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CHARACTERIZATION OF THE SEISMIC ZONE OF CHIȘINĂU

BY

EVGHENI CUTIA*

„Gheorghe Asachi” Technical University of Iași,
Faculty of Civil Engineering and Building Services

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Abstract. This paper presents information on seismic hazard in Chișinău city, Republic of Moldova. Analyzing historical data, eyewitness statements, and records of the Institute of Geology and Seismology of the Academy of Science of the Republic of Moldova, we can conclude that the Chișinău city is located in an active seismic area with an intensity exceeding 7 degrees on the MSK-64 scale.

Keywords: Chișinău; hazard; intensity; earthquake.

1. Introduction

The Republic of Moldova like Romania is periodically affected by subcrustal earthquakes in the Vrancea zone. One of the most exposed areas for earthquake is Chișinău city, the capital Moldova Republic, a city with a population over 800,000 inhabitants and with a population density of 5,576 inh/km². From the administrative point of view, the city is divided into 5 districts with total area of 123 km² (Wikipedia, 2017). Concerning the soil, a layer of sandy clay is present throughout the city at a depth of 2 to 20 meters.

Between 1920 and 1940, in the city has been build one and two-story structures made of bricks, raw clay with the addition of reinforced straw with

*Corresponding author: *e-mail*: evgheni.cutia@tuiasi.ro

clay mortar and crushed stone with lime or clay mortar (Alcaz *et al.*, 2011). After the Second World War in Chişinău began the construction of four-floor and five-floor structures. As fundamental for design of these buildings stands different types project that were developed by the designers of the former USSR, have been considered:

a) project for stone buildings series 1-311C, 1M-438AC, 102SC (Fig. 1);

b) project for large panel buildings series 1-464S, 1-464AS, 135, 143, 143MK, 92MSB;

c) individual reinforced concrete projects for construction up to 9 floors high buildings.

At the end of the XX century in city could be noticed a sharp increase of two- or three-story RC houses. As the basic material reinforced concrete starts to be used.



Fig. 1 – Building series 1M-438AC (GeoPortal, 2018).



Fig. 2 – Building series 135 (Vostochno-Sibirskoe Konstruktorskoe Bjuro, 2017).

Table 1

*Distribution of Buildings in Chişinău City According to the Construction Period (Alcaz *et al.*, 2011)*

Construction period	<1920	1920-1939	1940-1959	1960-1979	1980-1999	>1999
Number of constructions, [%]	6.9	7.0	12.8	40.8	22.8	9.7

2. General Information About Earthquakes in the Republic of Moldova Between XIX – XX Centuries

In the last century, the Republic of Moldova has been affected by a series of earthquakes the epicenter of which is the Vrancea area, Romania,

where earthquakes occur at depths from 60 km to 180 km. It can be noticed that there are two or three major earthquakes that exceeded the magnitude of 7 on the Richter scale in every century. Among the strongest earthquakes which affected the Republic of Moldova since the early 1900s the following can be listed:

1. The earthquake of October 6, 1908

The first major earthquake occurred in the early twentieth century with magnitude $M = 6.8$ on the Richter scale took place in October 6, 1908, lasted about 3 minutes and caused panic among the population. The effects of the earthquake were vibration of buildings, cracks in walls, broken windows and moving furniture. The description of these damages allows to assign the intensity of 5 degrees after the MSK scale. (Stepanenko & Kardanec, 2017).

2. The earthquake of October 22 and November 10, 1940

The Vrancea earthquake of November 1940 with a magnitude $M = 7.4$ on Richter scale occurred at 4:41 AM at a depth of 133 km and reached Moscow, Voronezh and Kiev (Cer și pământ Românesc, 2017). In Chișinău, the National Museum of Ethnography and Natural History, Cathedral of Christ's Nativity, and others buildings suffered damages. The Costiujeni Mental Hospital suffered the most. According to the "Chisinau Housing Estate List of 25 of January 1945", 256 buildings collapsed, 681 buildings needed some repairs and over 2,300 minor repairs. As a result of these two earthquakes, over 400 families have been left homeless. In the early summer of 1941, the earthquakes damages were partly liquidated. It was a priority to rehabilitate the hospitals, water pipes, schools and kindergartens from the list of the damaged structures. (Diez.md, 2017)

3. The earthquake of 4 march, 1977

The earthquake recorded in Vrancea on 4 March, 1977 lasted for 56 seconds and had a magnitude of $M = 7.2$ on the Richter scale, occurred at a depth of 100 km and was followed by a series of earthquakes with a magnitude $M = 1-4$ on the Richter scale. This was one of the strongest earthquakes registered in the Republic of Moldova. Even in Moscow the seismic waves reached up to 2-3 degrees after MSK-64 scale. The newspaper "Chișinău in the Evening" wrote (Chișinăul de Seară, 1977): "A special working group was established to solve the consequences of the earthquake. All the residential and communal services will also work during weekends ". Approximately 8800 buildings needed repair. The earthquake did not lead to any deaths. The Institute of Geophysics and Geology has collected data on seismic intensity in different regions of Republic Moldova from over 20,000 inquiries sent all over RM. Grigore Eremei, First Deputy Chairman of the Soviet Ministers of the RSSM, in his memoirs "The invisible face of power," writes about the total damage cost of

around 150 million rubles (Eremei, 2003), the nowadays equivalent of around 450 million USD.

4. The earthquake of 31 may, 1986

The Vrancea earthquake occurred in May 1986 is the third strongest seismic event with a magnitude $M = 7.0$ on Richter scale in the last 170 years, after that of 1940 and 1977. The strongest effect of this earthquake was reported in the South of the Republic, at Cahul, where the water stroked from the cracks of the upper soil layer. Following the earthquake, two people died, 1,200 collapsed houses and about 12,500 people were left without roof. The damages are estimated around 800 million dollars (Sputnik Moldova, 2017). This statistic was gathered, as in the case of the March 1977 earthquake, with the help of a questionnaire published in the Soviet Union, where citizens were asked to fill in this form to create a transparent picture of the damage caused by the earthquake and to describe how earthquakes occurred in different regions of the republic.

5. The earthquake of 30 may, 1990

This Vrancea quake of magnitude $M = 6.9$ on the Richter scale has been felt in an extended area, especially in the South-western part of Europe; in Romania (up to 8 degrees in epicenter areas), in the Republic of Moldova (from 7 degrees in the South of the republic to 5 degrees in the Northern part), Bulgaria (5-6 degrees), Ukraine (3-7 degrees), Russia (2-3 degrees). The earthquake was also felt in the territory of Greece, Turkey, and Poland. There are no clear recorded data about the damages after the earthquake.

6. The earthquake of 22 November, 2014

On Saturday evening, November 22, 2014, a powerful $M = 5.7$ magnitude earthquake, with a relatively low depth of only 39 km, occurred in the Vrancea region, reminiscent of a large area. Thus, the earthquake was felt intensely in the south, central and eastern part of Moldova.

7. The earthquake of 22 September, 2016

At 2:11 there was an earthquake of magnitude $M = 5.8$ at a depth of 82 km on the territory of the Republic of Moldova. The epicenter was in Vrancea, 145 km North of Bucharest, but it felt strong where the intensity reached 5.0-5.5, in the south of the country it felt 6.0. There were no casualties after the earthquake.

3. Seismic Zoning

The seismic zonation consists of mapping and dividing with isolines the region where the earthquake can be felt more or less with the same intensity. The operation of seismic zoning operation is carried out in two stages (Dimoiu, 1999):

1° Macrozonation – which includes the response of the population, the areas affected by the earthquake, to a model questionnaire, the notes of the engineers who investigated and inventoried the damage to the buildings in the area.

2° Geological and geotechnical studies - measurements of the soil layers, shear wave velocity, groundwater level, etc. are made and aims at correcting Macrozonation.

In the Republic of Moldova, seismic microzoning is made by using the Medvedev-Spanheuer-Karnik (MSK) seismic intensity scale, which represents a revised and updated version of the Mercalli scale.

A new map of seismic zoning on the territory of Moldova Republic was implemented in April 2013. The new map reflects the seismic intensity of the territory more accurately compared to the old map developed in the earliest 1980s. Also, on the map the area 8 degrees of the MSK-64 scale was reduced, which leads to the economy of construction materials. (Alcaz *et al.*, 2011) According to this map, the Republic of Moldova is divided into 3 zones with intensities between 6 to 8 degrees according to the MSK-64 scale, namely North-West with 6 degrees, in center of republic – 7 degrees and South-East – 8 degrees on MSK scale (Fig. 3).

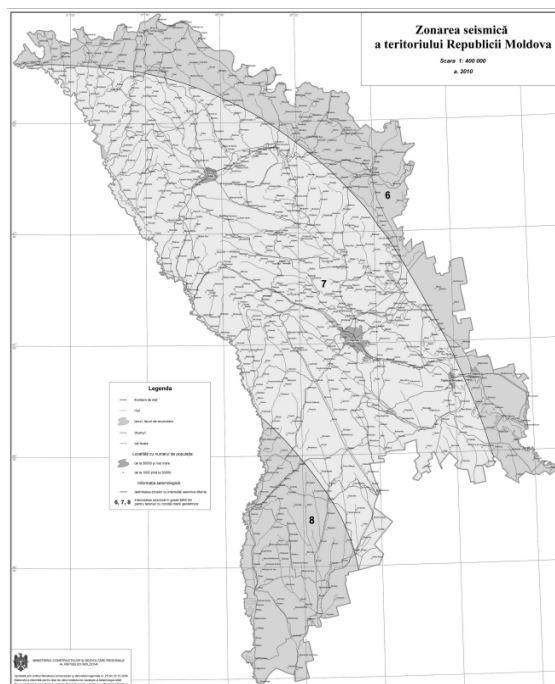


Fig. 3 – Seismic zonation of Republic of Moldova (FIM, 2017).

At the same time the seismic map of micro-zoning of Chisinau municipality was also developed. From the geographic point of view, the city of Chisinau is located in the central area of the Republic, which corresponds to the seismic intensity of 7 degrees, but in reality, these values are between 7 and 9 degrees according to the MSK-64 scale. This intensity varies due to geological conditions, the presence of groundwater, soil type, and so on.

3. Conclusion

This paper present some data and information about seismic hazard in Chisinau municipality along with the historical data about the strongest seismic events occurred in the past century. As it can be easily identified, approximatively 40 % of existing buildings have passed at least four major seismic events. Seismic zoning maps and seismic risk maps help to minimize the damage that may occur in the event of an earthquake.

In conclusion, one can say with certainty that the Republic of Moldova is in an active seismic area and the capital of the country, the city of Chisinau, is one of the most exposed urban localities in the dangerous seismic area.

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CARACTERIZAREA ZONEI SEISMICE A ORAȘULUI CHIȘINĂU

(Rezumat)

Sunt prezentate informații privind hazardul seismic în Republica Moldova, municipiul Chișinău. Analizând datele istorice, declarațiile martorilor oculari, înregistrările Institutului de Geologie și Seismologie al Academiei de Științe a Republicii Moldova se poate concluziona faptul că orașul Chișinău este situat într-o zonă seismică activă cu o intensitate ce depășește 7 grade pe scara MSK-64.

