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SESIMIC CODE OF UZBEKISTAN

Nadira Mavlyanova[1], Rashid Inagamov[2], Hirojillo Rakhmatullaev[3] and Nigora Tolipova[4]

SUMMARY

Uzbekistan is located in the middle of Central Asia within a zone of high seismic activity. After 1991 when the Soviet Union has broken up the Uzbekistan became the independent country. For the purposes of seismic resistant design, all the design institutes use the new seismic code KMK 2.01.03-96: "Norms and Regulations for Construction in Seismic Zones". The present norms establish the requirements showed to designing and construction new and reconstruction buildings in areas with seismic intensity VII, VIII, IX (by MSK-scale) and more. This paper presented the information about seismic hazard of Uzbekistan and seismic resistant code.

INTRODUCTION

Uzbekistan is located on the Asian continent in the basin of the great Amudarya and Syrdarya rivers, in the desert subtropical zone, taking the part of Turan Lowland in the West and mountainous highlands in the East (Fig. 1.). Natural environment of the Republic is characterized by high seismic conditions. There are many cities such as Tashkent (the capital, population 2,3 million), Samarkand, Bukhara and others have expected seismic intensity YIII and IX (MSK). The earthquakes on the territory of Uzbekistan are the most frequent and dangerous. It was only 1976-1986 that more than ten violent and destructive earthquakes with M = 5.5-7.3 took place Abdullabekov [1]. At the beginning of 2000 the population of Uzbekistan is equal to 24.5 million people. If the total population of Central Asia is 100%, then Uzbekistan makes up more than 42% of it.

After 1991 when the Soviet Union has broken up the Uzbekistan became the independent country. The government of Uzbekistan have been aware of the seismic threat for many years and have taken certain steps to increase earthquake disaster preparedness. One of the basic documents of independent Uzbekistan has become the law - About protection of the population and territories from emergency situations of natural and technogenic character. The law adopted in the Republic on August 20, 1999.

For the purposes of seismic resistant design, all the design institutes use the new seismic code KMK 2.01.03-96 "Norms and Regulations for Construction in Seismic Zones" and KMK 2.07.01-94 " Town-

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1 Chief of Project, Ph.D., Institute of Seismology, Tashkent, Uzbekistan. Email: nadira@seismic.ccc.uz
2 Project Scientist, Ph.D., Institute of Seismology, Tashkent, Uzbekistan. Email: tashkent@seismo.org.uz
3 Project Scientist, Ph.D., Institute of Seismology, Tashkent, Uzbekistan. Email: tashkent@seismo.org.uz
4 Project Scientist, Ph.D., World Economy University, Tashkent, Uzbekistan. Email: nig65@rambler.ru

planning, lay-out and building of urban and village settlements", put into operation by the State Committee for Architecture and Construction in 1994 and 1996. The present norms establish the requirements showed to designing and construction new and reconstruction buildings in areas with seismic intensity VII, VIII, IX (by MSK-scale) and more. The buildings constructed in seismically active areas, during settlement term of operation should observe the requirements of seismic stability and provide safe stay of the people, safety of designs with earthquakes of calculated intensity.

Fig. 1. Location of Uzbekistan.

The intensity and return period for earthquakes with probable seismic intensity more than VII, is determined under the special table, which is enclosed on this design code. Central Asia's urban earthquake risk is unusually easy to evaluate. Its buildings vary little in design and method of construction because the vast majority of them were built over a short period, when one central authority controlled design and construction. Because design and construction practices were centralized in the Former Soviet Union, four-fifths of all Central Asian residential buildings can be placed into one of only six structural types [2].

The seismic vulnerability of these types is variable and depends on such factors as design, detailing, materials, construction methods and maintenance. The seismic vulnerability of most of the six Central Asian structural types is high. The simplified version of the official seismic hazard map for the former Soviet Union that is shown here indicates that Tashkent can expect MSK VIII level of shaking. There two reasons to believe that this map significantly underestimates the regions hazard. First, it does not take into account the amplification effect of the soft-soil conditions common in large areas of the capital, which is important because soft soil can produce intensities one or more MSK units greater than on nearby stiff soils. Second, all of the recent destructive earthquakes in the Former Soviet Union have been significantly larger than would be expected examining the map (even allowing for soft-soil conditions) [2]. The six Central Asian structural types and the average levels of earthquake shaking are described briefly in the table below.

Table 1. Central Asian structural types of residential buildings and expected damage levels.

STRUCTURAL TYPE	DAMAGE LEVEL		
	MSK VII	MSK VIII	MSK IX
1.Unengineered structures, including small adobe and unreinforced masonry buildings	Heavy damage	Partial to total collapse	Total collapse
2. Brick bearing-wall systems with wooden floors, one to two stories, pre-1955	Moderate to heavy damage	Partial collapse	Total collapse
3. Brick bearing-wall systems with precast reinforced concrete (RC) floors, three to five stories, pre-1957	Slight to moderate damage	Heavy damage to partiall collapse	Partial collapse
4. Brick bearing-wall systems with precast RC floors, some seismic detailing, post-1957	No damage to slight damage	Moderate to heavy damage	Heavy damage to partial collapse
5. Precast RC frames with welded joints and brick infill walls, four to nine stories	Slight damage	Moderate to heavy damage	Heavy damage to partial collapse
6. Precast RC large-panel systems with dry or west joints	No damage to slight damage	Slight to moderate damage	Moderate damage

After 1991 when the Soviet Union has broken up, the Uzbekistan became the independent country. Since 1995 of Uzbekistan has an own design code for construction of buildings in seismic areas.

ASSESSMENT OF SEISMIC HAZARD FOR UZBEKISTAN

The territory of the Republic of Uzbekistan is related to tectonic active structure of the lithosphere of Western Tian-Shan, development of which is connected with forming of deep fault networks. Considerable part of the territory of Uzbekistan belongs to the zone of seismic intensity VII (MSK scale) and its eastern and south-eastern parts, where large cities and the capital-city Tashkent as well as numerous industrial units are located, fall into zone of intensity VIII and IX**.** Earthquake hazard is often expressed in terms of seismic intensity, which is a qualitative description of the consequences of earthquake shaking on people and structures. In the former Soviet Union, seismic intensity is measured on a 12-step scale, called the Medvedev-Sponheuer-Karnik (MSK) scale. This is similar to the Modified Mercalli Intensity scale used in the United States and Europe.

First available information about violent earthquakes of the past that occurred on the territory of contemporary Uzbekistan was found in works of famous scientists of the Orient. Macroseimic data on more than 500 strong earthquakes with magnitude $M > 5$ are available from historical manuscripts. Instrumental seismology in Uzbekistan started in 1892 when 14 seismoscopes of the Russian Geographical Society were installed in Tashkent. In May 1901 Repsold-Zelner instruments were installed and since July 13, 1901 regular stationary seismic observations has been started. The earthquakes on the territory of Uzbekistan are the most frequent and dangerous. Institute of Seismology of the Academy of Sciences of Uzbekistan was established on October 1, 1966 soon after the destructive Tashkent earthquake of April 26, 1966. In present time the Institute of Seismology has the full instrumental data base for earthquakes with M>2.5 from 1955 year to 2000 (8630 events) (Fig.2).

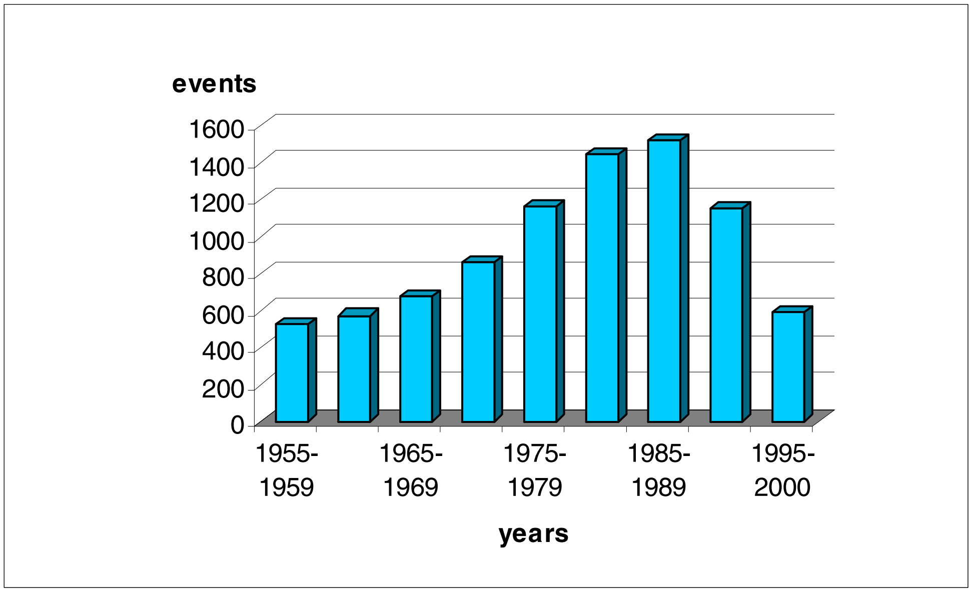

Fig.2. Earthquakes in Uzbekistan with Magnitude from 2,5 to 7,5 for period 1955-2000 year.

The quantity of seismic stations in 1955 at Central Asia was 34. The quantity of seismic stations in Uzbekistan during 1968 for 1976 was 14, since 1976 up to 1990 has increased up to 32 and has reached a maximum. Now in connection with financial problem in territory of Uzbekistan 23 analog and 5 digital stations function. In the period 1955-2000 year in territory of Uzbekistan happened 81 earthquakes with M>5. M=5 – 56 times; M=5.5 – 14 times; M=6 – 4 times; M=6.5 – 4 times; M=7 – 3 times (Fig.3).

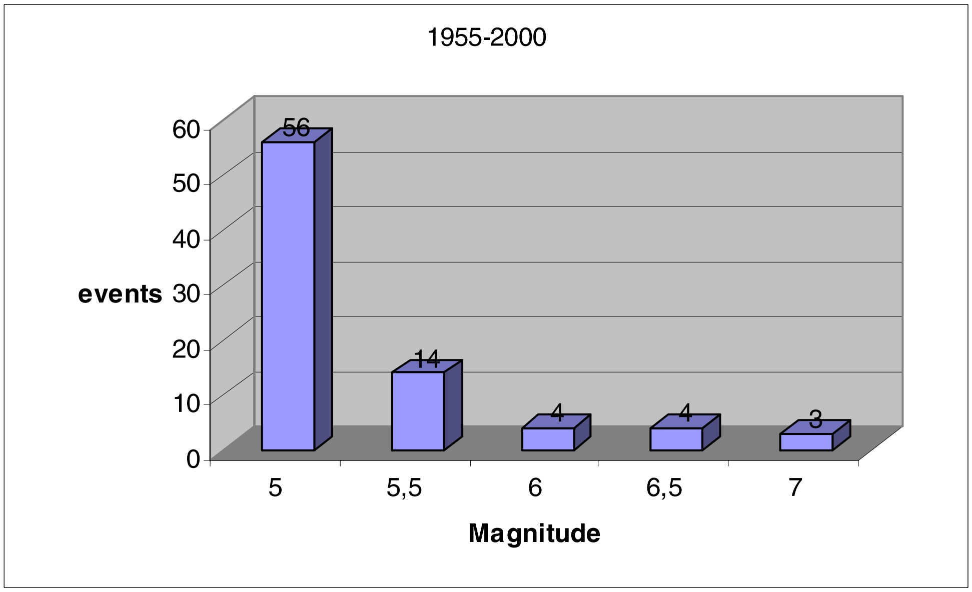

Fig.3. Earthquakes in Uzbekistan with Magnitude more than 5 (M>5), for the period 1955-2000

SEISMIC CODE OF UZBEKISTAN

For the purposes of seismic resistant design, all the design institutes use the new seismic code КМК 2.01.03-96 "Norms and Regulations for Construction in Seismic Zones" [3] and КМК 2.07.01-94 "Town-planning, lay-out and building of urban and village settlements", put into operation by the State Committee for Architecture and Construction in 1994 and 1996.

Seismic stability of buildings is provided with reduction of seismic loadings and increase of resistance to seismic influences. With designing new and reconstruction of existing buildings it is necessary to take into account parameters of a seismological regime of area of construction:

- expected intensity of seismic influence;
- repeatability of earthquakes;
- spectral structure of seismic fluctuations of the basis.

The seismic code consists of 6 basic sections.

1. The principal position. In this part of the code the basic problems are determined at construction in areas with seismic intensity more than VI. Seismicity of the site of construction should be determined on the basis of the seismic microzonation map for areas with seismic intensity VI and more by specialized scientific research institutes. In a seismic code the special table for an estimation of seismicity of the site of construction is given depending on soil conditions. For example seismicity of the site can decrease on 1 point from initial seismicity if the site of construction is located on rocky ground with speed of distribution of seismic waves $Vp > 3000$ m/sec and $Vs > 1700$ m/sec. Seismicity of the site of construction can be increased by 1 point from initial seismicity if the site of construction is located on loess soil with void ratio $e > 0.8$ or with speed of distribution of seismic waves $Vs < 300$ m/sec.

2. Calculations on seismic influences. Designs and the bases of buildings projected for seismic areas, calculated on the basic and special combinations of loadings in view of seismic influences. At calculation can be used:
   - dynamic method of calculation on the real or synthesized seismic influences, characteristic for area of constructions;
   - spectral method of calculation on the seismic loadings determined for ideally elastic systems.

3. Inhabited and public, industrial buildings and constructions. In this point various types of designs used are considered at construction.

4. Underground constructions and engineering networks. In this point requirements for construction of underground constructions and engineering communications in seismically dangerous areas are considered.

5. Restoration and strengthening of buildings. Requirements of the present unit should be observed at maintenance and increase of seismic stability of existing buildings, including restoration of the buildings damaged by earthquake and by the other natural hazard; strengthening in connection with change of settlement seismicity of area or reconstruction of object, change of a degree of its responsibility.

6. Features of manufacture and quality surveillance of works. At manufacturing building materials and construction of buildings it is necessary to observe a degree of quality providing functioning of object during a target date of operation. The given point of the code determines requirements to quality of building materials and the monitoring system at observance of rules of seismic construction. The enforcement of design rules is under the responsibility of the general state expert commission. The monitoring of construction is carried out under the architectural supervision of design organisations, technical service builders, and the General Architectural-Building Inspection of the State Committee for Architecture and Construction.

In the appendix I the intensity and return period of earthquakes with probable intensity more than VII, is determined under the special table (Tab. 2), which is enclosed on this design code. The given list includes 333 occupied items of Uzbekistan located in seismic areas. For an example we shall result a small part of this table for large cities of Uzbekistan [3]. In the appendix II of the seismic code the map of seismic microzonation for the territory of Republic of Uzbekistan is given, in the appendix 3 definitions for the general terms are given.

Table 2. Intensity and return period of earthquakes for the large cities of Uzbekistan.

CITY	Intensity and return period of earthquakes (year)			
	Intensity VII	Intensity VIII	Intensity IX	Intensity more IX
1.Almalik	50	600	---	---
2. Bukhara	50	---	---	---
3. Fergana	50	100		
4. Kokand	50	200	---	---
5. Muruntau	1000	---	---	---
6. Navoi	100	---	---	---
7.Samarkand	150	500	1000	
8. Shargun	50	200	1000	> 1000
9. Tashkent	25	100	---	---
10. Termez	100	---	---	---

VULNERABILITY OF RESIDENTAL BUILDINGS OF THE TASHKENT CITY

Tashkent is the capital of Uzbekistan, the area of the city is about 33.000 hectares and its population is about 2.3 million residents. It is the political, economical, social and tourist center of the country as well as the region. Among the hazards endangering the city, a special place belongs to earthquakes. Throughout its long history, the city of Tashkent has been shaken by many earthquakes, more than 11 times since 1868 to 2002 with intensity more than VI (MSK-scale) that have destroyed buildings and caused casualties. Recently, the earthquake of 26 April 1966 caused destructive damages to Tashkent.

Adobe buildings in Tashkent were heavily damaged in the 1966 earthquake (M=5.3, H=8 km). As a result of earthquake, the residential building area decreased from 7.2 million m^2 to 2.8 million m^2 . There were no cases of modern buildings collapsing. No buildings of local or modern construction collapsed in Tashkent during Nazarbek earthquake (M=5.1, H= 10 km) Rashidov [4]

Typical damage of buildings constructed of local materials includes separation of longitudinal walls from transverse walls, full collapse of non-load bearing walls, collapse of corners of buildings, lamination of brick walls, collapse of pin joints, pounding of adjacent buildings of different heights, and diagonal and horizontal cracking in walls. The reason for extensive damage to adobe brick buildings is that they were not designed to resist earthquake shaking, and many of them were located in the epicentral zone of the damaging 1966 earthquake. In addition, many of them had experienced general deterioration before the earthquake occurred. Damage to older brick buildings is caused by factors such as complicated configurations in design, lack of seismic joints and belts, large basements under part of buildings, and irregular and asymmetric wall locations.

Typical damage to 4 story buildings of Tashkent that were built in the 1940 and 1950s includes diagonal and horizontal cracking in single pier elements, x-type cracking in bricks between apertures, and diagonal and horizontal cracking in staircases. Ten to twelve of these buildings were damaged in the 1966 earthquake and were later restored.

Frame buildings in Tashkent have not been subjected to a major earthquake. In other areas these buildings have shown earthquake damage is possible in load-bearing structures and separation walls. Large panel building construction is fairly new an there is little information on earthquake damage to these types of buildings.

About 43% of the inhabitants of the Tashkent city live in buildings that were not adequately designed and constructed to meet the current standards for seismic resistance. In Tashkent, the area of multistory (4 or more stories) buildings that are of the dangerous construction types is estimated at approximately 1.750.000 m^2 with 217000 inhabitants.

The most vulnerable buildings types in Tashkent include the following Rashidov [4]:

- 9,12, and 16-story frame –panel buildings that include frame structures of the IIS-04 series. In general, many elements of these buildings are prefabricated and welded in the field. The quality of the welding is typically not good. These buildings have been constructed from 1974 to present.
- Frame structures without diagonal bracing built by lifting the ceilings, which have a round profile and one core of stiffness. These buildings have been constructed since 1980. As the Spitak earthquake (M=) revealed, these buildings have an irregular stiffness distribution and very little reserve strength.
- Brick residential buildings built before 1966 and of series 1-310 built 1954 to 1962.These buildings do not have interior longitudinal walls or reinforced concrete cores. In addition, many have experienced damage due to foundation settlement.
- Brick buildings of series 1-310 I built after 1966. These buildings often have low quality of workmanship and poor quality of construction materials. There are no means for controlling processes such as setting of bricks, vibration of concrete, and filling of joints with mortar.

According to current seismological knowledge, maximum expected seismic intensity in Tashkent is estimated to be a level VIII. Estimated recurrence periods given in the seismic code are for a future earthquake intensity VIII (every 100 years) and intensity VII (every 25 years). It should be mentioned that a large part of the city has unfavorable soil conditions in terms of seismic influence. Such soils magnify seismic effects. According to engineering-seismological estimations on the map of seismic microzoning of Tashkent, the city can be divided into 2 zones of maximum expected (design) seismic intensity at the level of MSK VIII and IX. This represents a rather serious danger for urban construction and city inhabitants.

Tashkent's vulnerability to earthquakes is increasing due to the rapid development of the city. The accommodation of an increasing population and industrial sites led to the proliferation of weak slap-dash buildings and structures. Seismic resistant construction norms are not taken into consideration, and immigrants to the area have no awareness of the seismic threat. Residential and industrial buildings are constructed in unsuitable areas, such as areas of reclamation, slopes and in other unfavourable conditions, which have not previously been occupied. If a large earthquake strikes today, it will affect a much larger and more populated are than during the past earthquakes.

CONCLUSION

Among the factors contributing to the existing high-risk level for Uzbekistan are the following:

- high level of seismic hazard;
- complicated and seismically unfavourable engineering-geological conditions;
- a rather high density of population, most of which live in zones of design intensity IX;
- low quality of workmanship and construction materials;
- a considerable vulnerable individual houses and buildings of old construction, built without modern seismic consideration and in need retrofitting.

The community limited of financial recourses needed for the purposes of state and social development, which is typical for developing countries, should be interested in optimization of disaster preparedness measures often competing with other urgent needs. For the reduction of seismic risk necessary to take to account the requirements of seismic code for the construction new buildings and strengthening of reconstruction buildings.

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