IRSTI 67.11.59

S.V. Evdokimov ©

Candidate of Technical Sciences, Associate Professor

ORCID *https://orcid.org/0000-0003-4006-2890*

Architecture and Civil Engineering Academy, Samara State Technical University, Samara, Russia

@ *evdokimov.sergey1970@yandex.kz*

https://doi.org/10.55956/AJKO9869

ANALYSIS OF SEISMIC LOADS IMPACT ON THE MAIN EQUIPMENT OF HYDROELECTRIC POWER PLANTS

Abstract. The paper analyzes the problem of seismic resistance of the main equipment of hydroelectric power plants, showing that the solution of this problem turns out to be much more complicated than previously imagined. The scenarios of hydroelectric power plant operation disruption in case of insufficient seismic resistance of its equipment are considered. It is concluded that exogenous and technogenic seismic events should be taken into account at the design stage when assessing geologic hazardous processes and phenomena at the site of HPP location.

Keywords: seismic resistance, hydroelectric power plants, hydroelectric power plant main equipment, foundation soils, exogenous seismic events, technogenic seismic events.

Evdokimov S.V. Analysis of seismic loads impact on the main equipment of hydroelectric power plants //Mechanics and Technology / Scientific journal. – 2024. – No.4(86). – P.182-185. https://doi.org/10.55956/AJKO9869

Introduction. The problem of seismic resistance of the main equipment of HPPs appeared in the former USSR after the earthquake with intensity of 8 points on MSK scale in the area of Kairakkum HPP on October 13, 1985. Spitak earthquake of 1988 in Armenia made this problem even more urgent. For HPPs, less attention is still paid to the issues of improvement of methods for analyzing, evaluating and increasing the earthquake resistance of the main equipment, mainly electric power equipment, than to the construction part of buildings and structures [1].

In the aforementioned earthquake in the area of the Kairakkum HPP, two phases of the block transformer arresters were destroyed at the building of the HPP, and at the ORU-220 – seven phases of disconnectors, three phases of the voltage transformer, and three phases of arresters. The transformers were displaced along the rails at several substations and at one substation a transformer weighing 66.8 tons "jumped" and displaced across the rails at a distance of about 0.3 meters.

The consequences of the 1990 earthquake in Moldavia were also characteristic: with seismic impact of less than 7 MSK, there were no significant mechanical damages at substations, but low functional seismic stability of the equipment resulted in significant losses in power supply, which led to the shutdown of 47 power lines, 44 substations, 157 settlements were de-energized, etc. [2].

In comparison with other earthquakes, Spitak earthquake was the most destructive that occurred on the territory of the former USSR, and in terms of damage to 35-220 kV substations it was the most characteristic. At the surveyed substations it's intensity ranged from 7 to 9 MSK. The most characteristic damages at 35, 110 and 220 kV substations were: the movement of transformers along rails up to 1 m and resetting of rails with breakage of bushings; damage of overhead switches with porcelain breakage; damage of 220 kV disconnectors with destruction of insulator support columns; destruction of 110 and 220 kV arresters; destruction of 220 kV current transformers; damage of high-frequency barriers when installing them on the support insulator; destruction of accumulator batteries of SC type; partial damage of building structures, control rooms and switchgears, and in the epicenter of the earthquake at "Spitak" substation three-storey building of the control room was completely destroyed.

A comparison of the consequences of the earthquake in Armenia (1988), where were actually no appropriate anti-seismic measures at power facilities, with the consequences of the earthquake in California (USA, 1989), where much attention was paid to the seismic resistance of power facilities, showed that in both cases there were significant destructions of electrical equipment. Apparently, this circumstance indicates that the solution of the problem of seismic resistance of electrical equipment turned out to be much more complicated than previously imagined. It is significant that equipment damage was observed not only in catastrophic earthquakes like Spitak earthquake, but also in a very "moderate" shaking.

Materials and methods. For conditions of hydroelectric power plants of the European part of Russia, taking into account available statistical data, it is of interest to consider the seismic resistance, first of all, of electrical equipment – high-voltage switches, disconnectors and arresters, as well as power transformers. In addition to electrical equipment, it is of interest for HPPs to assess the seismic resistance of the following equipment: gantry cranes of the spillway dam; main bridge crane of the engine room; hydraulic units; gates of the spillway dam [3,4].

As the analysis has shown, with insufficient seismic resistance of this equipment the following can happen [5]:

– cranes may "fly off" the rails, and the engine room crane may also fall;

– gates may be so deformed that they jam in their slots; the worst situation is if the earthquake occurs simultaneously with the spring-summer flood (May-June);

– disturbance of the hydro unit shaft alignment, inadmissible runout, resulting to the necessity of hydro unit shut down.

The seismic resistance of most currently operated equipment is unknown for the following reasons:

1) Previously, there were no relevant regulatory documents and, therefore, no relevant requirements were made and no relevant inspections were carried out;

2) Even if some types of equipment have been tested for earthquake resistance on a test bench, these products were subjected to such testing prior to their operation. During operation, the mechanical properties of the products and thus their earthquake resistance may have changed due to aging processes, wear and tear, etc.;

3) The condition for seismic resistance of technical products, especially large-sized ones, that have passed the relevant tests is also that the foundations or other structures on which they are installed must not amplify seismic vibrations; this condition is not always fulfilled when the products are installed, or the properties of the foundations change during operation.

The initial seismicity in the area where the hydroelectric power plants are located was clarified on the basis of collecting published data on events attributed to

earthquakes in the area under consideration and analyzing the nature of these events. The essence of the problem lies in the fact that in the primary Catalog of earthquakes of the Russian Empire to earthquakes referred all natural phenomena that were accompanied or could be accompanied by shaking on the earth's surface, such as - strong thunderstorms, aerolite falls, landslides, rockslides, karst failures, phenomena associated with frost heave, unusual sound phenomena, many of which were later included in catalogs of tectonic earthquakes [6].

Research results and discussion. As a part of the work conducted, data on 242 events that were referred to earthquakes in the literature were collected and analyzed. As a result of analyzing the nature and reliability of these phenomena and events, erroneous and unreliable events were highlighted [7]:

1) exogenous phenomena – accompanied or not by weak shaking (rockslides, landslides, meteorite falls);

2) technogenic earthquakes: caused by mining of mineral deposits in the mines of Kola Peninsula, Urals and oil fields of Volga region, as well as industrial explosions.

Thus, exogenous and anthropogenic seismic events should be taken into account at the project stage when assessing geologic hazardous processes and phenomena at the site.

Conclusion. As a result of the analysis, tectonic and probably tectonic earthquakes of indeterminate nature were singled out, which should be taken into account when assessing seismic hazard, as well as seismic active zones located on the periphery of the HPP location area were singled out.

References

1. Romanov A.A., Zhigulevskaya HPP. Operation of hydraulic structures. – Samara: Publishing house “Agni”, 2010. – 360 p.
2. Romanov A.A., Evdokimov, S.V. Modern and predicted condition of soils at the base of Zhigulevskaya HPP. //In Collection: Traditions and innovations in construction and architecture. Construction. Samara State University of Architecture and Civil Engineering. – Samara, 2016. – P. 133-136.
3. Romanov A.A., Evdokimov S.V., Seliverstov V.A. Investigation of vibrations of the Zhigulevskaya hydroelectric power station building //Industrial and Civil Engineering. – 2015. – No. 6. – P. 20-24.
4. Romanov A.A., Evdokimov S.V., Seliverstov V.A. Investigations of vibrations of the roof of the Zhigulevskaya hydroelectric power plant building //Scientific Review. – 2015. – No. 14. – P. 109-112.
5. Romanov A.A., Evdokimov S.V. Development of safety declaration of hydraulic engineering structures of Zhigulevskaya HPP //Nauchnoe obozrenie. – 2015. – No. 4. – P. 119-124.
6. Romanov A.A., Evdokimov S.V. Results of investigation of vibrations of concrete parts of Zhigulevskaya HPP sections //Scientific Review. – 2015. – No. 7. – P. 188-193.
7. Evdokimov S.V., Romanov A.A. The Investigation of soils in the Zhiguli Hydroelectric Station foundation contact area //In Proceedings: XXIV R-S-P seminar, Theoretical Foundation of Civil Engineering (24RSP) (TFoCE 2015). Ser. “Procedia Engineering”, 2015. – P. 183-187.

Material received on 30.09.24.

С.В. Евдокимов

[1]Самара мемлекеттік сәулет-құрылыс университеті, Самара қ., Ресей

СУ ЭЛЕКТР СТАНЦИЯЛАРЫНЫҢ НЕГІЗГІ ЖАБДЫҚТАРЫНА СЕЙСМИКАЛЫҚ ЖҮКТЕМЕЛЕРДІҢ ӘСЕРІН ТАЛДАУ

Аңдатпа. Мақалада су электр станцияларының негізгі жабдықтарының жер сілкінісіне төзімділігі мәселесі талданады, бұл мәселені шешу бұрын ұсынылғаннан әлдеқайда күрделі екендігі көрсетілген. Гидроэлектростанцияның жабдығының сейсмикалық төзімділігі жеткіліксіз болған кезде оның жұмысының бұзылу сценарийлері қаралды. ГЭС орналасқан жердегі қауіпті геологиялық процестер мен құбылыстарды бағалау кезінде жобалау сатысында экзогендік және техногендік сейсмикалық оқиғаларды есепке алу қажеттілігі туралы қорытынды жасалды.

Тірек сөздер: гидроэлектростанциялар, ГЭС-тің негізгі жабдықтары, негіз топырақтары, жер сілкінісіне төзімділік, экзогендік сейсмикалық құбылыстар, техногендік сейсмикалық құбылыстар.

С.В. Евдокимов

[1]Самарский государственный архитектурно-строительный университет, г. Самара, Россия

АНАЛИЗ ВОЗДЕЙСТВИЯ СЕЙСМИЧЕСКИХ НАГРУЗОК НА ОСНОВНОЕ ОБОРУДОВАНИЕ ГИДРОЭЛЕКТРОСТАНЦИЙ

Аннотация. В статье анализируется проблема сейсмостойкости основного оборудования гидроэлектростанций, показано, что решение этой задачи оказывается гораздо более сложным, чем представлялось ранее. Рассмотрены сценарии нарушения работы гидроэлектростанции при недостаточной сейсмостойкости ее оборудования. Сделан вывод о необходимости учета экзогенных и техногенных сейсмических событий на стадии проектирования при оценке опасных геологических процессов и явлений в месте размещения ГЭС.

Ключевые слова: гидроэлектростанции, основное оборудование ГЭС, грунты оснований, сейсмостойкость, экзогенные сейсмические явления, техногенные сейсмические явления.