

# Creating a Digital Model of the Damages of the Earthquake of Metropolitan Tarnovo /13th century/

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**Abstract.** The studying of the monuments and complexes in Tarnovo, as well as some other examples in its vicinity give us some strong points for determining of earthquakes and provide data for developing a digital model for this natural phenomenon in the urban environment, in accordance with the specific natural characteristics.

**Keywords:** Architectural monument, total destruction of most buildings, digital model of the technological anti-seismic solutions

## 1 Introduction

The studying of the natural phenomena as factors in everyday life, its damaging impact on the architectural environment, as well as its impact on the natural environment of metropolitan Tarnovo, certainly continues to be an unexplored field in the studying of the material culture. Often these exact factors are correlated to specific changes in the urban design.

They mark significant moments in the architectural history of particular monuments and have made an impact on the development of the building technology. The methodology of the field work allows for the reading and analysis of those factors of the material culture and undoubtedly of the political and military history of the medieval Bulgarian society. Characteristic of their impact is that they leave marks on the natural environment, architectural monuments and the society. This is the conclusion of the seismological analysis and the level of the damages on these specific factors classify the earthquakes according to their intensity. In this sense, the continuous study of the monuments and complexes in Tarnovo, as well as some other examples in its vicinity give us some strong points for determining of earthquakes and provide data for developing a digital model for this natural phenomenon in the urban environment, in accordance with the specific natural characteristics.

There is also enough data for creating a digital model of the technological anti-seismic solutions of the following restoration of certain architectural monuments<sup>1</sup>.

## 2 The earthquake zone of Gorna Oryahovitsa

It is a known fact that the earthquake zone of Gorna Oryahovitsa is one of the six most active zones in Bulgaria, along with the earthquake zones of Sofia, Struma, Rhodopa mountain, Maritsa and Shabla [2]. The earthquake zone of Gorna Oryahovitsa has a seismic activity over the 7th degree on the Richter scale and 10th degree of intensity on the Medvedev-Sponheuer-Karnik scale [3]. Actually, the 10th degree of intensity of destruction defines the earthquake as destructive. It leaves behind from significant to total destruction of most buildings, as well as 1 meter wide cracks and tearing to the soil, massive slides. The last destructive earthquake occurred on the 1st of June, 1913. There is some data that links the destructive earthquake that occurred in the metropolitan Tarnovo during the third quarter of the 13th century. It left a deep mark on the building chronology of many architectural monuments and complexes (in some cases destroyed and abandoned, and in others, destruction, followed by reconstruction via strengthening of the construction), as well as on the natural environment of the city.

Information for this kind of destruction has been collected from the St. Dimitar church and its monastery, also from the Holy Forty Martyrs Church and the monastery of Great Lavra; church №9 and its belonging monastery on the ledge of the so called Baldwin's Tower of Tsarevets; the church in the aristocratic residence, north of the castle of Tsarevets; the south-eastern part of the Trapezitsa fortress; the Rahovets fortress, etc.

The excavations at the St. Dimitar church show that the damages on the longitudinal wall /east-west/ are only in the southern direction. Large rock fragments have been discovered over the destroyed architectural remains, as well as on the western and the southern wing of the monastery. Large fragments, detached from the rock crown of Trapezitsa, are discovered on different levels.

Serious renovation activities on Holy 40 Martyrs church are dated to the middle of the 13th century through the coins that were discovered here [6]. The two layers of construction debris from the church and from the eastern wing of the monastery are spread across the entire northern yard of the Lavra [5]. The lower one dates precisely from the middle of the second half of the 13th century.

The first construction period of Church №9 of Tsarevets dates from the 90's of the 12th century to the 60's and 70's of the 18th century. After this follows a reconstruction, related to the rebuilding of the foundation of the already demolished temple. The carrying elements in the base of the foundation were strengthened. Mainly the eastern part of the church was stabilized. The shortening of the building plan undoubtedly increased its general stability. The reconstruction carries all of the characteristics of

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the anti-seismic construction. In the second half of the 13th century the church of the aristocratic residence in Tsarevets was destroyed. Architectural fragments have fallen southwards in the direction of the seismic wave [4].

During the last decades of the 12th century several smitheries have been founded in the eastern section of the southern fortification of Trapezitsa. They remained until the second half of the 13th century when large rock fragments dropped on them and on the waste pits, related to the production. The third half of the 13th century is a time of serious renovation activities and change in the construction plan of the large feudal complex in the south-east part of Trapezitsa.

### **3 Digital Model of the Damages of the Earthquake of Metropolitan Tarnovo**

The data for the established natural disaster is systemized and digitally archived with the cooperation of the Institute of Mathematics and Informatics at the Bulgarian Academy of Sciences [1]. This gives the opportunity for their complete future reconstruction and the digital reproduction of the natural disaster in question from the third quarter of the 13th century.

Due to its close proximity to Gorna Oryahovitsa, i.e. in the immediate range of the destructive impact of the earthquake shock caused by this active hypocenter, Veliko Tarnovo gives specific and direct opportunity to explore such past cataclysms through the findings of the archaeological research. It also gives an opportunity for creating a digital model of the natural disaster in the specific natural and urban environment. This model illustrates the direction of the seismic wave; the durability of the buildings in the conditions of available technological capabilities at that time /the second half of the 13th century/; the new technological methods of building for antiseismic durability in the following reconstruction of the affected buildings. All of this is possible on the basis of thorough studying and digital archivation of the seismic activity data along with the destruction of the natural environment, buildings and at last probably the human factor, which is understandably difficult to estimate. It's possible to create a complete map of the region falling within the trajectory of the most intense seismic wave.

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