ASSESSMENT OF THE 2012 M_W=5.6 EARTHQUAKE IMPACTS IN THE CITY OF SOFIA

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Abstract: In this work are represented the minimum and the maximum degrees of the seismic impact and the relevant effects on different types buildings on the territory of Sofia caused by the earthquake on 22nd of May 2012 with magnitude Mw=5.7 and I_0=8 MSK. In order to define better the impacts, here are collected and analyzed information and further identification of the damages in Sofia. The observed effects are evaluated using the macroseismic scale MSK-64.

Key words: earthquake, seismic impact, macroseismic intensity, the city of Sofia

Introduction

The Sofia area is the most populated (the population is of more than 1.5 mil. inhabitants), industrial and cultural region of Bulgaria that faces considerable earthquake risk.

The contemporary tectonic activity of the Sofia area is associated predominantly with marginal faults of Sofia graben. The boundaries of the graben are represented by SE-NW fault systems with expressive neotectonic activity. Earthquakes in the Sofia seismic zone seem to be distributed along these fault systems, which have played an active role in the recent geodynamic evolution of the area.

The available historical documents prove the occurrence of destructive earthquakes during the 15th-18th centuries in the Sofia zone (Watzof, 1902). However, the information about the ancient events is very incomplete and uncertain and only an approximate estimation of their location is possible. In 19th century the city of Sofia has experienced two strong earthquakes: the 1818 earthquake with epicentral intensity I_0=8-9 MSK and the 1858 earthquake with I_0=9-10 MSK (recently revised value in terms of EMS98 proves to be the same) (Christoskov et al., 1979). The 1858 earthquake caused heavy destruction to the city of Sofia and the appearance of thermal springs in the western part of the town (Watzof, 1902). After a quiescence of about 50 years a strong event with

M=6.5 occurred in 1905 near the town of Trun in the western marginal part of the zone (Grigorova et al, 1979).

During the 20th century the strongest event occurred in the vicinity of the city of Sofia is the 1917 earthquake with M_S=5.3 and I_0=7-8 MSK. The earthquake caused a lot of damages in the town and changed the capacity of the thermal mineral springs in Sofia and surroundings. The earthquake was felt in an area of 50000 km^2 and followed by aftershocks, which lasted more than one year (Kirov, 1952; Petkov and Christoskov, 1965).

Almost a century later (95 years after the 1917 earthquake) an earthquake of moment magnitude 5.6 (I_0=8 MSK) hit the Sofia seismic zone, on May 22nd, 2012, located at 25 km south west of the city of Sofia. No casualties and severe injuries have been reported. Predominantly moderate (grade2, according to Grünthal, edit., 1998) to substantial (grade3, according to Grünthal, edit., 1998) damages were observed in the city of Sofia and surroundings.

In the present study, distribution of macroseismic effects along the city of Sofia is estimated and analyzed. The approach used in the present study is applied for generation of deterministic scenarios using directly the intensity assessment of the strongest past earthquakes for the cities of Ruse (Solakov et al., 2009a,b) and Plovdiv (Solakov et al., 2011).

Observed macroseismic effects in the city of Sofia

Distribution of macroseismic effects (generated by the 2012 M_W =5.6 earthquake) along the city of Sofia is estimated on the base of documents and reliable information available in the "Archive" department at the Sofia municipality. The intensity map illustrating the distribution of macroseismic intensity (MSK) along the city of Sofia is presented in Fig.1.

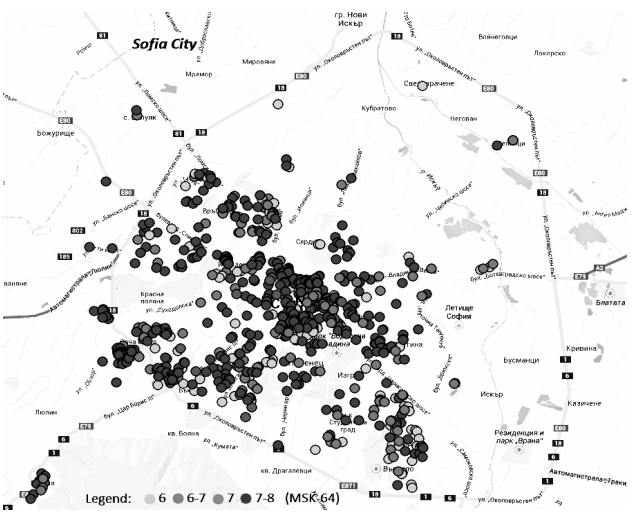

Fig. 1. Observed macroseismic effects (in MSK intensity scale) for the city of Sofia caused by the 2012 (M_W=5.6) earthquake

The figure shows that the intensity values range between 6.0 and more than 7 (MSK).

The highest intensity values (above 7 MSK) are related to old not well maintained buildings that were not reinforced (marked by red spots in Fig.1). Twelve cases of failures of 7-8 degree MSK in Sofia have been documented. Some of the most vulnerable buildings are shown in Figure 2.

Fig.2. Buildings with damages from 7-8 degree

One part of these buildings are uninhabited with unknown owners and self-destructives. Others are municipal property and are used for housing the socially weak families. Additionally these are buildings witch haven't been renovated recently. The third types of buildings with that kind of damages are declared for culture monuments. But because of the lack of clearance whose property they are, they are also uninhabited, strongly damaged from the atmospheric conditions and amortized.

The predominant degree of damage of the buildings in Sofia is 7th (MSK-64), its concentration is focused in the central city part. These are brick houses and buildings built at the beginning of the 20th century (such a house is illustrated in Fig.3).

Fig.3. One example of the damage from 7 degree

Most of these buildings are unkempt – without being done any basic renovation. As a result, the chimneys are with fallen cowls; partly or at half demolished bodies; with crumbled plastering, amenable to falling bricks. There are big pieces of fallen plastering from the facades of the buildings and also tiny cracks on the walls. In about 40 percent of the observed cases there are dislocation and sliding of the tiles from the roofs. The area with impacts from 7th MSK degree is expanding mainly westerly from the central parts of the city (from north-west to south-west, reaching Vladaya neighbourhood, situated in the south-west parts of Vitosha mountain).

Impacts from 6th and 6-7th MSK degree according to MSK experience big part of the schools and the kindergartens in the municipalities situated from south-south-western to north-western part of the city. In the apartment buildings (in these municipalities) regardless of the construction type (panel, monolithic), in the most of the cases the plastering of the walls is broken, the cracks are tiny and insignificant, non-causing influence of the entirety of the building construction. Damages of 7th degree MSK in the buildings are due to reconstructions in the apartments made by their owners like: removal of supporting walls or columns, merging of two apartments in one by making holes for doors in the supporting walls.

Impacts with degree of intensity 6 (MSK) predominates in the south-eastern parts of the city.

Generally, in the north-north-eastern part of the city of Sofia (where districts: Voenna Rampa's industrial zone, Benkovski are located) there are almost no evidences of damages. The same is the situation in the south-eastern parts of the city (districts: Druzhba 1 and 2, The Poligon, Tzarigradski Kompleks).

In the districts at the foot of the Vitosha mountain, where most of the buildings are 2-3 storeyed houses and new blocks (Dragalevtsi, Boyana, Krustova voda, Manastirski Livadi) there are also no information about damages.

Conclusions

Based on about 760 points, values of seismic impacts in which the damages occurred in buildings of the Sofia are determined. The most vulnerable types of buildings are those, built at the beginning of the 20th century and are unkempt. Others, more seriously damaged, are buildings, where the supporting walls and columns have been constructively changed. Such buildings are scattered throughout the city of Sofia.

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Оценка на въздействията в град София от земетресението на 22-ри май 2012г.

И. Александрова

Резюме. В тази работа са представени минималните и максималните степени на сеизмичното въздействие, както и съответните ефекти върху различни видове сгради на територията на София, причинени от земетресението на 22 Май 2012 с магнитуд Mw = 5.7 и I_0 = 8 MSK. За да се определят по-добре въздействията, тук е събрана и анализирана информация и последващо определяне на щетите в София. Наблюдаваните ефекти са оценени чрез използване на макросеизмична скала MSK-64.