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## SEISMOLOGICAL ISSUES IN THE EARTHQUAKE RESISTANCE OF BUILDINGS (AS AN EXAMPLE IN AZERBAIJAN)

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**Abstract.** Many dangerous processes of endogenous and exogenous origin occur on Earth. It has been established that natural and man-made emergencies such as earthquakes, landslides, droughts, floods, sea level rise and fall, and forest fires are more characteristic and dangerous for the territory of Azerbaijan. Since the territory of Azerbaijan is a part of the active Alpine-Himalayan fold belt, strong and destructive earthquakes have occurred here from time to time (427, 1139, 1235, 1667, 1902, 1961, 1963, 1989, 2000, 2007, 2012 years and etc.). From this point of view, it is one of the important issues on seismologists and builders to ensure that people can continue their life activities without problems and losses, buildings and facilities continue to exploitation without serious damage during an earthquake in such a seismoactive zone. To achieve this goal, civil engineers must have accurate seismological data reflecting the seismicity of the area. That is, the effectiveness of earthquake-resistant construction can be achieved when the parameters of probable seismic effects are correctly estimated and the effects of second-order factors (hazard) associated with these effects are taken into account. From this point of view, the new information obtained in the seismic monitoring of the territory of Azerbaijan with modern seismic devices since 2003 year has led to the resolution of many issue.

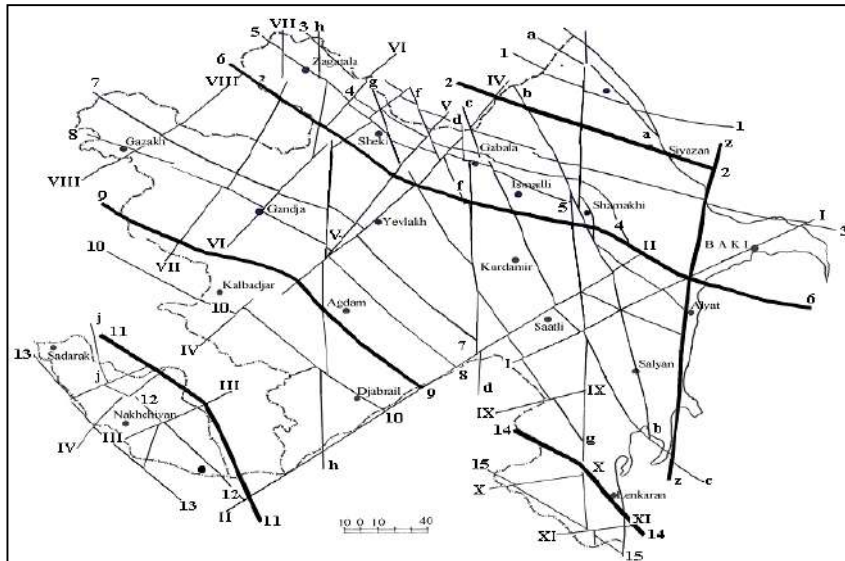
**Keywords:** earthquakes; tectonic faults; earthquake resistance of buildings; seismic code

**Introduction.** Since the territory of Azerbaijan is a part of the active Alpine-Himalayan folded belt, strong and destructive earthquakes have occurred here from time to time (in 427, 1139, 1235, 1667, 1902, 1961, 1963, 1989, 2000, 2007, 2012, etc. earthquakes). About 4,000 earthquakes are registered in the territory of the republic every year. About 20-25 of these earthquakes are felt (fig.1) [3].



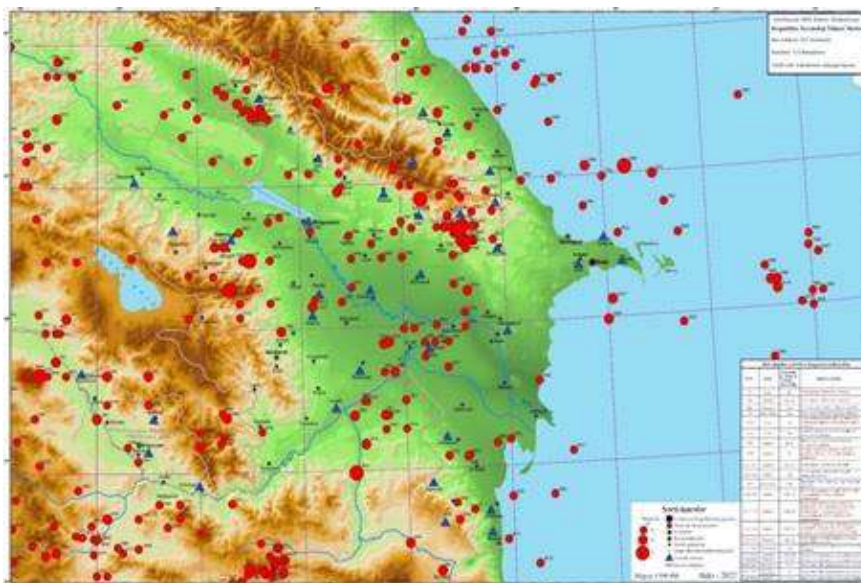
**Figure 1.** Map of epicenters of earthquakes in Azerbaijan and adjacent territories for the period 2003-2022 with  $m_l > 3.0$  [3]

The recording of this number of earthquakes in a small area is directly related to the tectonics of the area. A map of tectonic faults was prepared for the territory of Azerbaijan by different authors. One such map was prepared in 2005. As can be seen from the picture, the territory of the republic is characterized by numerous longitudinal and transverse tectonic faults (fig.2).



**Figure 2.** Fault map of the territory of Azerbaijan (Author: Kengerli T.N., 2005) [3]

According to the map of epicenters of strong earthquakes (with  $M \geq 5$ ) that occurred in the territory of the republic for the period 427-2022 years, we can say that strong earthquakes occurred mainly due to longitudinal depth faults (fig.3) [3].



**Figure 3.** The epicenters map of strong earthquakes of Azerbaijan with magnitude  $M \geq 5$  (for the period 427-2022 years) [3]

Non-missing recording of low-magnitude earthquakes on the territory of the republic was achieved thanks to the creation of a seismic network consisting of modern seismic stations (produced by the USA company “Kinometrics”). These stations were purchased and installed after the earthquake that occurred in the South Caspian Sea on November 25, 2000. Currently, the seismic network consists of 92 seismic stations, 35 of which are stationary.

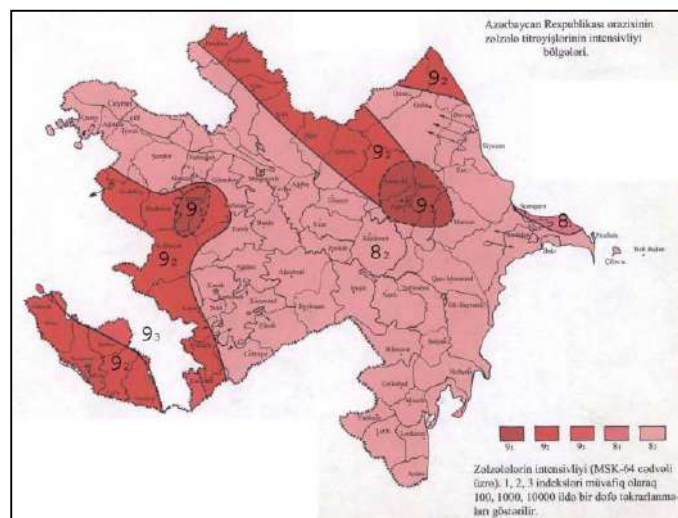
The earthquake of November 25, 2000 caused serious damage in the capital city of Baku, so it became a research object for seismologists and civil engineers.

The earthquake manifested itself in the form of 2 shocks, the time between shocks was 1.5 minutes, the magnitudes were  $M_{pv}=6.2$  and  $M_{pv}=6.4$ , respectively, and the depth  $h=30-35$  km. As a result of the earthquake, a total of 7350 buildings were damaged in the territory of the republic, 34 houses were partially destroyed.

Mainly, 1-3-story houses built at the beginning of the last century were damaged and destroyed, high-rise large-panel and frame buildings built 30-40 years ago were slightly damaged, 23 people lost their lives [3].

Unfortunately, the records of this earthquake overlapped on the seismogram and experts could not study it extensively.

From this point of view, in such a seismoactive zone, ensuring that people can continue their life activities without problems and losses, and buildings and facilities without serious damage, is one of the important issues facing seismologists and builders, and is the basis for designing earthquake-resistant buildings. To achieve this goal, civil engineers must have accurate seismological data reflecting the seismicity of the area. That is, as we know, the effectiveness of earthquake-resistant construction is largely determined by correct forecasting and taking into account possible seismic effects and the additional seismic loads caused by them on buildings and structures. And these tasks are taken into account in regulatory documents. From this point of view, I want to note that, until now, the Temporary Seismic Zoning map of the Republic of Azerbaijan (TSZ-89) is used in the assessment of the seismic hazard of the territory of Azerbaijan (fig.4). Certain changes were made to this map by the State Urban Planning and Architecture Committee in 1991 year. The map is drawn according to the intensity parameter based on the MSK-64 seismic scale. As the name suggests, the map is temporarily prepared and needs to be prepared on the basis of parameters (pga, pgv, pgd and etc.) that meet modern requirements and are of interest to construction professionals.



**Figure 4.** Temporary Seismic Zoning map of the Republic of Azerbaijan (TSZ-89) [3]

Observations show that in ensuring the earthquake resistance of the building, it is necessary to take a complex approach to the issue and solve complex issues, not by looking at it from one perspective, that is, not only by making engineering calculations.

As we know, consequences of the earthquakes depends on the intensity of seismic waves reaching the surface, the duration of seismic vibrations and their spectral composition, on the design features of buildings, the type and condition of the foundation soil. In this regard, when considering the results of earthquakes (16 June 1964 year Niigata earthquake, 17 August 1999 year Kocaeli earthquake and etc.) in recent decades, one of the most striking points is that buildings of the same type, built in close proximity to each other, behave differently. This should be explained in connection with local engineering-geological issues. From this, we can conclude that it is not correct to calculate and design buildings located close to each other according to the same geological conditions based on the close distance, and geological and geophysical exploration should be carried out to study the engineering-geological conditions for each building.





**Figure 5.** Kocaeli earthquake, 17 August 1999 year [3]

One of the main issues that should be solved by Azerbaijani seismologists and builders is bringing the currently used building code Az.DTN 2.3-1 to a level that meets modern requirements. Here, in particular, one can note the importance of determining the dynamic coefficient  $\beta_i$  from the response spectrum using acceleration records of real earthquakes.

### Conclusion

1. According to the of epicenters map of strong earthquakes (with  $M \geq 5$ ) that occurred on the territory of the republic for the period 427-2022 years, it can be said that the territory of Azerbaijan is characterized by high seismicity and strong earthquakes occurred mainly due to longitudinal deep faults.
2. The building code Az. DTN 2.3-1 and TSM-89 map does not meet modern requirements and it is important to update it.

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