THE LESSONS OF THE DESTRUCTIVE EARTHQUAKES OCCURRED IN TURKEY AND ARMENIA

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The earthquakes in Armenia and Turkey appeared to be the most severe seismic events in Europe throughout the last 15 years.

The experts from different countries including those ones from Kazakhstan took part in collection and analysis of data characterizing the aftereffects of the above earthquakes.

The lessons of Armenia and Turkey's seismic events provided the experts with valuable material, which is necessary for further perfection of "Code on aseismic building" as well as for enhancing the safety measures of people's protection during earthquakes.

Only some the most essential reasons of tragedies caused by seismic events are analyzed in this article.

The Earthquake in Armenia

Armenian earthquake happened on December 8 1988. Its epicenter was not far from Spitak (a town in Armenia).

The specific peculiarity of the earthquake was the following:
it developed in the form of the series of seismic shocks. The second shock occurred 4 minutes 20 seconds after the first one. The magnitude of the first shock was 7.0 and the epicenter was at 12-15 kilometers deep. The magnitude of the second shock was 5.8-6.5.

There lived about 1 million people in the region struck by the earthquake. 514 thousand people became homeless. Approximately 800 buildings of schools, kindergartens and hospitals were either completely destroyed or appeared to be in emergency condition. 170 industrial ventures stopped their functioning at all.

The most of collapsed or severely damaged buildings were observed in Spitak and Leninakan. About 60 settlements were almost completely destroyed. 25 thousand people have been lost (including 5 thousand in Spitak, 13-15 thousand in Leninakan). 19 thousand people were injured.

The epicenter of the earthquake appeared to be within the zone with seismicity 7 according to the standard requirements and regulations code operated round the former USSR. Leninakan situated at a distance of 32 km from the epicenter of the earthquake was classified as the zone with seismic intensity 8.

The instrumental recording of ground oscillations with time was obtained only in Gukasyan and Erevan located at 35 km and 120 km from the epicenter correspondingly. No other reliable instrumental data were obtained. Therefore, the assessment of intensity and characteristics of the seismic influence was done mainly by means of engineering interpretation of macroseismic data (using MSK-64 scale) and analysis of aftershock process results' registration. According to the results of macroseismic examination it was established that the intensity of seismic influence mainly reached 9-10 grades in Spitak and 8-9 grades in Leninakan (and within some places it was 7).

Actual intensity of seismic impact in Spitak exceeded the standard one by no less than two grades and as for Leninakan it coincided with the standard intensity.

The destructive aftermath of Spitak earthquake could be just explained through the unforeseen high intensity and specific peculiarities of the severe seismic impact. However, the fact that the seismic intensity displayed in many regions of Leninakan coincided with the standard one, indicates mistakes committed during seismic zoning of the territory of Northern Armenia, and it's only one of the reasons that caused tragic effects.

The basic factor of disastrous destructions in Spitak was the exceding of earthquake intensity by 2 grades. The examples of some building destructions in Spitak are shown on pictures of the Report. The main reasons of destructions were errors of designing and bad quality of building in Leninakan. The most part of population loss was caused by severe and complete collapse of 9-storey-frame-panel buildings designed with prefabricated reinforced concrete constructions (111 series). Unfavourable constructive solution and low degree of earthquake resistive capacity of those buildings were determined long before the seismic events. It was fulfilled according to vibration test results by Moscow Tsniiepzhilishya (Dr Ashkinaze) in 1976. Unfortunately this type-building-construction was continued without regarding the above test results.

At the same time 3-storey-frame buildings with cage-spacial-framework withstood the severe earthquake, being damaged a lot, though, that saved people's lives.

The large-scale-panel building behavior considerably differed from that one of framed buildings. The 9-storey large-scale-panel buildings were damaged slightly during the earthquake.

The study of design solutions and quality of construction of large-scale-panel buildings showed that having some defects they quite meet standard requirements in general.

The high capacity of multy-storey large-scale-panel buildings to resist the seismic influence was not unexpected event at all.

The numerous experimental researches including full-scale object testing preceded the mass construction of large-scale-panel buildings in the former USSR.

The aftermath of Spitak's earthquake vividly demonstrated how the effective engineering solutions and high quality of construction allow buildings and constructions to withstand seismic load influence even when intensity of the real seismic impact exceeds the standard designed one by 1-2 scale grades. The visual support of this thesis is the fact that two 5-storey large-scale-panel buildings were exposed to seismic impact with intensity of 10 grades during the earthquake in Spitak; though the above buildings were designed to be constructed in areas with seismic intensity of 7 grades. Those buildings were slightly damaged against the background of complete collapse of the neighboring buildings.

The Earthquake in Turkey

The earthquake in Turkey occurred on August 17, 1999. The macroseismic epicenter of the earthquake was near Golcuk. The magnitude was 7.4. The epicenter of the earthquake was at the depth of 15-17 km.

The seismic influence intensity reached 8-10 grades according to MSK-64 scale. In the result of that earthquake about 50-70% of dwellings were either severely damaged or destroyed in some large towns in North-West Turkey. Official death-roll made up about 16 thousand people and about 44 thousand were injured. The most amount of loss was registered in Golcuk (5025), Izmit (4093), Adapazary (2629), Yalova (2502) and in the suburb of Stambul Avcilar (981).

The regions adjacent to the earthquake origin are referred to the most dangerous territories by seismicity and are denoted on the maps of seismic zoning of the country as zone 1 (9 grades according to MSK-64 scale classification).

Instrumental records of soil vibration witness the intensity of registered seismic influence was as a rule in satisfactory conformity with standard intensity of designed zone 1.

According to macroseismic data, the earthquake intensity exceeded the designed one by 1 grade within some sites.

The most of domestic buildings, turned out to be in the earthquake area, had the constructive system in the form of reinforced concrete frame with brick wall filling. The height of those buildings varied within the range 2-8- storey as a rule.

Most of framed buildings had either trade occupancy or offices on the ground floor. The height of the ground floor reached 4-5 metres and essentially exceeded the height of the upper dwelling storeys. The filling of the frame within the ground floor either was not provided or was of much less stiffness than that one of the above storeys. In the world practice such buildings are classified as constructions with the first flexible storey.

The columns of continuous reinforced concrete frameworks of the most typical buildings had the rectangular shape in plan with cross-section dimensions of 25-30 cm in one orthogonal direction and from 50 to 70 cm in the other one. In most cases the columns' dimensions made up 25x50 cm.

According to the requirements of Code on building in Turkey the concrete compression strength of supporting constructions of framed buildings should be of no less than 225 kg/cm2.

The reinforcing of columns and girders of the skeleton was implemented as a rule out of the smooth reinforcement. The diameters of the longitudinal active reinforcement made up no more than 14-16 mm and those of the transverse one and hoops were 4-6 mm. The reinforcing of framework bearing constructions by bars with large diameter or bars having the periodic profile were met far too rarely.

Side by side with framed buildings there were erected rather many framed buildings with stiffening diaphragms in the regions suffered from the earthquake most of all. Stiffening diaphragms were made of continuous reinforced concrete and had the rectangular shape in plan. Sometimes they had angle shape. The reinforcing of stiffening diaphragms was fulfilled the same way like that one of columns namely by smooth hot-rolled bar reinforcement of 12-16 mm in diameter.

The qualitative analysis of building constructive solution showed the following:

1. Constructive schemes of major frameworks were extremely irregular and asymmetric. Columns, girders and stiffening diaphragms cross-section dimensions as well as their location and orientation in plan of a building were not stipulated by the constructive considerations but by endeavor to improve the interior at the expense of placing the framework elements within the thickness of exterior and interior brick walls.

2. The ratio of the thickness of rectangular columns to the storey height was, in the most of buildings, within the range 0.05-0.08. There is a requirement in "code on building" of some countries according to which the thickness of walls of vertical load bearing constructions should be as a rule no less than 0.1 of storey height. The objective of this requirement is to provide the steadiness of vertical constructions under seismic influence.

3. The concrete quality in load bearing constructions of most frameworks was rather low. For concrete manufacturing everywhere were used sand and pebbles quarried from seacoast.

The fulfilled research displaued that the concrete strength in columns mostly had 120-160 kg/cm2.

4. The adopted schemes of reinforcement didn't provide the prevention of lateral bending (deflection) of vertical bar reinforcement under reversal load influence as well.

5. Butt joints of framework elements active reinforcement were located in the maximum effort areas under the seismic load influence.

6. For masonry work of walls and dividing walls there were used hollow bricks with hollow content exceeded 50%. The masonry was neither reinforced nor fastened to columns, girders and floor slabs.

The check analysis of 5-8-storey buildings showed that the Strength in columns with cross-section dimensions at 25x50 cm and designed reinforcement was inadequate for reseiving seismic influence of 7 grade intensity.

The most widespread cause of a framed building collapsing was the destruction process in joints connecting columns to foundations and girders and hinge formation in them.

The other characteristic reasons were: destructions caused by thin columns and plane diaphragms steadiness loss.

The filling of the framework, thanks to its low strength and lack of fastening to columns and girders didn't affect essentially the building power to resist the seismic load influence.

Case buildings with stiffening diaphragms withstood the earthquake in a little better condition than the framed ones.

Although, the great majority of them were about to collapse, and were severely damaged, multistory frame buildings erected on the hazardous sites with bad soils in seismic respect got the most damages almost in all cases. The spectral analysis of instrumental recordings registered within areas with soft soils, reconfirmed again the well-known fact that the soft soil vibration contains intensive long-period components, which were extremely hazardous for flexible and relatively flexible frame buildings.

The macroseismic examination showed that the intensity of seismic influence made up 8-9 grades within the areas with normal soil conditions. As for the sites with unfavourable soil conditions the macroseismic intensity increased by 1-2 grades. The building witlnin soft, soggy soils was carried out disregading strengthening of foundation.

The most unfavorable aftermaths of the above were observed in Adapazari, where because of ground dilution, some multistorey buildings with foundation embedded at 0.8-1.0 m deep, overturned, bent and partly submerged into soil.

The carried out analysis results allow to assert that the basic cause of such destructive aftermath of the earthquake occurred on August, 17th, 1999 was stipulated by practically complete disregarding of standard requirements of "Code on aseismic building" in Turkey.

INFERENCES:

The tragic lessons of two earthquakes occurred in Europe at the end of the 20th century vividly show that the task of providing people with safety during seismic events are still far from their final completion.

The disastrous aftereffects of the earthquake occurred in Turkey and Armenia are basically stipulated by the great amount of buildings and constructions erected without necessary observation of 'national code on building' requirements as well as low quality of construction.

The analysis of modern condition of exsisting buildings displays that both social and economical aftermath of a severe earthquake could be no less tragic.

To the most extent this deduction is connected to the fact that there is a great number of objects erected within the territory of Central Asia, which don't meet the modern building requirements and regulations and are considered to be non-resistant to seismic load influence. According to data of international group of experts, participated the conference, took place in Almaty in 1996, only within the territory of this city (the population is about 1.5 mln people) up to 75 thousand people will be lost and about 300 thousand will be injured in case of a severe earthquake.

Prevention of such heavy aftermaths of disaster is directly connected to the necessity of full-scale examination of existing buildings as well as to development of measures for their effective reinforcement. Such kind of work is already begun in Almaty.