95th Journées Luxembourgeoises de Géodynamique

Echternach, Grand Duchy of Luxembourg
November 9-11, 2009

Attenuation Relation and Development of Seismic Hazard of Caucasus Region

N. Jorjiashvili (1), M.Elashvili (2)

1)Ilia Chavchavadze State University, Seismic Monitoring Center, 77 Nutsubidze st.,0177 Tbilisi, Georgia. nato@seismo.ge,
2)Ilia Chavchavadze State University, Seismic Monitoring Center, 77 Nutsubidze st.,0177 Tbilisi, Georgia.
m.elashvili@seismo.ge

Extended Abstract

Caucasus lies between Black Sea and Caspian Sea, within a broad zone of deformation, which forms part of Alpine-Himalayan collision belt. The present-day tectonics of the area is dominated by the motion of Arabian plate northward relative to the Eurasian plate. The Eurasian and Arabian plates converge at 28 mm/y along 26°N near the Caucasus. The Geological history of the Caucasus region is complex, and is described by several investigators. Fig.1 shows the recent earthquake with its aftershocks within a month in Greater Caucasus, Racha Region.

Main shock occurred on 7^{th} of September 2009 at 22:41 with magnitude 6.0 (Ml) which was followed with about 300 aftershocks within a month.

During recent years many important work has been done in the field of seismology by help of Georgian funding as well as foreign funding. It has been compiled probabilistic maps of seismic hazard that needs to be updated continuously. Many works have been already done. Instead of general parameter of macroseismic intensity, it is used a peak ground acceleration and spectral acceleration approved by Europian, American and Japanese Building Codes. It has been improved scheme and parameterization of seismic active faults, after field exploration it has been added new seismic active structures (for example, at Javakheti plateau, in Tbilisi) and such research have been continued until now. Apart, it has been done improvement and modernization of Georgian seismic network. Today, 25 digital seismic stations have been operating, some of them in online regime. It has been done seismic database and that is important since 2003 (when the first digital seismic station was installed) a huge number of data have been accumulated.

All mentioned above give us possibility to make one step forward in the field of seismic hazard and earthquake effect analysis.

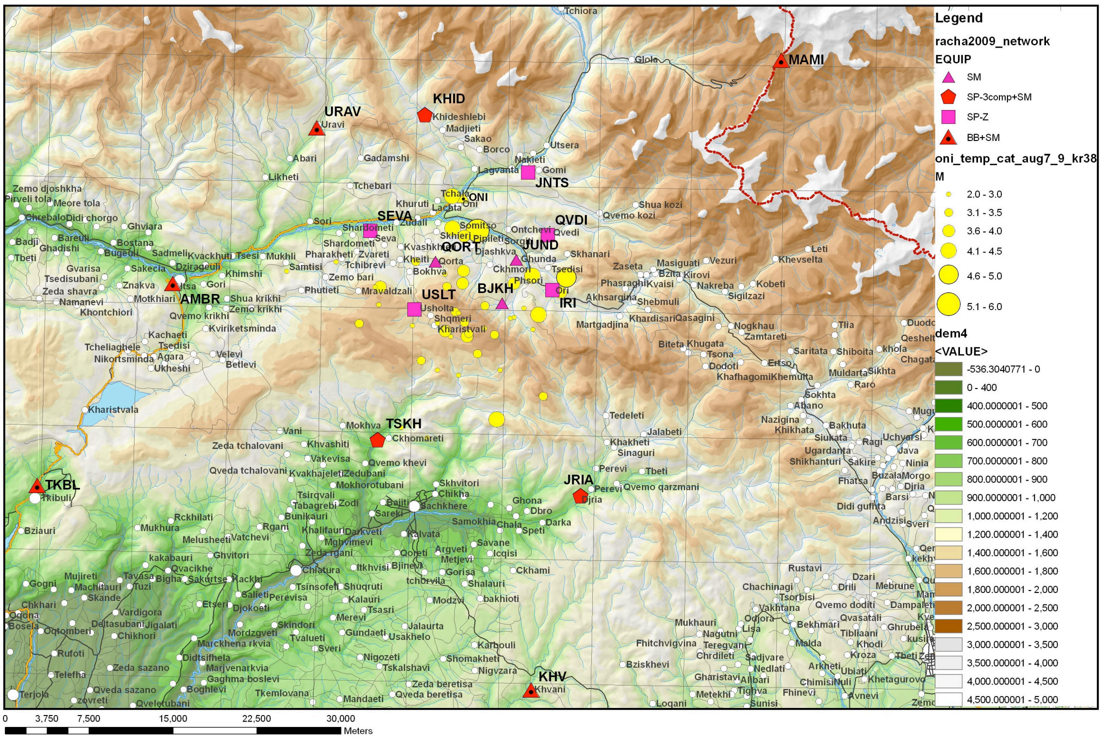

Fig.1. Recent network in Racha Region, Epicenter map of Racha EQ with its aftershocks.

Earthquake effect at the surface is defined by following factors: 1) Seismic source process – i.e. earthquake mechanism and released energy; 2) Seismic wave propagation in earth crust and its attenuation; 3) Site effect at the observation place that is depend on local conditions of the ground and causes earthquake effect at the surface.

For the seismic hazard assessment apart those factors it should be taken into account earthquake sources (seismic active faults and their distribution) and their parameterization.

In this work an attention is paid on last two factors because done works until now provide us very general empirical attenuation relation of ground motion and site effect have never been taken into account.

Generally, ground motion and damage are influenced by the magnitude of the earthquake, the distance from the seismic source to site, the local ground conditions and the characteristics of buildings. Estimation of expected ground motion is a fundamental earthquake hazard assessment. This is the reason why this topic is emphasized in this study.

For the present study waveform data from 384 earthquakes were used recorded on 20 stations strong motion and broadband type. In total, 699 records were chosen for study. Acceleration data from strong ground motion database were used from 237 earthquakes recorded on 16 stations. Besides, some data were used from 147 earthquakes recorded on 4 broadband stations.

Fig. 2 shows distribution of epicenters of earthquakes used for the present study. Besides, this figure shows distribution of travel paths of shown earthquakes.

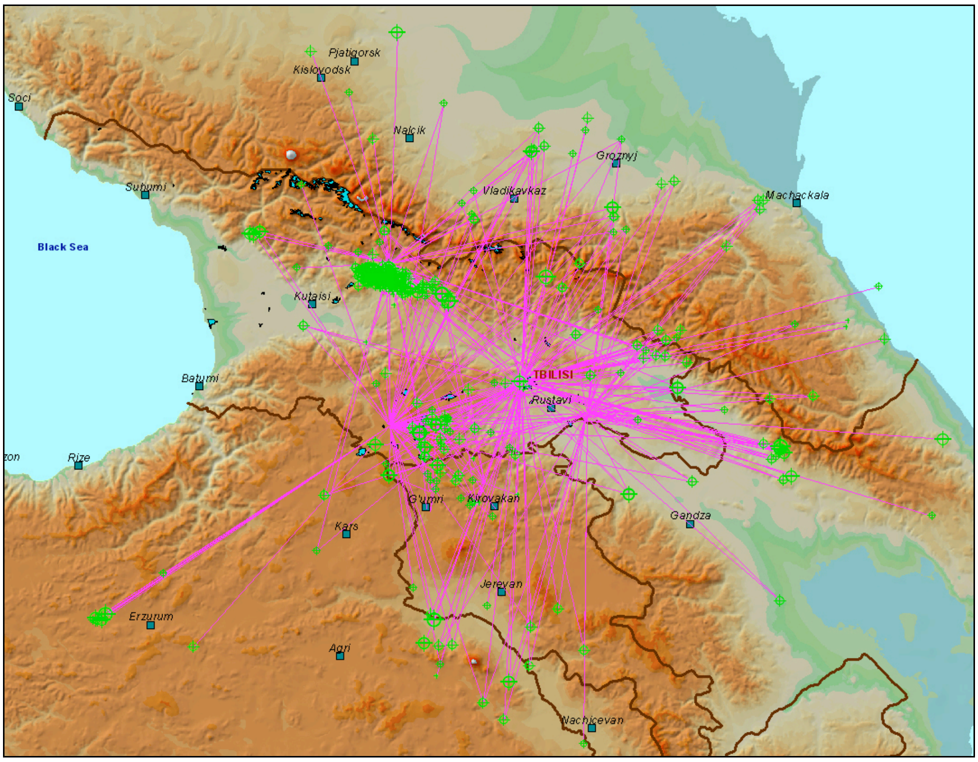

Fig. 2. Distribution of epicenters and travel paths of earthquakes.

In order to obtain attenuation relation based on very local areas depending on seismic activity after using all data mentioned above some data were selected for specific areas such as Greater Caucasus and Javakheti Volcanic Plateau. Data were selected based on epicenters and travel paths too to cover areas of our interest.

Attenuation relation the present study was obtained using regression analysis.

In the present study attenuation relation suggested by Boore et al. (1993) was used with slight changes based on local features.

$$\log PHA(g) = b_1 + b_2 M + b_3 M^2 + b_4 R + b_5 \log(R) + b_6 G_B + b_7 G_C \qquad (1)$$

where R is the epicentral distance, PHA is the maximum absolute acceleration response (larger horizontal) in gals,

$$G_B = \begin{cases} 0 & \text{for site class A} \\ 1 & \text{for site class B} \\ 0 & \text{for site class C} \end{cases}, \quad G_C = \begin{cases} 0 & \text{for site class A} \\ 0 & \text{for site class B} \\ 1 & \text{for site class C} \end{cases}.$$

The site class are defined based on shear wave velocities in the upper 30m (Table 1).

Table 1. Definition of Site Classes for attenuation relation

Site class	$\overline{V}_S$ in upper 30m
A	>750 m/sec
B	360-750 m/sec
C	180-360 m/sec

$b_i, i = \overline{1,7}$ coefficients were obtained by regression analysis PGA (Peak Ground Acceleration) for entire data set and separately for different areas as mentioned above. They are listed bellow (Table 2). For this analysis special codes were done in MatLab software.

Table 2. Coefficients and standard deviation obtained by regression analysis

Coeff.	b_1	b_2	b_3	b_4	b_5	b_6	b_7	ε
Entire data	0.7553	0.3984	-0.0027	-0.0014	-1	-0.0047	-0.0096	0.3379
Caucasus Region	0.775	0.4766	-0.0046	-0.0018	-1	-0.009	0	0.2685
Javakheti Plateau	0.5147	0.4163	-0.0075	-0.0003	-1	0.0042	-0.0211	0.2505

Fig.3 shows attenuation curves for different magnitudes.

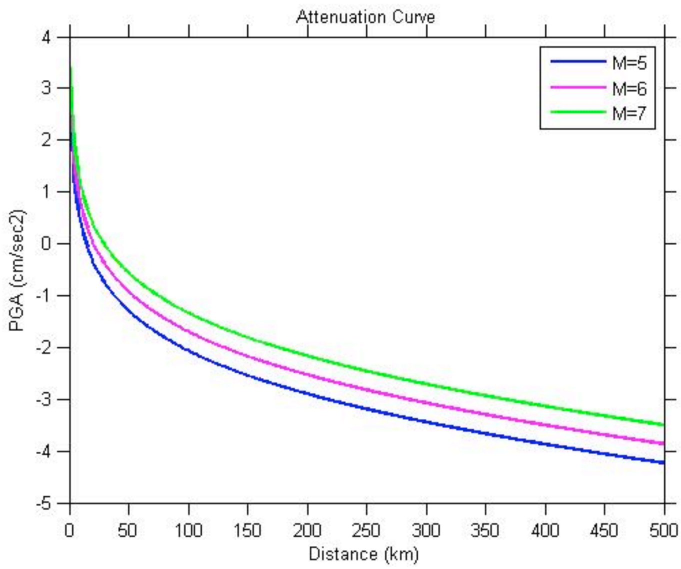

Fig.3. attenuation curves for PGA in cm/sec^2.

Finally, Seismic Hazard will be assessed using GIS (Geographic Information System) based on updated attenuation relation obtained in this study.

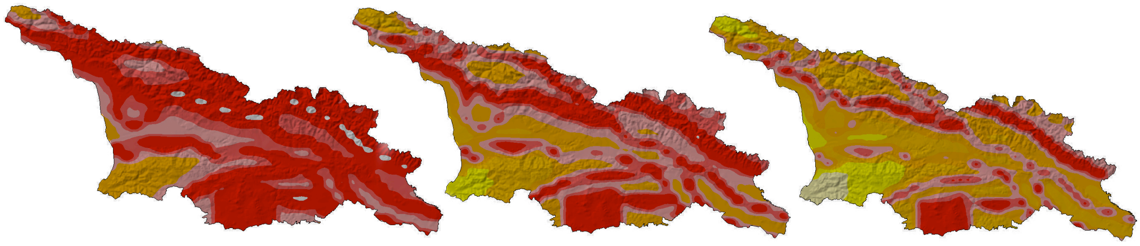

Fig.4 PGA (Peak Ground Acceleration) of 5%, 2% and 1% probability of being exceeded in 50 yrs.

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