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Application of Vibration Damping Technology in High Rise Building

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Abstract: In recent years, Great development have been happened in the damping technique for high-rise building structure, how to build a structure which can ensure the safety of buildings in the sudden earthquake and how to adopt a new system structure which is more safe, more reasonable and more effective plays a decisive role in reducing earthquake disaster.This paper introduces the architectural structure of energy dissipation shock absorption system, isolation system,structure of passive system and structure of active control of the new system, and lists various kinds of application systems in engineering, provides reference for seismic design of engineering structure vibration.

Keywords: Energy dissipation damping system, passive system and active system, vibration isolation system.

1. INTRODUCTION

China is in the world's two largest earthquake belts intersect, because of this,there are more sudden earthquake, in the earthquake, a large number of damaged or collapsed buildings result in the serious earthquake directly [1]. How to build a structure which can ensure the safety of buildings in the sudden earthquake and how to adopt a new system structure which is more safe, more reasonable and more effective plays a decisive role in reducing earthquake disaster. In addition, China is also a country where typhoon often occur, So high-rise buildings have also put new demands on the vibration control of wind loads.

In the design of high-rise structure, wind and earthquake loads is the main factor to control action, according to the conventional design method, in order to withstand the hit of hurricanes and earthquakes, we often strengthen the lateral force resisting system structure, which will lead to the increase of construction cost [2]. According to the situation of our country, we must find a vibration control system of building structure which is safe, applicable,and economy to the implementation of seismic fortification on a wide range, With the high-rise building is becoming more and more common, the energy dissipation system (Fig. **1.1**), the vibration isolation system (Fig. **1.2**), the passive control system (Fig. **1.3**) and the active control system (Fig. **1.4**) is widely used in structure seismic system [1].

The structure characteristics of seismic design, seismic isolation design and vibration control design can be summarized as shown in Table **1** [1]:

2. THE ENERGY DISSIPATION SYSTEM

2.1. Brief Introduction of The Energy Dissipation Structure

The energy dissipation system is an system which to put some non-bearing members designed to effect structure member, or set up an energy dissipation device in the structure of certain parts, While under the wind load and slight earthquake, the energy dissipating device is still in elastic state, the structure still have enough lateral rigidity to meet the requirements of normal use. In the event of strong earthquakes, with the increase of the structure stress and deformation, the energy dissipating devices to enter the inelastic deformation (we can also call it the state of energy dissipation), producing larger damping and consuming a large amount of seismic energy input structure, They can make the main structure to avoid entering the inelastic state obviously and slow down the seismic response of structure, so as to protect the main structure suffered damage in the strong earthquake [1], From a strategic perspective, energy dissipation is mean to lead the energy of earthquake input to the institutions and element particular set to the further absorption and dissipation, which to protect the safety of main body structure. The energy dissipation seismic damping system is widely used in high-rise buildings and towering structures (tower, frame) to resist seismic or wind.

According to the difference of energy dissipation device, The energy dissipation system Can be divided into energy dissipation components damping system and damper energy dissipation damping system, the energy system is the system which use the non load bearing structure as the energy dissipation structure system device. The energy dissipation components we often use is energy dissipation brace (block energy dissipation brace, circular energy dissipation can support fire support, the K shape eccentric) and energy dissipation shear wall (vertical joint energy dissipation shear wall, transverse joint energy dissipation shear wall, peripheral joint energy dissipation shear wall); the damper energy dissipation system is the structure installed with dampers in certain parts. During the earthquake, with the occurrence of large deformation, the damper installed these parts of the structure play an effective energy dissipation effect.

2.2. Engineering Application [1]

The capital planning building built in the central axis of Beijing City East, North four ring road to the north, and the Asian Sports Village International Conference Center across

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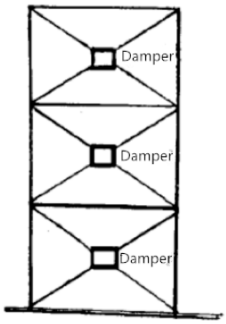

Fig. (1.1). The energy dissipation system.

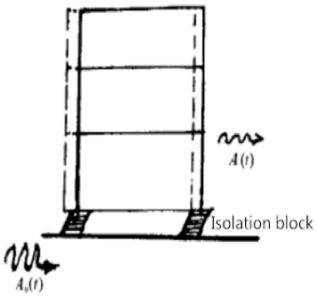

Fig. (1.2). The vibration isolation system.

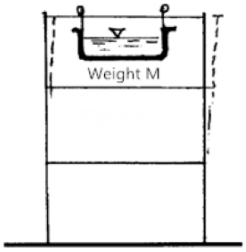

Fig. (1.3). The passive control system.

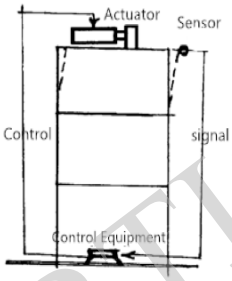

Fig. (1.4). The active control system.

Table 1. The structure characteristics of seismic design, seismic isolation design and vibration control design.

Classification	Main Consider	Control Objective	Accessory Equipment and Venues
Seismic Design	Big Earthquake	Control the Damage of Main Structure	No Need
Seismic Isolation Design	Big Earthquake Medium and Small Earthquake	Control the Earthquake Force	Rubber of Arch Layer and Spring on the Basis All Kinds of Dampers on the Basis
Vibration Control Design	Big Earthquake	Control the Deformation of Main Structure and Improve the Living Condition	All Kinds of Dampers(every parts) TMD,AMD on the Top

the road, the building is 205 meters high and it is a high-rise building with 50 story steel structure, it is designed by the Beijing Architectural Design Institute, it is the highest structure of high-rise building designed with full steel in China so far .The plane of the structure is a missing angle square, the whole structure is composed by the steel core tube composed of steel frame and herringbone support and the outer ring of four pieces of steel frame. In order to enhance the lateral stiffness of the structure, the 14 layer, 30 layer and 47 layer of the structure is equipped with three rigid layer.

According to the principle of not increase or decrease the cost of structure,we use the viscoelastic damper to ensure that the earthquake intensity does not exceed the design limits of comfort of high-rise steel structure technical regulations in our country ,the specific practices are as follows:

(1).Except herringbone steel first ~ three layers and three rigid layer all the rest of the structure layer support changed to support herringbone viscoelastic damper.

(2).In order to ensure the whole structure lateral stiffness constant, the viscoelastic damper steel support must be maintained the lateral stiffness.

(3).The viscoelastic damper support must have enough energy dissipation capacity, to reduce the seismic and wind induced vibration response of structure.

We designed the herringbone viscoelastic damper support on the inner tube of the Capital planning on the basis of the above approach, which as shown in the follow diagram:

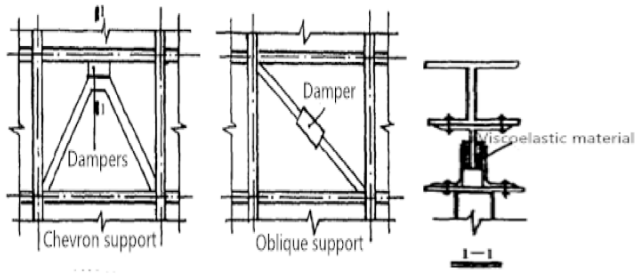

Fig. (2.1). The herringbone viscoelastic damper support on the inner tube.

3. VIBRATION ISOLATION SYSTEM

3.1. Brief Introduction of Vibration Isolation System

The vibration isolation system is the system which set some isolated energy dissipation devices between the bottom surface of the structure and foundation. Specifically, the design of isolation layer should meet the following requirements [5]: ⊖ To bear the super structure steadily, isolation layer should have sufficient vertical stiffness and vertical bearing capacity,; ⊜ Having an adequate level stiffness to ensure the basic cycle extension of the buildings and to reduce the earthquake; ⊛ Having a certain isolation layer damping to ensure the vibration attenuation and limit the role of structural displacement ,in the meanwhile, it can reduce the structure under strong winds and small earthquakes shaking; ④The chosen isolator must have sufficient durability and at least a reference period of the design of buildings ; ⑤ Isolated building construction measures should meet regulatory requirements.

According to it's type, the isolation device can be as follows [1]: Laminated rubber isolation, isolation tilting, sliding isolation, isolation and hybrid roller isolation. Currently, Rubber bearing is the most widely used, its principle is to use the large vertical stiffness of rubber isolation to withstand the load of the upper structure, through which the level of flexibility to the upper horizontal seismic isolation structure is passed, and Lead section can increase the damping device to improve the mechanical properties of isolation pads.

3.2. Engineering Applications

Shantou museum is located in the west end of shantou zhongshan company, which is 42 meters high hall and ten storeys high-rise buildings. The total area of 16600 square meters, covers an area of flat which shape is complex, it is a building and the integration of the zhongshan park of of primitive simplicity of tower building. It is the first building adopts the aseismic design of large public buildings in China.

Due to the isolation pad in the first layer of pillars, so the door of the elevator shaft, stair, big steps, as well as the main pillar, are hanging on the second floor structure, out of a layer structure. Shantou is a city of isolation pad application earlier in our country, but vibration isolation cushion is proved for structural seismic can have obvious effect.

4. THE VIBRATION CONTROL TECHNOLOGY

4.1. Brief Introduction to The Structure of The Passive Control Damping System [1,2]

Setting up a subsidiary in certain parts of the substructure building structure,and changing the dynamic characteristics of the original structure of the system. When the original structure to withstand seismic shocks and severe vibration, it's energy dissipation also play a role in damping the vibration response of the rapid decay of the original structure due to the inertia of the sub-structure of the mass and the force structure is applied to the reverse of the original, the sub-structure is called "tuned mass damper" TMD. As no external energy input,it is called passive TMD control system.

According to the difference of sub-structure,the TMD passive control system constituted by three types:support type, suspended and hammer (Fig. **4.1**) [1], when the quality material used for the liquid,the damping system became sink, which is called TLD.

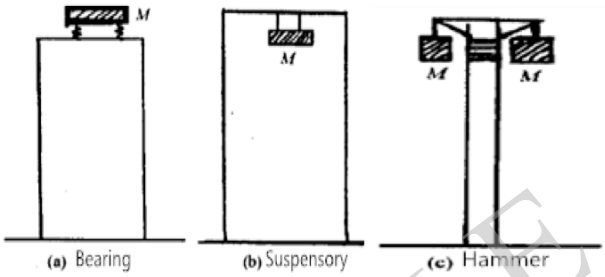

Fig. (4.1). The passive control damping system.

4.2. Brief Introduction to The Structure of The Active Control Damping System

During the vibration of the structure, the active control system using an external energy change the the dynamic characteristics of structure and applying control to attenuate the response of the control architecture instantaneously. Active vibration control system installed sensors in parts of structures, the instantaneous transmission of seismic response measured to the computer system, after the information processing and computing, computer control substructure is applied, changing the dynamic characteristics of the structure to the drive mechanism, make the structure of the rapid decay of the vibration response.The active control method rely on external energy to offset structural dynamic response[3,4] has opened up broad prospects for the research and design of various self-control structures .

Currently, according to the different composed of substructures,The seismic active control system developed for structural seismic is also divided into two types: active tuned mass dampers and active cable control system.The flow of active control system is shown in Fig. (**4.2**) [1]:

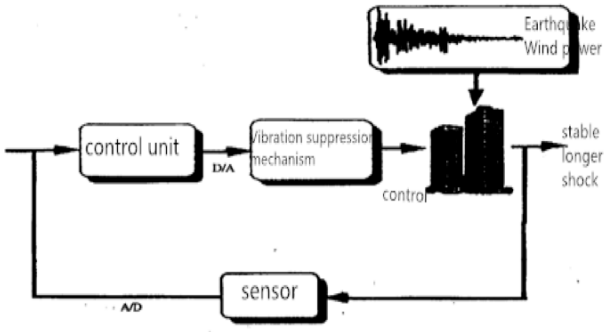

Fig. (4.2). The active control damping system.

4.3. Engineering Applications [1]

The height of the Shanghai Oriental Pearl TV Tower (the Shanghai Tower) is 463.8m, the structure of the Tower is the concrete structure of prestressed and reinforced, and be composed by the foundation, basement, tower, mast reinforced concrete, steel masts and three spheres, the tower is three 9m

diameter of the cylinder, a triangular distribution. Shanghai Tower is located venue for a typical soft ground, the seismic intensity of 7 degrees, the earthquake was one of the main load of the tower, in the earthquake, the reaction capsule and steel mast on top of a large, and therefore we proposed to use the control passive TMD capsule and steel mast top.

CONCLUSION

In recent years, a kind of design idea which take the vibration damping control as a measure and take active defense have made rapid development in some countries with earthquake often happened. In particular, the control method of the structure have developed over the past decade, raising the practice of people to the height of the theory. In the structural design of seismic damping, with the popularity of high-rise buildings, seismic vibration requirements continue to increase, we should learn from the experience at home and abroad, the research and application of structural vibration control of traditional and high-tech construction techniques need to phase combine to make the security system structure become an important part of smart structures for mankind to create a working and living environment more secure and comfortable [7].

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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Declared none.

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