper first yields and saves energy by deforming or damping the main structure. This is a very useful seismic mitigation measure. Several typical energy dissipation and shock absorption devices and their application progress are introduced below.

2. Energy Dissipation and Shock Absorption Technolog

Energy dissipation and shock absorption technology is a new structural system composed of energy dissipation and shock absorption devices at some locations of the structure, so as to control the seismic response of the structure, avoid and reduce the damage of the main structure, so as to achieve the purpose of energy dissipation and shock absorption.

2.1 Principle of Energy Dissipation and Shock Absorption Structures

The essence of energy dissipation is to provide damping by dampers, to dissipate seismic input energy and to reduce structural vibration response. From the energy point of view, the energy dissipation of traditional aseismic structures mainly depends on the hysteretic energy dissipation of structures, and the structures themselves will suffer serious damage. In the energy-dissipating structure system, energy consumption mainly depends on dampers. The fuller the hysteretic curve of dampers, the more energy consumption, which reduces the energy of the structure, and avoids or delays the damage of the building structure.

From the point of view of energy, energy dissipation and shock absorption are described. The equation is as follows:

The shear wall structure has the following characteristics after installing the energy dissipation device rationally: it can reduce the horizontal and vertical seismic action of the structure at the same time; because the energy dissipation device does not change the basic structure of the structure, the seismic structure of the energy dissipation structure is not reduced compared with the ordinary structure. On the contrary, the seismic safety of energy dissipation devices has been significantly improved, because it is equivalent to adding a defense line to the structure.

2.2 Advantages of Energy Dissipation and Shock Absorption Structures

Energy dissipation structure can advance into the state of energy dissipation and effectively absorb and consume seismic energy. Its energy dissipation effect is much more useful than traditional methods. Repair or replacement of shock absorbers is relatively simple, repair efficiency is improved, and help to restore life after the earthquake. It has the advantages of simple installation, no external energy supply, simple operation and low cost. It can be used in all kinds of buildings. Besides, it can also control the vertical and horizontal seismic forces of the structure at the same time.

3. Several Common Energy Consumption Devices

In China, after a long period of development, more and more dampers have been used in energy dissipation design. At present, four types of dampers are commonly used, including metal dampers, viscoelastic dampers, friction dampers and viscous dampers[2]. The working principle and characteristics of the four main dampers are briefly introduced below.

3.1 Viscoelastic Damper

In the 1960s, thousands of viscoelastic dampers were installed in the World Trade Center Building in New York to reduce wind loads. Viscoelastic dampers can store or dissipate energy generated by alternating stresses in the form of heat.

Viscoelastic dampers are energy-consuming, sensitive, easy to manufacture and install, and relatively reliable, stable and durable. However, the ambient temperature and humidity have a great influence on the energy dissipation capacity of viscoelastic dampers. When the strain exceeds the necessary limit, the viscoelastic material will emit more heat energy, which will cause non-linear deformation, and its energy dissipation capacity will inevitably be affected.

3.2 Viscous Damper

Nowadays, viscous dampers are widely used to control the vibration of buildings. The working principle of viscous dampers is to force liquid through piston holes through the motion of piston rods, resulting in greater damping force and energy dissipation.

Viscous damper has many advantages, but its own production process is difficult, so it is easy to present viscous liquid leakage phenomenon. Viscous dampers can provide high damping for structures. They have the advantages of maintaining linear response, insensitivity to heat, non-synchronization of damping force and displacement in broadband. They have good control effect on acceleration and shear force[3]. This is becoming more and more popular in engineering field.

3.3 Metallic Dampers

In the 1970s, Kelly et al. first proposed the idea of installing metal dampers in structures for seismic response control. Subsequently, a series of theoretical and experimental studies on metal dampers have been carried out by researchers all over the world, and various types of energy dissipation devices have been proposed[4]. Metal dampers are more convenient to install and replace in building structures. They are usually used together with other isolation devices, which are mainly used in isolation and vibration reduction of buildings and bridges.

Metal damper has good energy dissipation ability, simple device, reliable function and is not affected by external factors. With lower maintenance cost, it can be set in the corresponding parts of the building structure alone, or can be used in combination with the isolation system.

3.4 Friction Damper

The energy dissipation method of friction damper is to achieve energy dissipation by relative slip between components, depending on the friction force or damping force generated. When the applied load is small or a small earthquake occurs, the device will not have friction sliding, but when a strong earthquake occurs, the damper will change the natural vibration frequency of the structure, so as to achieve the goal of energy dissipation.

4. Development of Energy Dissipation and Seismic Absorption Applications

Energy dissipation technology breaks through the traditional seismic design method. It can not only keep the structure from collapsing when the big earthquake comes, but also reduce the displacement and acceleration response of the structure under the big earthquake by additional damping. This technology can be used in new construction projects, and is suitable for seismic reinforcement and improvement of buildings. It has a wide range of applications and prospects.

Since the 1980s, domestic scholars and engineers have been devoting themselves to the research and practical application of energy dissipation and shock absorption technology. A lot of mechanical properties and shaking table experiments have been carried out, and a lot of valuable research results have been obtained.

5. Summary

The energy dissipation technology has the advantages of simple concept and convenient manufacture. However, in order to make the energy dissipation technology widely used, there are still many problems to be discussed:

(1)The mechanism of stress and deformation at structural joints is still unclear. Although there are many kinds of energy dissipation components, more attention should be paid to their practicability, economy and supporting connection forms.

(2) Energy dissipation technology has been widely used in all kinds of building structures, but the mechanism of the influence of the parameters of dampers on the effect of different types of structures is still unclear. At the same time, how to choose the type, parameters and layout of dampers to optimize the damping effect needs more and more in-depth discussion.

(3) At present, there are no systematic codes and standards for the design, manufacture and installation of dampers, and there is no unified evaluation mechanism for the effect of shock absorption. Establishing a unified standard will play an active role in promoting the development of dampers and improving the construction quality.

(4) Partial displacement dampers depend on metal yielding to dissipate energy. They need to be replaced because of large deformation after large earthquakes. There are few studies on how to observe and evaluate the deformation of dampers after earthquakes, and how to repair and replace dampers in time.

(5) At present, the design evaluation of energy dissipation technology is not closely related to the performance-based seismic design method, considering various environmental factors, such as temperature and humidity affecting the durability and reliability of energy dissipation system.

References

[1]. Zhou Fulin. Seismic Control of Engineering Structures [M]. Beijing: China Earthquake Press, 1997.

[2]. YANG Runlin.Study on structural control based on fuzzy control theory [D] .Beijing: China Academy of Building Research,2002. (in Chinese)

[3]. Skinner R I,Kelly J M and Heine A J. Hysteresis Dampers for Earthquake — Resisstant Structures [J] . Earthquake Engineering and Structural Dynamics,1975(3) : 287 — 296.

[4]. Zhao Hongtie, Xu Zhaodong, Zhang Xinghu. Research, application and development of energy dissipation and shock absorption control [J]. Journal of Xi'an University of Architectural Science and Technology, 2001, 33 (1): 1-5.

[5]. Zheng Jiujian, Meng Fanxing, Liu Ruiyong. Structural analysis and design method for viscous dampers [M]. Shenyang: Northeast University Press, 2009.