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Study of the Operation of a Building Model with a Seismic Isolation Sliding Belt

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ABSTRACT: Due to its location, the territory of the Republic is subject to seismic impact of 7-9 points. Along with the traditional methods of seismic protection, a rational solution is the introduction of new active methods, one of which is a sliding belt. The purpose of the work is to test the effectiveness of the use of a sliding belt, in the conditions of construction on the territory of the Republic of Uzbekistan, using the example of a building with a flexible structure.

KEY WORDS: seismic protection, foundation, seismic isolation belt, fluoroplastic, earthquake, seismic impact, building, structure, foundation platform, seismic protection, sliding layer, seismic protection control system

INTRODUCTION

Summarizing the work on the theory and practice of earthquake-resistant construction, we will follow the logic of research, which leads to the conclusion that a systematic organization of research is necessary for the effective long-term development of earthquake-resistant construction, since the current state is characterized by problematic miscalculations, including:

- inconsistency of the normative theory of the spectral method of calculation with the real physical nature of the seismic impact (not taking into account the first shock, etc.);
- the gap between geodynamic information in points and its reproduction and use in building design;
- neglect of the characteristics of real foundations, which significantly affect the seismic resistance of the upper structure, the lack of development of earthquake-resistant foundations;
- paradoxes arising from the desire to "refine" the normative theory in the case of complex soil conditions;
- practical absence of development and application of external seismic protection devices and systems for automatic control of seismic safety of buildings (structures), etc.

Thus, by updating and modernizing existing norms, it is impossible to ensure long-term development, deeper (radical) changes are needed. Development of constructive safety methods. The shortcomings (weakness) of the normative theory have a negative impact on the development of constructive seismic safety methods, which, according to engineering design, are based on a real picture of seismic impact, and the normative theory does not correspond to it. Apparently, for this reason, a number of constructive principles and recommendations that do not follow directly from the normative theory are not reflected in the current norms.

We point out that the use of sufficient dimensions of a spatial foundation platform on a sliding layer successfully performs both of these functions (it has a greater distribution capacity from vertical loads and a decrease in the transmission of horizontal displacements from the base to a spatial foundation platform with a topside structure), without requiring an artificial foundation device (ramming, piles). etc.) and a large additional "cushion"

Active methods of seismic protection include the device of a seismic isolation belt. The sliding belt seismic isolation system in the foundation is the creation of a sliding surface with a lower coefficient of material friction between the top of the building and the foundation. All seismic isolation systems with dry friction elements are structurally made in the form of upper and lower support elements, between which a layer of materials of mineral origin, sand, clay, etc. is placed. or synthetic gaskets with a low coefficient of friction, for example, fluoroplastic (k=0,1-0,2).

The United States Geological Survey (USGS) has calculated that since 1900, approximately 18 earthquakes of magnitude 7 to 7.9 and more than one earthquake of magnitude 8 have occurred on earth every year [1]. In 2011, the Circum-Pacific seismic belt entered a period of seismic activity, and several large earthquakes occurred in just four months [2] (Table 1).

Таблица 1

№	Дата	Страна	Масштаб	Глубина очага
1	01.01.2011	Аргентина	7.0 баллов	576.8 км
2	02.01.2011	Чили	7.1 баллов	25.1 км
3	13.01.2011	Вануату острова	7.0 баллов	9 км
4	18.01.2011	Пакистан	7.2 баллов	68 км
5	22.02.2011	Новая Зеландия	6.5баллов	4 км
6	09.03.2011	Япония	7.2 баллов	32 км
7	11.03.2011	Япония	9.0 баллов	24.4 км
8	24.03.2011	Мьянма	7.2 баллов	20 км
9	11.04.2011	Япония	7.1 баллов	10 км

The destruction and collapse of buildings is one of the main consequences of an earthquake. Analysis of previous destructive earthquakes and their investigation on the ground showed that most of the buildings suffered damage, which led to the destruction of load-bearing elements. Therefore, the building loses its stability and strength, collapses, which leads to human casualties and large material losses.

Seismic isolation is considered one of the most effective modern means of ensuring the seismic resistance of buildings and structures. In Russia, 301 civil seismically isolated buildings and several dozen seismically isolated bridges are currently in operation. Hundreds of civil, industrial and transport structures with seismic isolation elements have been built abroad, and the French firms Spie Batignolle and. Electrecity de France designed and built several reactor compartments of nuclear power plants, including those in the 8-point zone near the city of Koiberg (South Africa). Despite such a wide distribution of seismic isolation systems in earthquake-resistant construction, the problems of theoretical substantiation of the effectiveness of these systems and optimization of their parameters, especially under various soil conditions, have not yet been fully and acceptable for practical use.

Solving the problem of seismic resistance of buildings by strengthening their strength is the first thing that started the practice: earthquake-resistant construction. However, with the growth of the complexity of structures and the expansion of knowledge about seismicity, the situation has reached a dead end. Increasing the strength based on the maximum impact, with the growth of the latter, led to the need for the construction of powerful structures. It was necessary to look for another way.

Therefore, it is no coincidence that both in Vietnam and abroad, recent years have been marked by an increased interest in studying the seismic resistance of building structures, and the rapid development of the sciences that serve as the basis for the development of the theory of seismic resistance (engineering seismology, structural mechanics, etc.) . Attention is drawn to the increased interest in the methods of seismic isolation of buildings, which follows from the analysis of reports at international conferences.

METHODS

Practice has shown that the anti-seismic design method, although effective, brings with it some problems. [3].

1. "Rigid resistance" as the main way to increase the rigidity of the structure, with an increase the size of the section of the structural element and the consumption of reinforcement. But with an increase in material consumption and structural rigidity, the weight of the building will also increase, and therefore the impact on building structures from an earthquake also increases, i.e. a vicious circle is formed.
2. Many important structural members cannot function as inelastic members.
3. When the overall structure of a building is operated in an inelastic state, the result is large deformations and cracks, making the building unfit for further use.
4. Traditional methods of seismic resistance of a structure are based on an assessment of the level of seismicity in a given area. But in some areas, the determination of the level of seismicity has a low accuracy, which leads to uncertainty.

Based on this, in order to ensure the seismic resistance of buildings, some new theories are looking for more rational, cost-effective designs that take into account safety issues. In recent years, a new method of increasing the seismic resistance of buildings, called the active method of seismic protection, has been used in experimental construction, in contrast to the traditional (passive) method, which requires additional costs for anti-seismic strengthening of structures. The active method of seismic protection provides for the reduction of seismic loads on structures by regulating their dynamic characteristics during the oscillatory process during an earthquake. The dynamic parameters are controlled in such a way as to avoid a resonant increase in the vibration amplitudes of the structure or, at least, to reduce the resonant effects. This is achieved by an appropriate choice of dynamic stiffness and, accordingly, the frequencies and periods of natural oscillations of the structure.

Changing the dynamic stiffness or frequencies and periods of natural oscillations during an earthquake can be achieved using special design devices. Seismic isolation also includes the so-called rubber-metal supports [4] in the form of rubber poles with metal spacers and a lead core in the center. Undoubtedly, rubber-metal poles, used in China, Japan and some other countries, have great advantages as a seismic protection method for buildings. Unfortunately, scarce material and prefabrication make them too expensive for mass use, especially in locations far from manufacturing plants. All this limits the use of rubber-metal bearings. In this sense, sliding belts, made from traditional reinforced concrete at any landfill, have their advantages. The sliding belt seismic isolation system in the foundation is the creation of a sliding surface with a lower coefficient of material friction between the top of the building and the foundation. During an earthquake, the superstructures of the building have the ability to carry out horizontal movement in relation to the base with a further return of the building to its original position. The main condition for the effective operation of such a system is the remoteness of the frequencies of its natural oscillations from the prevailing frequencies of the seismic movement of the soil of the base of the structure.

In the sliding belt technology, the key element is the sliding device, which includes a friction minimization component and a horizontal movement limitation component [3]. Justification of the effectiveness of external seismic protection. Sliding layer under the foundation platform. Seismic protection methods are presented in the current standards in a very limited way: external seismic protection is not provided, and the use of seismic isolation inside the building is unreasonably limited by the requirement to place it “above the foundation”. Methods of external seismic protection have ancient roots and are now being developed in the form of foundation platforms on a sliding layer.

Note that damping and seismic isolation devices have received sufficient development. At the same time, slip devices, incl. by regulating and reducing friction, developed insufficiently. It was possible to show on the basis of computer simulation that the installation of a sliding layer (for example, in the form of several layers of film) between the foundation slab and the base leads to a many-fold reduction in the seismic impact on the foundation and the superstructure.

In the state scientific planning for the development of earthquake-resistant construction in the Republic of Uzbekistan, there are no search and implementation innovations for external and internal seismic protection. In practice, they are guided by expensive foreign (Chinese, etc.) devices, neglecting domestic devices. Traditional internal (above the foundation) seismic isolation in the form of kinematic supports, rubber-metal dampers reduces tangential impacts that cause oscillations of the upper structure (approximately by 1-2 points).

The proposed external (under the foundation slab) seismic protection: the sliding layer under the foundation platform limits the level of transmitted tangential impacts on the system (foundation + superstructure) - no higher than the design level.

Insulating elements require not only vertical bearing capacity to support the top structure of the gravity of the load, but also a low coefficient of friction to ensure good insulation effect. The friction minimization component consists of a top and bottom plate and a central sliding surface. For the central sliding surface, a PTFE-4 film, an elastic coating of graphite, stainless steel, sand, talc, etc., are usually used in the upper and lower plates [7]. high-strength concrete or steel can be used. The device of the component for limiting horizontal movements does not provide a vertical load, but only stabilizes the structure and limits movements under horizontal load. Rubber gaskets, steel spring, U-shaped steel, flexible steel rods, etc. can be used as such a component.

RESULTS AND DISCUSSION

Depending on the shape of the sliding surfaces, seismic isolation devices of the sliding type can be divided into two groups: non-return devices and structures with a gravitational restoring force. The first group includes support devices with horizontal sliding platforms. The potential energy of the mutual position of the structural elements in the process of their relative movement remains constant, i.e., the system is always in a position of stable equilibrium. Devices of the second group, which generally have non-horizontal sliding surfaces, ensure the return of a structure displaced as a result of a seismic shock to the initial position of stable equilibrium due to the occurrence of a gravitational restoring force, constant in magnitude (inclined surfaces) or positional, i.e. sloped surfaces work as components of limiting movements.

The task was set - to develop a constructive solution for the seismic isolation mechanism and evaluate the effectiveness of its introduction into the foundation structure.

As an object for analyzing the operation of a sliding belt during a seismic vibration, a business center building was taken, the modeling of which was carried out in the Allplan complex (Fig. 1).

The seismic isolation mechanism is performed as follows (Fig. 2). The foundation slab is arranged in a mold along the second group of sliding surfaces with an angle of inclination a=6°. Displacement limiting walls are made in such a way that a gap (0.5 m) is formed between the lower slab of the building and the limiting walls, which allows the building to move in all directions by values equal to the displacement of the base.

The gap is filled with sand, because. it works like a damper. 2 layers of fluoroplastic film are laid on the surface of the foundation slab (b=4-6 mm) . On the upper layer, the lower reinforced concrete slab of the building is concreted, and the building itself is erected on it. During an earthquake, the foundation slab with displacement limiters and the bottom layer of fluoroplastic film will repeat the vibrations of the foundation.

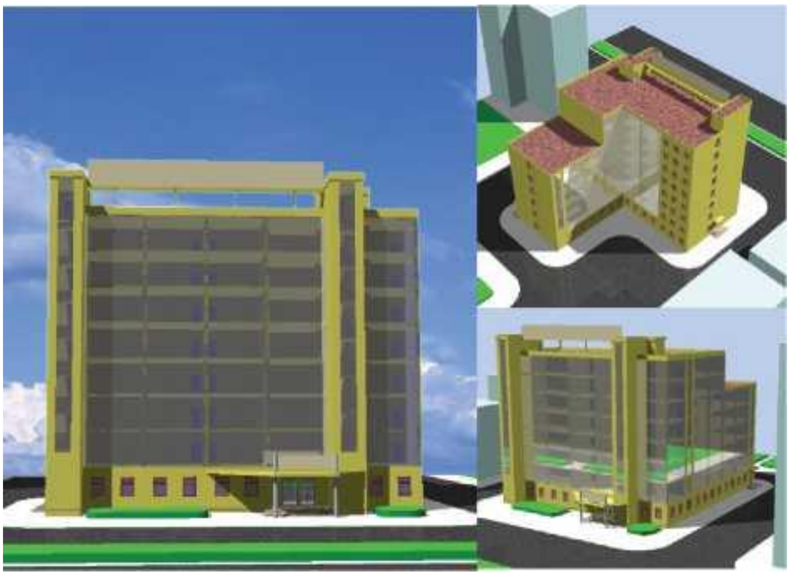

Figure 1. Model in Allplan

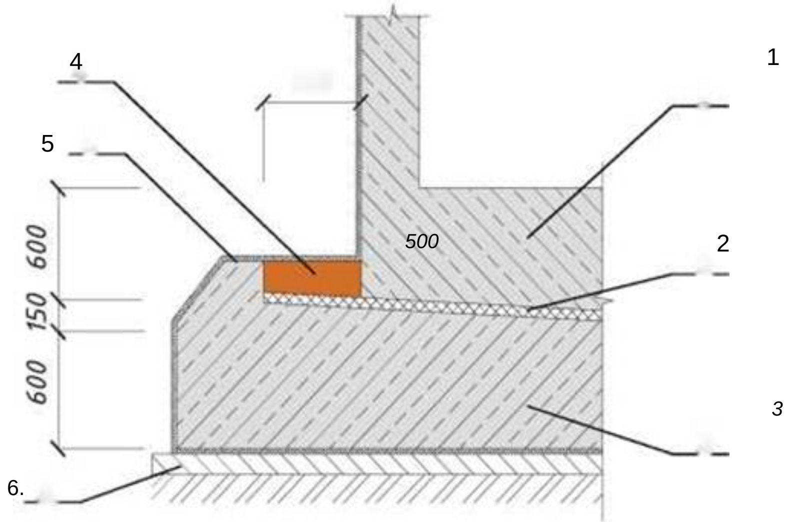

Figure 2. Scheme of a seismic isolation sliding belt:
1 - the lower part of the building at the foundation level; 2 - fluoroplastic plates; 3 - foundation; 4 - coarse sand (damper); 5 - waterproofing; 6 - concrete preparation of rest.

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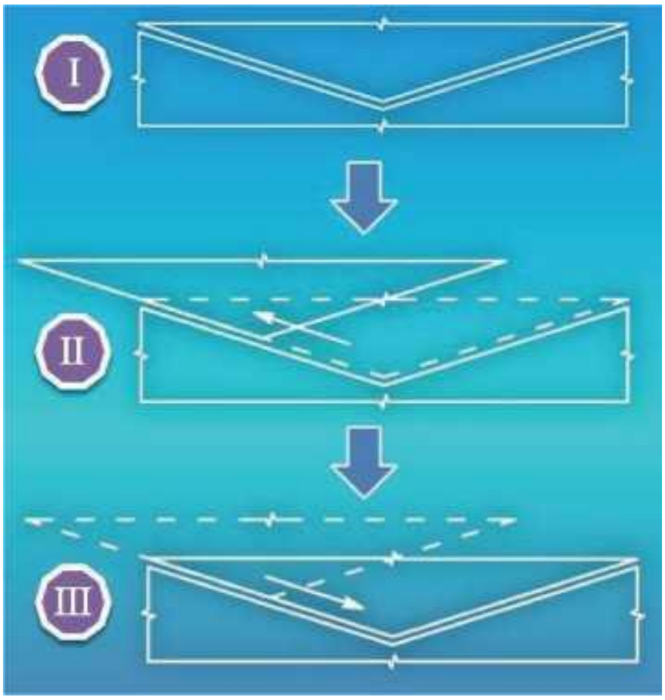

Figure 3. Diagram of the principle of operation of the sliding belt.

The upper layer of the fluoroplastic film interacts with the lower one. Due to the low coefficient of friction in the contacts [12] fluoroplast-fluoroplast Ктр=0,1-0,2, and also due to the inertia force of the building, the structure will be in a state of relative rest.

- The principle of operation of the seismic isolation system under the influence of seismic load is divided into 3 states (Fig. 3):
- state 1 - in small earthquakes, the friction rest prevents the upper structure from sliding, so that the structure is stable;;
- state 2 - after exceeding a certain threshold value of the seismic load, the shift in the horizontal direction on the insulating layer is greater than the friction of rest, the sliding surface begins to slide to play the role of seismic insulation;
- state 3 - return of the upper part of the building to its original position.

Let's build a foundation model with a sliding belt (Fig. 4.).

When studying the behavior of seismic isolation systems during dynamic action, it is important to pay attention to the change in natural vibration frequencies. It is known that seismic isolation properties appear with a decrease in the rigidity of the building, that is, the oscillation period increases, the frequency decreases, and thereby seismic loads are reduced.

An analysis of the results showed that an increase in the periods of resonant oscillations of the system is linearly related

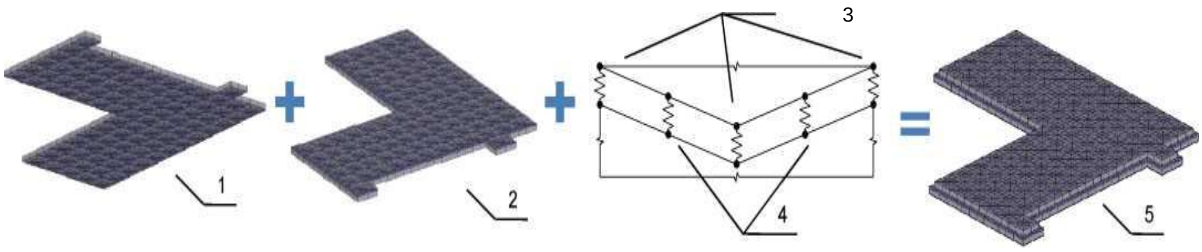

Figure 4. The scheme of modeling the foundation with a sliding belt:
1 - a model of the lower slab of a building with a 3x3m element; 2 - a model of a foundation slab with a 3x3m element with a 0.5 m extension relative to the lower slab of the building; 3 - the first group of stiffness characteristics with an elastic bond in the form of 55; 4 - the second group of stiffness characteristics with an elastic bond in the form of 55; 5 - a sliding belt model

to an increase in translational displacements in the level of sliding devices.

In the absence of slippage in seismic isolating supports, the attenuation in the structure, determined by the shape of the resonance curves and the relative oscillation parameter (the ratio of the acceleration of the structure to the acceleration of the impact), remains constant when the disturbing load changes. The inclusion of dry friction elements, which are sliding belts, leads to an increase in attenuation in the system in proportion to the change in the disturbing load. The growth of energy dissipation in the sliding elements ensures the stabilization of the reaction of the structure at a quite certain level.

Based on the selected design scheme of the seismic isolation mechanism, two finite element models of the building were created: one, which includes the seismic isolation mechanism according to Fig. 4., and another similar one without it (Fig. 5.).

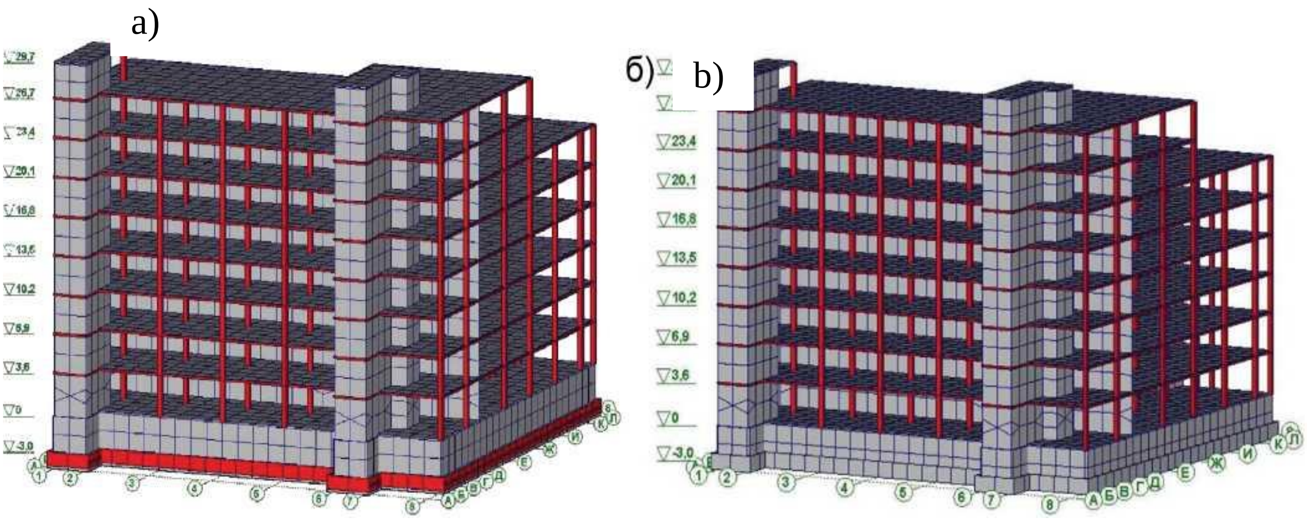

Figure 5. Calculation models: a) seismically isolated building; b) non-seismic isolated building

CONCLUSION

Thus, a constructive solution has been developed that provides the ability to move the building by the amount of displacement of the base during an earthquake, while maintaining the spatial rigidity of the seismically isolated structure.

According to the results of the study presented in the article, the following can be noted. The introduction of a seismic isolation mechanism into the foundation design makes it possible to reduce vibration frequencies and stresses in the structure and, as a result, reduces the likelihood of structure collapse, which ensures the safety of human lives and valuable equipment, and also reduces the consumption of reinforcement, which makes the building structure more economical.

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