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METHODS FOR REDUCING SEISMIC FORCES ACTING ON BUILDINGS AND STRUCTURES

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ABSTRACT

This article examines, analyzes, and develops recommendations for reducing seismic forces affecting buildings and structures. Various devices have been developed and put into practice by scientists. The advantage of these devices is that their use in dynamic structures allows to reduce the seismic forces acting on buildings and structures. In viscous and dry friction dampers, the friction work decreases sharply with decreasing vibration amplitude, while it is advisable to keep the damper energy distribution level unchanged to maintain efficiency, which also requires the system to maintain the vibration amplitude unchanged. The introduction of damping allows to significantly expand the effective frequency range of vibration dampers. Despite measures to prevent vibration (vibration), including the use of vibration isolations, vibration of a particular structure in the excitation harmonic series is still common.

KEYWORDS: *Active, Passive, Base, Damper, Friction Damper.*

INTRODUCTION

The main purpose of earthquake protection measures used in construction today is to reduce the seismic forces acting on the building and structure. The use of such devices in the construction of buildings and structures allows to improve the dynamic characteristics and significantly reduce the impact of seismic forces.

In recent years, the method of seismic insulation of buildings and structures from the effects of earthquakes is developing around the world. Various devices have been developed and put into practice by scientists. The advantage of these devices is that their use in dynamic structures allows to reduce the seismic forces acting on buildings and structures. They are usually divided into active and passive measures to protect buildings and structures from earthquakes.

Seismic resistance is achieved through the use of vibration damping material in the construction of buildings and structures at the beginning of construction. In ancient times, in some cases, builders insulated the foundation by installing soft pads in the form of a special compound or reed gasket on top of the foundation to reduce the impact of earthquakes on buildings and structures. All of these methods can be called methods of seismic protection of buildings and structures located in the structure. Some authors call them passive methods of protecting buildings and structures from the effects of earthquakes [1-2].

At the beginning of the last century, there was a tendency to add additional connections to the construction of buildings and structures. They are very diverse and can be called a constructive method of extinguishing seismic vibrations of buildings and structures. In practice, such devices are often found in the form of seismic insulation systems with flexible low-rise buildings, vibrating column buildings on kinematic supports, springs, balls, houses on rubber-metal supports, etc. [3-4]. Some authors call them an active way to protect buildings and structures from the effects of earthquakes.

To date, there are various devices that absorb the energy of seismic forces applied in the practice of construction of buildings and structures. These devices are used in various parts of buildings and structures (foundation, floor level, roof, etc.).

The design of the method of active protection of buildings and structures is diverse. The use of each type of device in different parts of buildings and structures allows to improve their dynamic characteristics by changing their geometric parameters. As a result, significant results can be achieved in ensuring their seismic stability.

Statistics show that in recent years, the number of such devices used in the construction of buildings and structures around the world to ensure their seismic resistance has increased (Fig 1). The main part of extinguishing devices used in buildings and structures are rubber and sliding supports with additional extinguishing devices.

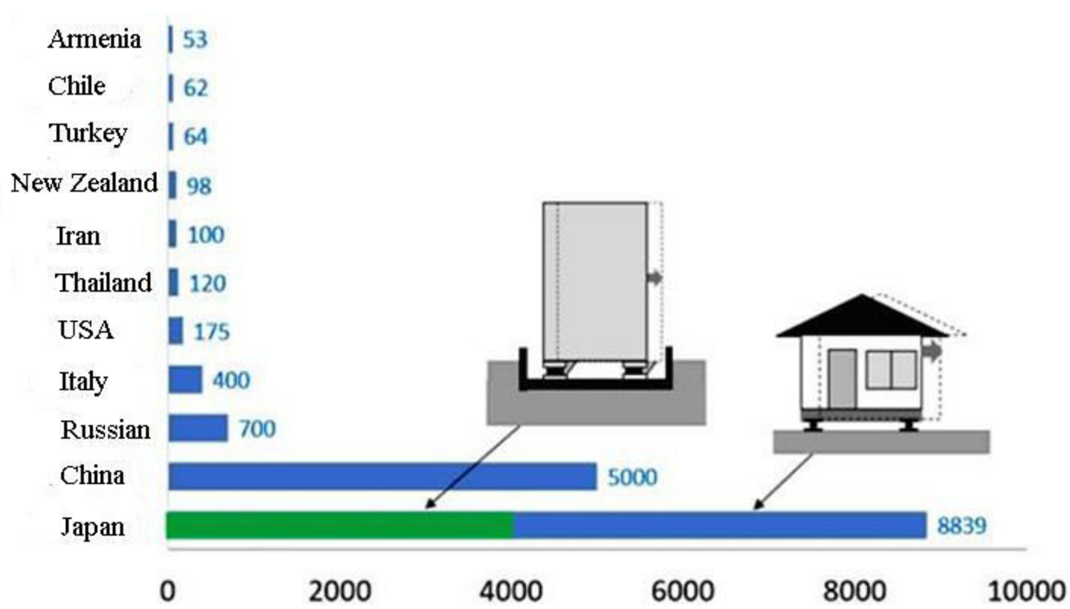

Figure 1.Quantitative indicators of the use of seismic insulation in countries around the world.

Active (active) protection of buildings and structures from earthquakes can include dry friction joints, hysteresis-type friction, connecting and disconnecting joints, etc. [5-6]. Various extinguishers and dampers play an important role in active anti-seismic measures. They allow to improve the dynamic characteristics of buildings and structures. Their designs can be selected during the design process. Dynamic vibration dampers are made in the form of an additional mass attached to the protected structure by means of elastic and damping element. Extinguishers that move along a curved surface or are suspended, such as a pendulum, are also widely used. The extinguisher design consists of a solid body with separate loads or a removable load or container filled with liquid. Elastic elements include steel springs, rubber elements, elastic rods or plates, and materials with high dissipative properties for energy dissipation. The dynamic vibration damper is named after Fram, first invented in 1909. This extinguisher was invented to calm the vibrations of ships from the waves [7-8]. The introduction of damping allows to significantly expand the effective frequency range of vibration dampers. Despite measures to prevent vibration (vibration), including the use of vibration isolations, vibration of a particular structure in the excitation harmonic series is still common. For some reason, it seems impossible to change the mass of the structure or the elastic variable in order to get out of the resonance zone. In such cases, they try to use dynamic dampers. Currently, there are rubber-based, sliding-based, steel-based, arc-based lead-based, hydraulic shock absorbers and friction dampers, etc. in the construction industry around the world. Extinguishing devices in the form of

Rubber-metal supports. Vertical cylindrical lead-core rubber-metal supports that act as energy absorbers have been proposed in [9-10]. It is believed that the lead core provides high hardness in the vertical direction. Under strong seismic effects, large plastic deformations occur in the core, which allows to increase the vibration damping by 3-5 times. Such a structure is the most economical system of seismic insulation, but studies have shown that in some cases the lead core can be damaged (Fig 2.a).

Steel supports. Japanese scientists have invented steel supports to increase the seismic strength of buildings and structures. Such supports allow to work in transverse, longitudinal, vertical and rotational (torsional) vibrations during an earthquake. Since the Kobesko earthquake in Japan in 1995, more than 150 houses have been built each year using this type of foundation [11-12]. This base is located between the foundation and the trunk of the building. During an earthquake, the base allows the foundation under the beam to mix, and as a result, most of the energy from the foundation does not pass to the surface of the building. Applying this insulation almost halves the seismic force. The base is made of high-strength elastic steel in the form of four round springs (Fig 2.b). The disadvantage of this seismic insulating base is that it corrodes in wet conditions, and over the years, the steel loses its strength due to stress.

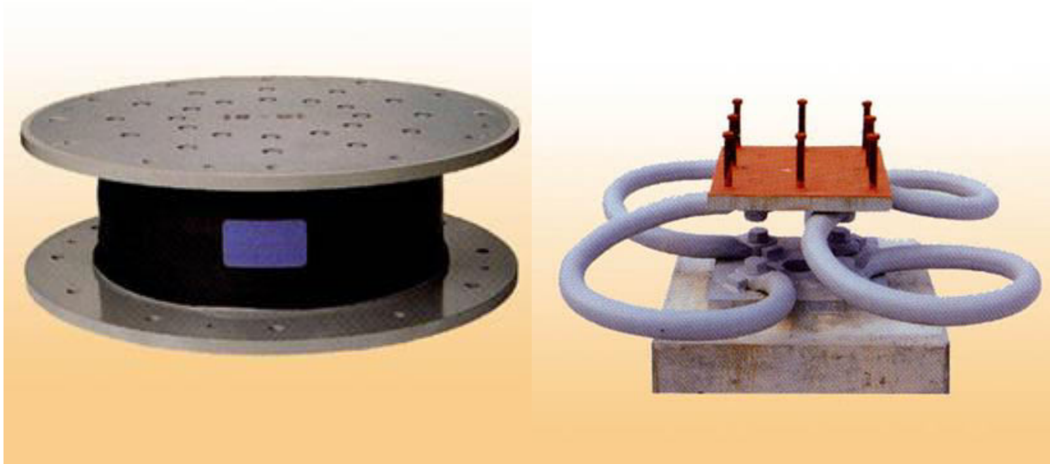

Figure 2.a - rubber base, b - steel base.

Bow-shaped lead supports. Japanese scientists have invented a seismically insulating base in the form of an arc in the form of lead [13-14]. The base is firmly attached to the foundation of the foundation and is installed on the foundation of the building with the foundation.

This base is made of rubber and steel. Lead has plastic properties, so most of the energy generated in the foundation during an earthquake is lost due to the plastic properties of the base. The effect of this type of insulating base is significant, the seismic force is almost halved(Fig 3 a).

Figure 3.a - arc lead base, b - adhesive shock absorber for buildings.

Adhesive friction shock absorbers. Adhesive friction shock absorbers with elastic couplings are widely used in construction practice [15-16]. The elastic bond in them is usually in the form of a spring containing a liquid that sticks to the cylinder. Deformation of the shock absorber causes energy loss due to the sticky friction in the cylindrical bath. In viscous and dry friction dampers, the friction work decreases sharply with decreasing vibration amplitude, while it is advisable to keep the damper energy distribution level unchanged to maintain efficiency, which also requires the system to maintain the vibration amplitude unchanged. This resistance is easily lost in adhesive friction dampers, because in such dampers it is known that due to the significant oscillation of the damper mass it is possible to achieve complete calm of the main system and obtain a significant energy dissipation by adding adhesive resistance to the damper system. The main disadvantages of elastically connected dampers, as is well known, are that they have a more pronounced selected properties, absorbing the vibrations of the desired part. The disadvantage of many viscous friction dampers is that the viscosity properties of the oils are not constant with temperature changes, which leads to deformation of the dampers (Fig 3 b).

Friction damper. Scientists have developed a dry friction damper for use in frame buildings [17-18]. Such a damper is used in the frame cell of the X-shaped and L-shaped connection. Such joints usually provide the transverse and longitudinal rigidity of frame buildings. During an earthquake, dry friction occurs due to the displacement differences of the layers in the friction damper due to the displacement of the two channels (Fig. 4 a). There is a special gap between the supports and the main channel to allow the sliding channels to move. Due to the elastic fastening of the two channels with the help of bolted joints, the Coulomb force was created on the surface of the channel during the movement.

These dampers come in many forms in the construction industry. These dampers are mainly used in high-rise buildings. The effect of such a damper is a sharp decrease in the amplitude of vibration due to dry friction during an earthquake and the vibration does not fall into the resonant mode.

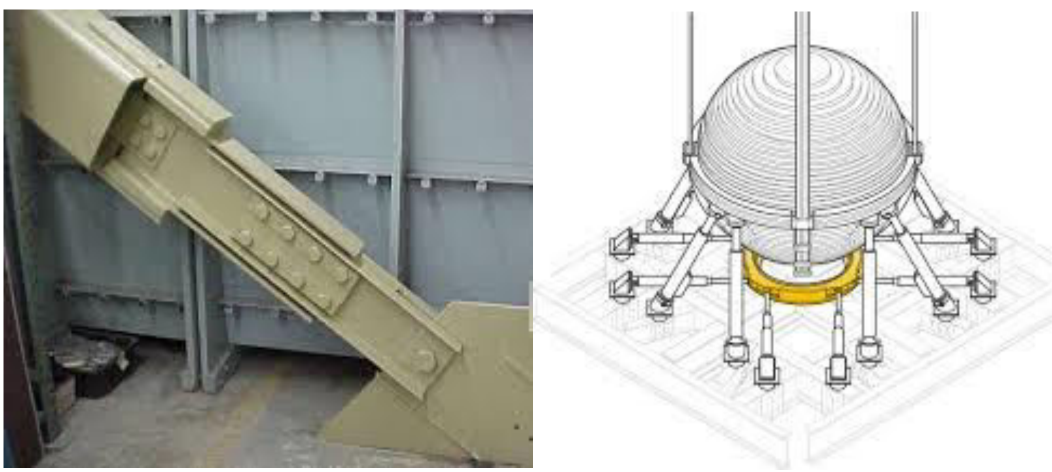

Figure 4.a - friction damper, b - pendulum damper in high-rise buildings.

Pendulum Extinguisher. Pendulum dampers for use in tall buildings and structures have been proposed in the study [19-20]. For damping, the dampers are installed at a height (mark) selected according to the trajectory of the center of gravity of the load. Dumping in pendulum extinguishers is carried out by means of steel wings. Experimental studies have shown that the decremental oscillations of such a extinguisher initially increase with increasing oscillation amplitude and then decrease. At relatively large amplitudes of vibrations, the damping on the wing (rope) is determined by the dry frictional forces between the threads. A second accessory connected to the extinguishing mass near the lower end of the cable may be used to increase damping. The advantage of such extinguishers is their simplicity of design, durability and ease of use (Fig 4 b).

CONCLUSION

Based on the above data, the following conclusions and recommendations were made:

• Design and construction of buildings and structures using active seismic systems in construction practice;

• Installation of dynamic shock absorbers in the construction of multi-storey buildings, especially to help reduce the level of high-spectrum, high-frequency vibrations, loads on the upper floors of buildings during shock and seismic propagation;

• Installation of earthquake dampers with a certain mass on the roofs of multi-storey buildings;

• In the construction of 1-2-storey buildings and structures, to reduce the impact of earthquakes by creating a special layer under the foundation;

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