http://doi.org/10.58225/sw.2023.2-133-140

SEISMIC RESISTANCE OF ENGINEERING SYSTEMS OF BUILDINGS

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Abstract. The seismic resistance of a structure is ensured both by the choice of a seismically favorable construction site, and by the development of the most rational structural and planning schemes for the structure, special design measures that increase the strength and solidity of the supporting structures, creating the possibility of developing plastic deformations in structural elements and nodes, significantly increasing the resistance of structures to action seismic forces. Of great importance for improving the seismic resistance of structures is the high quality of building materials and works. This article outlines the general requirements for engineering systems of buildings under construction in earthquake-prone areas.
Keywords: seismic resistance, engineering systems, earthquake-prone area, fastening pipelines

BİNALARIN MÜHƏNDİS SİSTEMLƏRİNİN SEYSMİK MÜQAVİMƏTİ

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Xülasə. Quruluşun seysmik müqaviməti həm tikinti üçün seysmik cəhətdən əlverişli bir sahənin seçilməsi, həm də quruluşun ən rasional struktur və planlaşdırma sxemlərinin inkişafı, dəstəkləyici strukturların gücünü və monolitliyini artıran, struktur elementlərdə plastik deformasiyaların inkişafına imkan yaradan xüsusi konstruktiv tədbirlər ilə təmin edilir.strukturların seysmik qüvvələrin təsirinə qarşı müqavimətini əhəmiyyətli dərəcədə artıran Komponentlər. Tikinti materiallarının və işlərinin yüksək keyfiyyəti strukturların seysmik müqavimətini artırmaq üçün böyük əhəmiyyət kəsb edir. Bu məqalədə seysmik təhlükəli ərazilərdə tikilməkdə olan binaların mühəndis sistemləri üçün ümumi tələblər göstərilir.
Açar sözlər: seysmik müqavimət, mühəndis sistemləri, seysmik təhlükəli Rayon, montaj boru kəmərləri

Introduction. Seismic engineering is a branch of civil engineering that specializes in studying the behavior of buildings and structures under seismic impact in the form of ground shaking, soil loss of its bearing capacity, tsunami waves and the development of methods and technologies for building buildings that are resistant to seismic impacts [1]. The seismic resistance of a structure is ensured both by the choice of a seismically favorable construction site, and by the development of the most rational structural and planning schemes for the structure, special design measures that increase the strength and solidity of the supporting structures, creating the possibility of developing plastic deformations in structural elements and nodes, significantly increasing the resistance of structures to action seismic forces [2]. Of great importance for improving the seismic resistance of structures is the high quality of building materials and works. This article outlines the general requirements for engineering systems of buildings under construction in earthquake-prone areas [3].

Seismic resistance and internal engineering systems. Over 20% of the territory of Azerbaijan belongs to seismically hazardous zones, in which tremors exceeding 4 points on the Richter scale are possible. Recent studies and observations have shown that in many areas the estimated level of seismicity is underestimated. Also, a technique has not yet been developed that makes it possible to predict with high accuracy where and at what time an earthquake will occur [4].Therefore, the forecasting of seismic activity and the development of special measures for construction in seismically hazardous areas is one of the most important objects of state attention.

According to experts in Azerbaijan, there is no need to completely abandon the construction of facilities in potentially seismically dangerous zones. For example, in China, Japan and Chile, technologies are successfully used to ensure the safety of structures in seismically active areas. One of the technical solutions is to increase the rigidity and stability of structures. Also abroad, the technology of building on seismic isolators is very widely used. Their main task is to dampen dynamic loads at the base of buildings. In our country, seismic isolators are just beginning to be used [5]. To ensure the safety of buildings in seismically hazardous areas, special seismic-safe foundations and special seismic belts are used, which are "reinforcements" between the floors of buildings. In addition, buttresses are used to strengthen buildings - vertical protruding parts of the walls that ensure the stability of the structure by creating a counterweight [6].

At the same time, experts are concerned about the safety of high-rise buildings that have been actively built in our country over the past 10 years. The higher the building, the greater the amplitude of oscillations it develops. It is important that not only the structures of such buildings withstand the earthquake, but also the engineering systems. The modern building is a complex of complex engineering systems. Water supply, heating, cooling - in all these systems there is a large volume of water, if they are damaged at the initial stage of an earthquake, the evacuation of people from the building can be significantly complicated. But according to the recommendation of the Ministry of Emergency Situations, at the first tremors, it is necessary to leave the building as soon as possible. The performance of the fire extinguishing system is also important. It is known that significant damage during earthquakes is caused by subsequent fires. The reasons for their occurrence are the breakage of electrical wiring in buildings during tremors, the fall of heating devices, stoves, etc [7]. When designing water supply networks and structures for areas with a seismicity of 5–9 points, special measures should be provided (installation of emergency pumps, electrical installations, etc.) to ensure the supply of water to extinguish fires that may occur during an earthquake, uninterrupted supply of drinking water , as well as water supply for urgent needs of production [8].

Fire hydrants, as well as wells with valves on pipelines, should be located so that the likelihood of their blockage in the event of a collapse of surrounding buildings and structures is the least. To do this, it is recommended that fire hydrants and wells with valves be located at the ends of buildings.

Figure 1. Suspension Seismic Bracing System Steel Support for HVAC Duct [9]

General rules. During seismic shocks, loads significantly exceeding its own weight act on the pipeline network, since the weight of the transported liquid and the weight of heat-insulating and protective materials are added to it. This requires an increase in the rigidity of the entire pipeline structure and the organization of reliable resistance to overloads.

In Azerbaijan, there are basic rules for the design of residential and public buildings for construction in seismic areas, which should be followed not only in the development of load-bearing structures, but also in the design of engineering networks and structures [9-11].

When developing project documentation, you should:

– apply structural schemes, materials and structures that provide the lowest values of seismic loads;

– make space-planning and design decisions that, as a rule, ensure the symmetry and regularity of the distribution in terms of the structure and height of its mass, stiffeners and loads on floors;

– assign sections of structural elements and their connections, taking into account the results of calculations;

– design butt joints, support elements and nodes in such a way that they ensure reliable transmission of forces and joint operation of load-bearing structures during an earthquake;

– to create the possibility of development of admissible inelastic deformations in certain elements;

– provide for constructive measures that ensure the stability and geometric invariability of structures during the development of inelastic deformations in the elements or joints between them, as well as excluding the possibility of their brittle fracture;

– locate, if possible, the joints of the elements outside the zone of maximum effort.

– Testing of pipelines and equipment

– In accordance with the law "On Technical Regulation", new building materials and products intended for mass production are subject to mandatory assessment and confirmation of compliance with safety requirements.

– An important step in such studies is the evaluation of characteristics that affect the seismic stability of materials and products, such as critical shock, vibration and longitudinal-transverse mechanical loads. For research, dynamic loading stands, vibration platforms, as well as special vibration machines capable of reproducing three-dimensional vibrations and simulating the loads experienced by engineering systems during earthquakes are used. Both pipes and supports on which pipelines are attached are tested.

– The data obtained as a result of the tests make it possible to determine the physical-mechanical, operational, and, if necessary, other characteristics, for example, the dynamic performance of the system under test. If during the testing process there was a destruction or violation of the tightness of the pipeline, then the manufacturer needs to develop ways to improve their reliability.

– Features of laying pipelines in seismically hazardous areas

– The following features of laying pipelines in seismically hazardous areas should prevent their deformation and destruction under seismic loads:

– Rigid sealing of the pipeline in masonry walls and foundations of buildings and structures is not allowed. Holes for passing pipes through walls and foundations must have dimensions that provide a pipe gap of at least 0.2 m in the masonry. The gap must be filled with an elastic water- and gas-tight material, the elastic properties of which have a durability comparable to the estimated operating time of the object;

– with a design seismicity of 9 points, a deformation compensator is installed at the points of entry into the building of pipes of water supply systems, which makes it possible to neutralize vibrations and possible precipitation of the building and pipelines;

– it is not allowed to cross the constructions of expansion joints of buildings with sewer pipelines;

– butt joints of socket pipes and pipes connected on couplings laid in areas with seismic activity of 8–9 points should provide compensation for possible subsidence, for which rubber sealing rings should be used;

– in places where the riser is turned from vertical to horizontal, concrete stops should be provided;

– when designing water supply systems for buildings of industrial enterprises located in areas with a seismic activity of 8–9 points, for which the interruption of water supply can cause accidents or significant material losses, two inputs using two independent water supply sources should be provided;

– inside buildings at the intersection of expansion joints on pipelines, the installation of compensators should be provided;

– at the inputs in front of the measuring devices, as well as at the points of connection of pipelines to pumps and tanks, it is necessary to provide flexible connections that allow angular and longitudinal movements of the ends of the pipelines;

– when performing welding work on the implementation of joints of steel pipe joints, equal strength of the welded joint with the pipe body should be ensured. Manual gas welding is not allowed. Welded joints of pipelines laid in areas with a seismic activity of 9 points should be reinforced with overhead couplings for welding;

– internal wiring of water communications must be securely attached to the supporting structures;

– risers of pipeline systems should be laid in places least vulnerable to earthquakes (internal walls, stairwell walls, sanitary blocks, etc.).

Supports for fastening pipelines. Main pipelines inside the building are usually laid parallel to each other with perpendicular intersections and branches. The operability of the pipeline is ensured by the ability to withstand the destruction (collapse) of communication networks, guarantee the minimum number of possible damages localized in each network circuit and the possibility of the safe presence of people and the use of the premises and networks of the facility for its intended purpose.

Resistance to destruction is primarily due to the general ability of the pipeline network to flexibly (elastically) respond to the displacement of the building structure. The minimum number of possible damages is provided by the resistance of each element of the network to seismic action. Therefore, the pipeline supports must compensate for the displacement of building structures during an earthquake so that mechanical stresses do not arise in the pipes, leading to their deformation and destruction.

On fig. 1 shows a view of a pipeline support with compensation slides and a guide collar. This support allows the pipeline to move two-dimensionally to compensate for the resulting deformation loads.

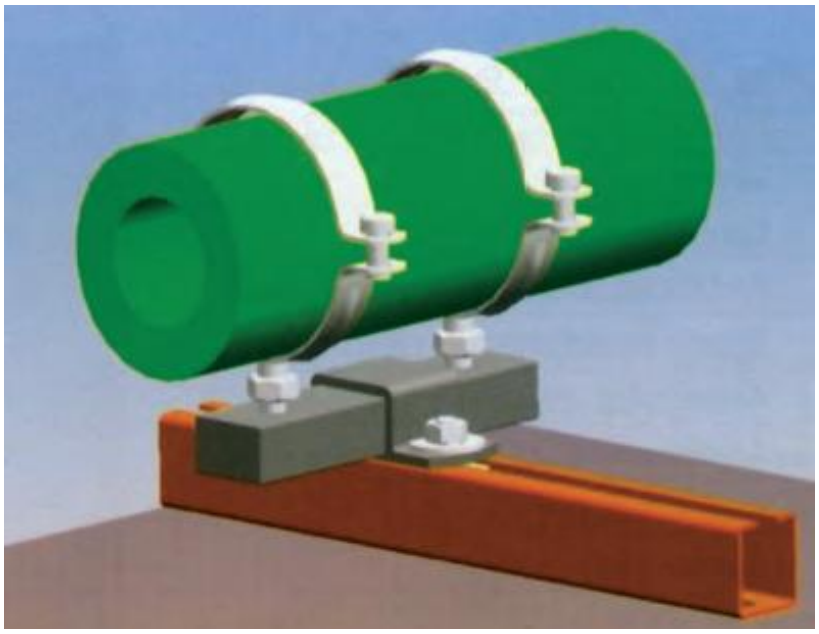

Figure 2. Pipe support with compensating slides and guide clamp [11]

On fig. 2 shows the method of fastening the channels on the compensation rollers. This method of fastening has its drawbacks: breaks are required in the heat-insulating layer in the place of the pipeline where it comes into contact with the rollers. In addition, in the event of lateral movement, the pipe may go beyond the roller.

Fig. 3. Fastening of channels on compensation rollers [11]

In order to ensure three-dimensional movement of the pipeline, a pipeline hanger, shown in Fig. 3. The suspension provides freedom of movement of the pipe, ease of installation of a heat-insulating coating, but requires a large number of spacer anti-seismic fasteners. In addition, for the installation of such a suspension, it will be necessary to install special support scaffolding for temporary laying of the pipeline console.

Figure 4. Seismic suspension of pipelines [11]

At present, an anti-seismic element for engineering networks has been developed specifically for Japan, which makes it possible to compensate for the stresses that occur in the system during earthquakes of more than 9 points when the pipeline crosses the damping joints in the building. A similar anti-seismic system, shown in Fig. 4, consists of a flexible section of the pipeline and its attachment to the building envelope.

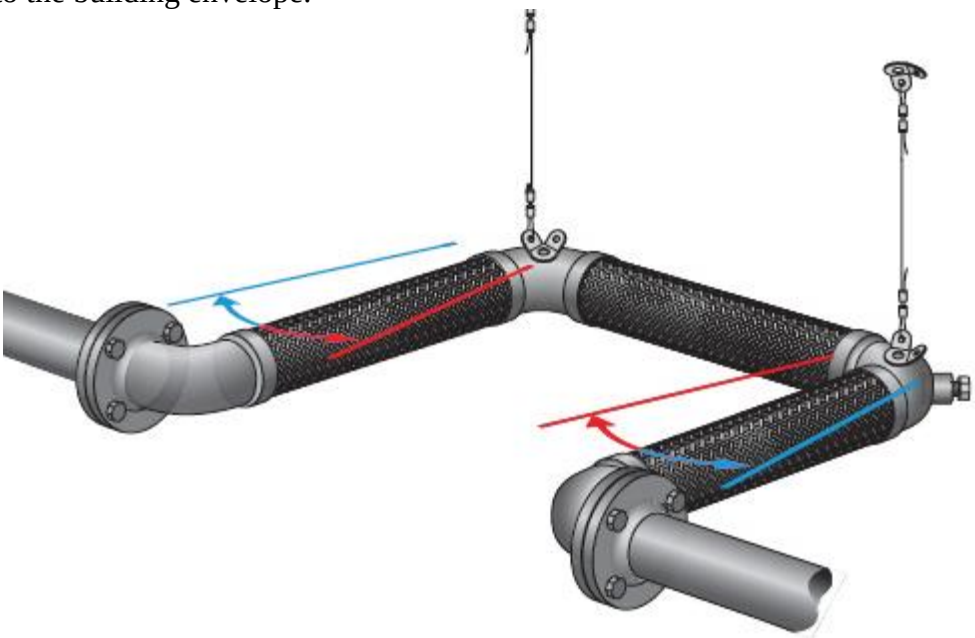

Figure 5. Anti-seismic system [11]

Conclusion. Restoration and strengthening of engineering communications after earthquakes. Engineering structures during an earthquake receive the following damage:

–If the load-bearing structures of a building or structure are preserved during a calculated earthquake, water supply and heating systems made of metal pipes with a diameter of 25–75 mm receive minor damage. Engineering communications are damaged by an earthquake with an intensity of 8 points or more;

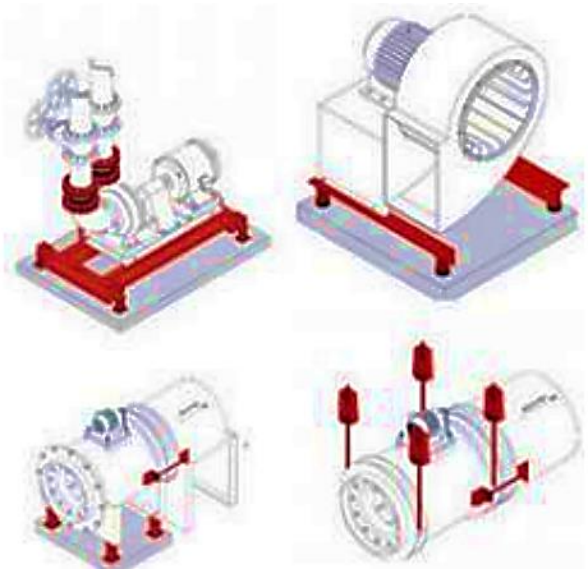

Figure 6. Gensets [11]

– Significant damage to metal piping systems in buildings and structures is observed when the supporting structures are destroyed, as well as in the case of unreliable fastening of communication pipes to these structures or in the absence of elastic gaskets in the fastening devices;

– the requirement to preserve external communications near the building and structure during an earthquake is mainly due to the deformation properties of the base soil and is provided by a constructive solution for introducing pipes into the basement of the facility.

– Restoration and strengthening of water supply, heating and sewer networks is carried out in accordance with the state of the supporting structures of the building and structure.

– All damaged sections of pipelines are replaced with new or serviceable ones. Nodal connections and angles of rotation must be securely attached to the supporting structures of the building or structure. Fixing devices of pipelines must have elastic gaskets.

– In all pipelines entering a building or structure, it is necessary to arrange elastic outer shells with a wall thickness of 2-4 cm, excluding hard contact of pipes with bearing and enclosing structures.

– When replacing pipes, preference should be given to lightweight and durable metal structures, arranging, as far as possible, flexible butt joints.

– Activities carried out for seismically hazardous areas

– In order to reduce the risks for the population living in seismic areas, it is necessary to:

– development of fundamentally new and effective ways to improve the seismic resistance of buildings and structures;

– improving the quality of designing facilities for seismological zones;

– strict control over compliance with the quality of construction, building codes and regulations, the exclusion of defects;

– Carrying out certification (inventory) of civil, industrial, transport and municipal facilities in seismically hazardous zones in order to identify their seismic resistance;

– Carrying out special works to improve the seismic resistance (strengthening) of buildings and structures, dismantling (dismantling) insufficiently resistant buildings and structures.

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Məqaləyə istinad: Əkbərova S.M., Əkbərli R.S. Binaların mühəndis sistemlərinin seysmik müqaviməti. Elmi Əsərlər jurnalı/ Scientific works. AzMİU, s. 133-140, N2, 2023
For citation: Akbarova S.M., Akbarli R.S. Seismic resistance of engineering systems of buildings Elmi Əsərlər jurnalı/ Scientific works. AzUAC, p. 133-140, N2, 2023

Məqalə INTERNATIONAL CONGRESS ON ADVANCED EARTHQUAKE RESISTANT STRUCTURES (AERS2023) adlı konfrans materialıdır.