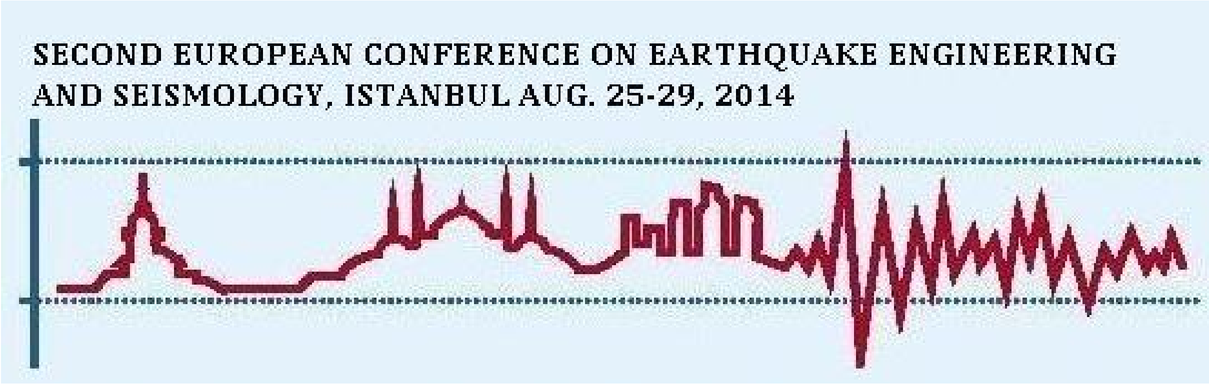

THE EARTHQUAKE LOSS SCENARIO FOR THE CITY OF TBILISI

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Risks of natural hazards caused by natural disaster are closely related to the development process of society. Disasters pose hazard to sustainable development of the country. The high level of natural disasters in many countries makes necessary to work out the national programs and strategy. The main goal of these programs is to reduce the natural disasters risk and caused losses. This problem is of vital importance for Tbilisi as it is a big city and capital of Georgia.

The attempt has been approached within the framework of the project "EMME – Earthquake Model for Middle East Region: Hazard, Risk Assessment, Economic and Mitigation". The primary scientific objective of this project was to combine analysis of the contemporary elements at risk inventories, seismicity and vulnerability to assess seismic hazard and seismic risk for the capital of Georgia – Tbilisi.

Tbilisi lies at the eastern end of the Achara-Trialeti fold-thrust belt. The North Achara-Trialeti (ATN) thrust separates the Achara-Trialeti belt from the Georgian block to the north. The South Achara-Trialeti (ATS) thrust separates the Achara-Trialeti belt from the Artvin-Bolnisi block to the south. Tbilisi lies between the eastern terminations of these two thrusts The city is characterized with rapid increase of population density, high speed of urbanization and vulnerable infrastructure, which increases seismic risk.

The Tbilisi area had been considered as a region of relatively low seismicity. Historical seismicity in this area has been recorded since the 13th century and all known strong ($Ms > 5$) earthquakes in this area are associated with the above mentioned faults. In 2002 Tbilisi earthquake with $Ms = 4.5$ took place that was the result of seismically active, newly discovered fault passing the capital territory.

In risk assessment one of the most important parameters is the inventory of elements at risk. In urban area, elements at risk are comprised of buildings, lifeline systems, population, socio-economic activities. Extensive and comprehensive collection of element at risk inventories is vital for estimation of losses to elements at risk during the earthquake. So the first step was creation of high quality building inventory map in GIS.

The second step was to obtain seismic site conditions and amplifications map for Tbilisi city. This aspect deserves major attention since it plays considerable role in the definition of the seismic impact to be considered in the design and retrofitting of structures. The most important parameter of soil maps of seismic site conditions, the shear wave velocity in the upper 30 m section of the ground (V_{S30}) on regional scales are relatively rare since they required substantial investment in geological and

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geotechnical data acquisition and interpretation. For this purpose all available large-scale maps, published archived materials, as well as unpublished materials from private archives was discussed. Available geotechnical information, as well as seismic data obtained during implementation of the project was collected and analyzed.

Multichannel seismic prospecting system: RAS-24 6 was used to carry out seismic prospecing work. Combined all obtained data together with obtained geo-engineering map were summarized and local map of seismic site conditions in 25 000 scale have been evaluated.

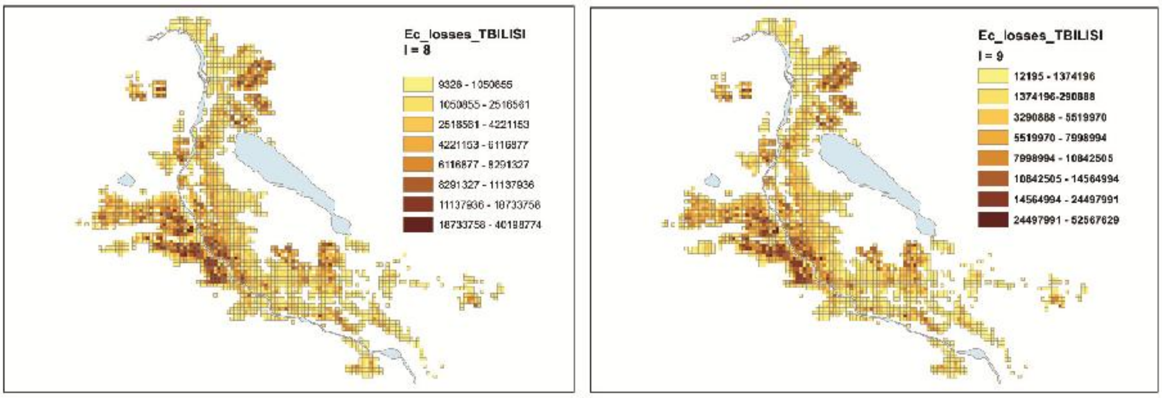
The third step was investigation of active structure of Tbilisi in large scale 1:25 000. 2 & 3D structural model of Tbilisi area show that the east Achara-trialeti fold and thrust belt is active thin-skinned fold and thrust belt; Structure is represent by fault-related folds (fault-bend and fault-propagation), duplexes and backthrusts; Frontal part of eastern Achara-Trialeti are represent by triangle zone; Tbilisi earthquake may be related north-vergent thrust. Historical Mtskheta earthquake may be related north-vergent thrust.

The next step was assessment of probabilistic seismic hazard (PSH) on the bases of selected GMPE models Cotton et al. (2006). For ranking and selecting candidate GMPEs using the data-driven testing procedure proposed by Scherbaum et al. (2004), Scherbaum et al. (2009) and Kale and Akkar (2012). Proceeding from this analysis, GMPEs (Akkar et al., 2013; Chiou and Youngs, 2008; Akkar and Cagnan, 2010; Zhao et al., 2006) were used with equal weights in the logic tree combination in the seismic hazard calculation (EMME, 2013).

On the bases of empirical data that was collected for Racha earthquake (Ms = 6.9) on 29 April of 1991 and Tbilisi earthquake (Ms = 4.5) on 25 April of 2002 some intensity based vulnerability study were completed. These records does not explain the building height. For this, according to the actual observable inventory and expert opinion the following assumptions are made: simple stone are consider as mid-rise M3M ; Pre code masonry rc floors are considered as low rise M6LPC; MC masonry rc floors are consider as mid-rise M6LMC. Also industrial types of building large panel buildings that do not have analog in European buildings were investigated. The vulnerability for large block buildings were developed on the data bases of the same house in Irkutsk on the bases of experts' judgment.

Probabilistic seismic risk assessment in terms of structural damage and casualties were calculated for the Tbilisi city for 1 km grid cells using obtained results. This methodology gave prediction of damage and casualty for a given probability of recurrence, based on a probabilistic seismic hazard model, population distribution, inventory and vulnerability of buildings. ELER software (Hancilar et al., 2010) were used for this calculation. The approach used in damage estimation is to obtain a normally distributed cumulative damage probability for each building type. The damage probability distribution is a function of each building's vulnerability and ductility parameters (Lagomarsino and Giovinazzi, 2006).

Very important is to estimate the initial cost of building for assessment of economic losses. From this purpose the attempt was done and the algorithm of this estimation were prepared taking into account obtained the inventory. Build quality, reliability and durability are of special importance to corresponding state agencies and include different aesthetic, engineering, practical, social, technological and economical aspects. The necessity that all of these aspects satisfy existing normative requirements becomes evident as the building and structures come into exploitation. The long term usage of building is very complex. It relates to the reliability and durability of buildings. The long term usage and durability of a building is determined by the concept of depreciation. Depreciation of an entire building is calculated by summing the products of individual construction unit' depreciation rates and the corresponding value of these units within the building. This method of calculation is based on an assumption that depreciation is proportional to the building's (constructions) useful life. We used this methodology to create a matrix, which provides a way to evaluate the depreciation rates of buildings with different type and construction period and to determine their corresponding value. Finally economic losses were calculated for some possible scenario earthquakes. In Figure 1 a,b are presented Tbilisi earthquakes scenario calculation in terms of damage an economic losses.



a b

Figure 1. Economic losses for some possible earthquakes for Tbilisi city: a) I = 8 MSK; b) I = 9 MSK

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