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Sistems With a "Flixible Bottom" of the Bilding Objekt

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Abstract: The article describes the most frequently used methods for ensuring seismic resistance of buildings and structures designed for construction in seismic areas.

Key words: seismic resistance of buildings and structures, traditional methods, active seismic protection, seismic protection methods.

INTRODUCTION

The work offered for attention is intended for senior students, postgraduates and engineers, teachers and researchers involved in earthquake-resistant construction. The work is devoted to a progressive direction in the field of effective and reliable seismic protection - active seismic protection systems. The increased interest in the noted systems observed in recent years from specialists is due to higher efficiency and reliability indicators that they demonstrate in comparison with traditional methods and ways of seismic strengthening of construction objects.

MAIN PART

The idea of reducing seismic impact on a construction site due to elastic compliance or mobility (displacement) of the frame, its elements and units is the basis of a number of active seismic protection systems. The main advantage of such seismic protection is its simplicity and low cost.

The idea itself is not new - it has centuries of practical implementation experience. Even a thousand years before the new era, according to the noted principle of operation of load-bearing structures, frame-clay houses were built in Ancient Egypt, China, India; closer to us in time - in the Caucasus and Central Asia. Moreover, this method was used to build palaces of nobles, walls of fortifications, housing for the poor. Thousands of years have passed, but even now, in the private sector, frame-clay houses are often built.

The basis of the objects being marked is a wooden frame with filling from local materials; fired and unfired brick, adobe mass, etc. Then the whole structure is coated with clay and, after drying and painting, the result is quite warm, comfortable and inexpensive houses (Fig. 1.1, a-d). The roof is made of straw or is made according to the same frame-clay principle.

The weak point of the structures was the separate operation of the flexible frame and rigid clay filling, which simply falls out of the plane of the frame during shaking. The wooden frame itself has proven its high efficiency and reliability in many earthquakes. To confirm the high seismic resistance of frame-clay houses, it can be noted, for example, that the examination of such houses after the Dagestan earthquake of 1970 and the Gazli earthquake of 1976 allowed specialists to conclude that the destruction of frame-clay houses occurs at the maximum earthquake calculated according to SNiP of 9 points. This means that the seismic resistance of the noted buildings is no less than the seismic resistance of ordinary houses made of fired brick.

The class of systems based on changing elastic forces includes a group of systems with elastic supports and shock absorbers and partially a group of systems with low rolling friction with kinematic supports based on spheroids and racks with spherical end surfaces. In turn, the group of systems with elastic supports and shock absorbers is subdivided into:

- on systems with a “flexible bottom” of supporting structures;
- systems with "springs or suspension supports";
- And systems with "rubber-metal supports".

Since the elements and nodes of the frame of a construction object can be flexible and pliable not only on the first floor (Fig. 1.2, a), then in construction practice systems are often divided into systems with a “flexible pile foundation” (Fig. 1.2, g-d), with a “flexible basement” (Fig. 1.2, g-z), etc. However, in general, all of these are systems with a “flexible lower part”.

In general, the idea is based on the idea that in all earthquakes, the seismic response of buildings with a flexible structural scheme is always lower than that of buildings with a rigid structural scheme. This is achieved by using the inherent flexibility and pliability of the materials of the load-bearing elements and by structurally providing the frame elements or pile heads with the ability to freely move at ground or first floor level during an earthquake. As a result, during an earthquake, the load-bearing support elements can move independently of each other in accordance with the complex, chaotic movement of the soil, which reduces the seismic impact on the building.

The emergence of seismic protection systems with a “flexible pile foundation” (Fig. 1.2, d-e) is due to poor soils and their high water content. A classic example of this is the Gereon (the Temple of Hera), built in the 8th century in the Peloponnese, which was erected in Olympia on poor soils formed as a result of the alluvial process of a mountain river. The bedrock was deep, and the surface layers were clayey quicksand with

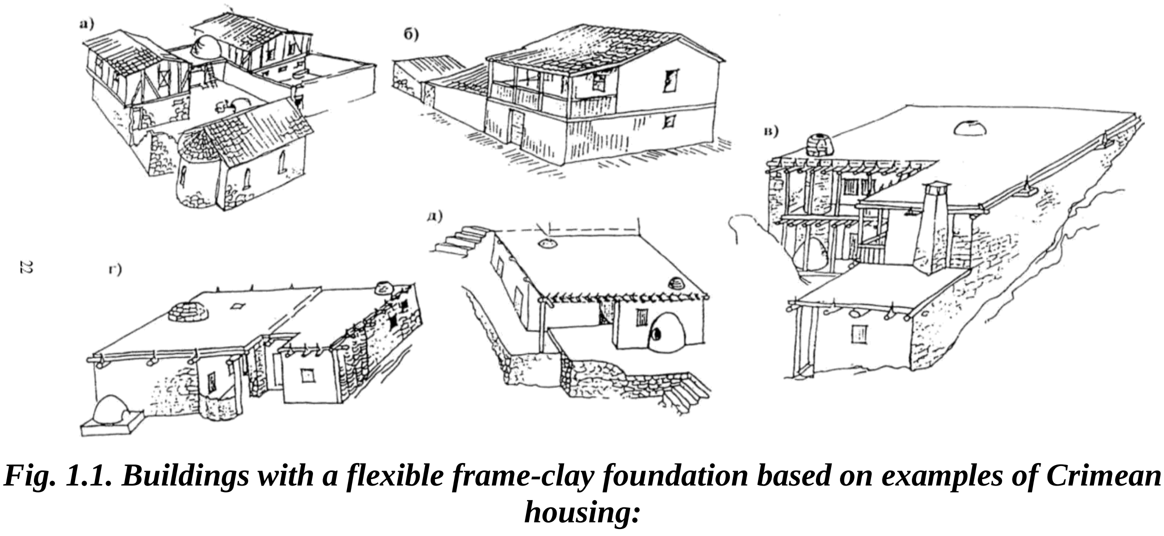

Fig. 1.1. Buildings with a flexible frame-clay foundation based on examples of Crimean housing:

A) two-storey house of the Tats (Shelen village, Sudak district); b) medieval residential house (based on excavation materials at Eksikermen); c) two-storey house (Shelen village, Sudak district); d) house in Shelen village, Sudak district); d) house in Verkhniy Ai-vasil village (Yalta)

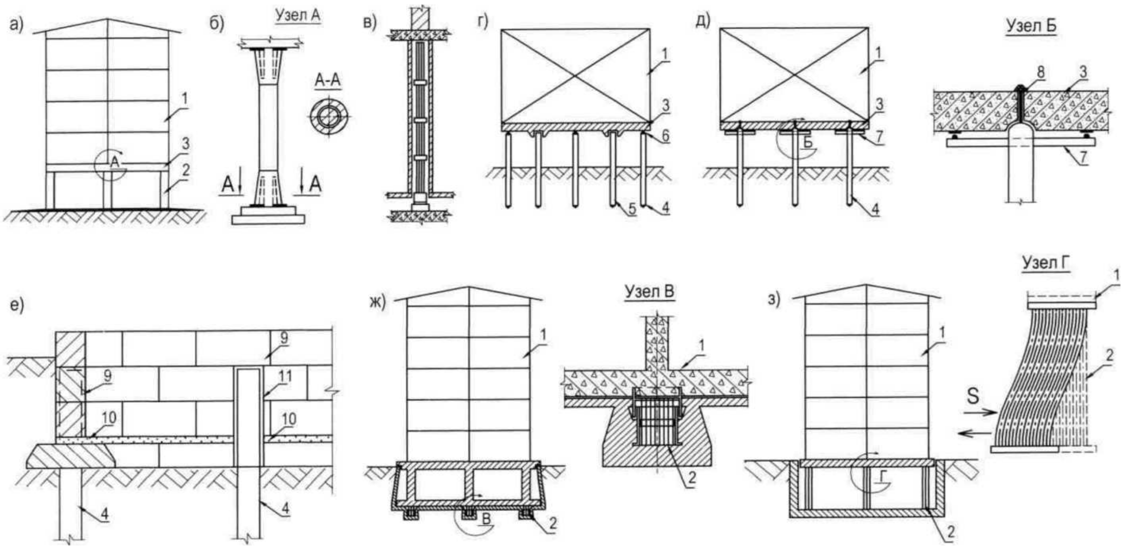

Fig. 1.2. Structural examples of active seismic protection systems with a "flexible lower part":

with a "flexible first floor" option: a) reinforced concrete supports, b) according to No. 510577 - Russia, d) according to Japanese patent No. 7663/77, with a "pile foundation" options: d) according to No. 1161662 - Russia, e) according to No. 540970 - Russia, e) "strip foundation" according to A.S., Russia No. 522307, with a "flexible basement", option according to Japanese patent: g) No. 41845/72, h) No. 43029/74 (all I. class. E 01 627/34 and h 9/02);

1 - construction object, 2 - flexible supports, 3 - strapping beam (grillage). 4 - main piles, 5 - limiting piles, 6 - hinge joint, 7 - pile rotation angle limiter, 8 - compression rods, 9 - strip foundation blocks. 10 - expansion joint, 11 - structural gap. close occurrence to the surface of the groundwater level. In addition, this is a seismically active area. Therefore, Gereon was placed on an artificial platform built from frequently driven piles, the space between which was filled with rubble and river pebbles. Stone slabs of the temple plinth were laid on this site, and the walls of the temple were erected on them. Despite the short-lived material, thanks to timely repairs, with the replacement of wooden columns with stone, the temple stood for more than a thousand years.

A similar approach to solving the problem can be seen in the earthquake-resistant foundation of the Russian Federation No. 522307 E 02 D 27/34 (Fig. 1.2, e). Here, in order to increase the seismic resistance of the building, pile heads are introduced into the technological breaks of the strip foundation.

For Venice, the choice of pile foundations with a high projecting pile head was predetermined by the city's location. Venice, as is known, is located on 118 islands of the Venetian Lagoon, separated by 150 canals. Thus, the noted practical implementation of construction projects is based on geological conditions and the lack of opportunity for builders to choose a construction site. In many cases, the same reasons and considerations dictated the constructive implementation of a number of similar construction projects in China, India, and Southeast Asia.

Modern solutions, for example, according to the Russian Federation Order No. 1161662 and No. 540970 E02 D 27/34 and D 27/12 (Fig. 1.2, d-e), are, in general, similar to their historical predecessors, with the exception of the pile material and construction technology.

The use of buildings and structures with a “flexible first floor” based on a reinforced concrete or metal frame (Fig. 1.2, a-c) is associated with the replacement of wood with more industrial materials - metal and reinforced concrete, and the material of the frame filling - with stone and fired brick.

At the same time, in modern solutions, the "flexible lower part" is structurally implemented both without filling and with partial wall filling. Unfortunately, strengthening the flexible floor leads to a tightening of the system and a change in its dynamic parameters, which directly affects the seismic insulation properties of seismic protection.

The seismic protection with a "flexible first floor" owes its wide distribution in construction practice to its structural simplicity, low cost, efficiency and reliability. However, the consequences of a number of strong earthquakes, the analysis of their records indicated the possibility of the occurrence of very noticeable accelerations in the area of periods up to 1-2 s, and sometimes even up to 4-5 s, during some earthquakes. In the case of the location of construction objects with a "flexible lower part" in the zone of such earthquakes, their catastrophic destruction is possible, which is what happened in Caracas (Venezuela) on 30. YU .67, in Agadir (Morocco) on 29. YU .60, Skoplje (Yugoslavia) on 26. YU .63, Bucharest (Romania) on 4. III.77 [17-18]. Considering that earthquakes with a predominance of low-frequency vibrations are quite rare, objects with a “flexible lower part” can be used as a means of active seismic protection, but only in combination with other additional means, for example, in combination with on-off connections, dampers, etc.

Then, due to the misalignment of the center of mass with the center of rigidity, the phenomena of bending and twisting of the building object around its axis, caused by the spatial, dynamic nature of the seismic impact, the extreme and corner elements of seismic protection, in relation to the centrally located ones, are overloaded, working not only on alternating compression forces, but also alternating bending and stretching forces. Which, on the one hand, requires their additional reinforcement, on the other hand, leads to additional, design restrictions on the mass, number of storeys, dimensions and configuration of the object.

Unfortunately, buildings with a "flexible lower floor" are poorly adapted and adapted to the perception of the vertical dynamic component, although the experience of real earthquakes shows that the vertical component of the seismic impact can be quite significant. For example, in the case of the Chilean earthquake of 1985, the vertical acceleration of the ground reached 0.85 g , in the Gazli earthquake of 1976 - 1.2 g , and in the earthquake in Imperial Valley (California, USA) in 1979 - 1.66 g [20-22].

Hence the need for mandatory provision of an integrated approach and general seismic protection of the construction site.

In general, active systems with a “flexible lower floor” deserve attention from specialists and additional scientific and technical research, since they undoubtedly have a certain positive potential, especially when applied and used as part of an integrated approach and ensuring seismic protection of construction projects.

Methodology

The researchers employed theoretical and practical strategies to analyze seismic protection systems with flexible bottoms for buildings located in seismic zones. A detailed examination of present seismic protection techniques occurred first through literature analysis that emphasized flexible lower structural elements like flexible foundations along with basements and first floors. Performance data from past earthquakes was studied along with contemporary examples across earthquake-prone regions. The evaluation investigated different active seismic protection systems through a comparison that measured their performance and economic viability based on past seismic events and their incarnation of flexible supports and shock absorbers with rubber-metal bearings. Dynamic building simulations based on structures with flexible bottom systems assessed their seismic performance during low- and high-frequency seismic wave scenarios according to the study. These computational models enabled researchers to simulate how these structures would react during actual seismic incidents. Research included field examinations of buildings constructed with flexible bottom systems that provided data about the systems' ability to reduce earthquake-related structural damage from previous earthquake events. A visual inspection analysis confirmed the performance results of these buildings by checking them against seismic records from the Gazli (1976) and Dagestan (1970) earthquakes. The scientists used laboratory tests on reduced-scale buildings equipped with deformable base systems. Seismic loading conditions were applied to study model building responses alongside the assessment of various support system methods. The study yielded design recommendations for modern earthquake-resistant construction through which flexible bottom systems can be integrated while considering materials selection and structural configurations and safety buffer values. The analysis revealed weak points in structural safety allowing researchers to identify corrective measures that enhanced building protections. The authorization approach generated thorough assessments of flexible bottom systems by conjoining theoretical examination and computer modeling and site investigations alongside experimental tests for the emergence of optimal seismic safety protocols.

Results and Discussion

The research discovery revealed that seismic protection systems assisted by flexible bottom structures significantly decrease the building vulnerability to seismic events. Tests showed these systems using flexible pile foundations combined with flexible first floors supported by shock-absorbing supports minimized structural seismic responses in earthquake settings particularly where the foundation areas contained poor soil materials. Examples from ancient historical sites including the Temple of Hera in Olympia and Venetian buildings prove that flexible foundation systems achieve effectiveness during seismic events in active zones. Reinforced concrete frames combined with rubber-metal supports allow engineers to achieve seismic hazard reduction benefits through contemporary building materials and sophisticated construction approachesLaboratory tests along with dynamic simulations verified that flexible bottom systems minimize catastrophic failures of structures under intense earthquake events. Current studies indicate that specific low-frequency earthquakes can cause system vulnerabilities demonstrated by the Caracas (1967) and Agadir (1960) seismic incidents. Under high-frequency seismic waves these systems displayed excellent performance yet their structural stability weakened when striking low-frequency waves persisted. The flexible nature of the building's lower section successfully decreased earthquakes-related torsional motions and lateral flexions thus limiting potential collapse hazards. When used with additional measures like damping devices and structural reinforcements the effectiveness of flexible bottom systems reaches its maximum potential. The research team found that flexible bottom systems present beneficial characteristics yet require inclusion within a complete seismic protection framework. More research and development efforts must occur to optimize these systems for future applications in earthquake-resistant construction practice.

Conclusion

The combination of active seismic protection systems with flexible lower structures functions as an effective earthquake mitigation method especially for buildings located in seismic areas with uneven soil conditions. Modern and historical buildings demonstrate that foundation solutions incorporating flexible pile systems and flexible first floors enhance seismic resistance by reducing structural movements throughout earthquakes. These systems demonstrate effectiveness in decreasing seismic forces yet their performance limitations become apparent under low-frequency earthquake occurrences. The performance of these systems under seismic conditions requires supplemental seismic protection through damping devices and structural reinforcements for maximum effectiveness. Ongoing research combined with technological improvements will boost the reliability level and suitable applications of these systems for earthquake-dependent construction.

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