# CURRENT SEISMIC HAZARD ASSESSMENT (CSHA) FOR EARLY WARNING AND NOTIFICATION

Prof. Serguei Balassanian
Armenian Association of Seismology and Physics of the Earth (AASPE)
13 Vardanants Str. Yerevan, 375010, Republic of Armenia
Tel: 374 1 544514 Fax: 374 1 544524
Email: Sbal@themail.com

The earthquake early warning is one of the most complicated issues, because it should be based on short-term earthquake prediction, which is still an unsolved scientific problem.

In Armenia, the current seismic hazard assessment (CSHA) approach for earthquake early warning was developed in 1991 (Balassanian, 2000). The CSHA differs from earthquake prediction, as it does not request strict requirements to determine the place, magnitude and time of a possible strong earthquake. The CSHA is evaluation of the hazardous change of the strain accumulation able to produce strong earthquake within the studied area. Thus, the CSHA approach uses some intermediate scientific results of earthquake prediction research, which is sufficient, if the number of preconditions exist, for adequate countermeasures aimed to earthquake risk reduction. The main goal of adequate countermeasures is to concentrate the attention of central and local governments on the area of probable seismic event, aimed to implement the developed master plans for probable loss mitigation.

*Scientific background of CSHA* is that at any particular site within a seismically active zone, the pre-seismic strain accumulation till the threshold level should induce remarkable changes in physical, physical-chemical and chemical parameters of the deformed lithosphere. It must be accompanied by formation of temporary sources of different geophysical fields that may be recorded in all three phases (solid, liquid, and gaseous) of the lithosphere. Temporary sources of various geophysical fields are formed at macro- and micro- hierarchic levels of the geological medium during accumulation of elastic deformations, and disintegration during its discharge. Temporary sources are formed in the deformed lithosphere (initial seismogenic source), inducing secondary sources in atmosphere and biosphere at the stages close to the threshold and to the seismic event. Temporary sources represent a system with changing properties in time and space, creating different dynamic physical fields definitely recorded on observation sites.

*Main elements of CSHA technology are:*

- a database of long-term multidisciplinary observations;
- a well studied region from geological, geophysical, seismological and seismotectonic points of view with a comprehensive database;
- a specific site selection, including highly-sensitive energy-active points (HEP Phenomenon, Balassanian, 2000) for setting of the multi-parameter observation stations;
- a multi-parameter unified real-time monitoring network;
- state-of-the-art equipment, hardware and software for data processing and analysis;

- the CSHA Expert System based on multidisciplinary retrospective analysis of all the seismic events that have occurred and are occurring in the region.

*A data base of long-term multidisciplinary observations* is necessary to select the most informative parameters to pre-seismic changes of the medium for real-time monitoring as well as to select the observation sites with clear pre-seismic changes of the particular parameters of medium in case of the preparation of strong earthquake. This data base is needed for retrospective analysis of all the seismic events in the region.

*A well studied region* from geological, geophysical, seismological and seismotectonic points of view must be selected to start real-time monitoring of medium with well-known geodynamic peculiarities.

*A specific site selection* including highly-sensitive energy-active points (HEP phenomenon) is needed for setting the multi-parameter observation stations taking into account that pre-, co-, post-seismic changes of the various parameters of the lithosphere in the view of its heterogeneity are taking place by various modes in various observation sites, from complete absence of any response to clearly displayed anomalies. Pre-, co-, post-seismic changes of various parameters of the lithosphere mainly depend on local geology of the observation site. The most sensitive to the external physical impacts generally, and to the elastic strain accumulation in particular, are the so-called energy-active points. Any physical, physical-chemical and chemical parameters of the energy-active points could be informative for the CSHA.

*A multi-parameter unified real-time monitoring network* is needed for recording the pre-seismic changes of the physical, physical-chemical and chemical parameters of the medium under the permanently increasing pre-seismic strain, within a seismically active zone. The unified network is necessary to get comparable data from different observation sites. The real-time monitoring is required in order to note in time the pre-seismic changes of different parameters of the medium at high magnitude earthquake preparation area.

*State-of-the-art equipment, hardware and software* are required for precise recording of the pre-seismic signals, data processing and analysis.

*The CSHA Expert System* is needed for selection of pre-seismic signals among others with non-seismic origin, and for current seismic hazard assessment with certain probability based on retrospective analysis of all the seismic events that have occurred and are occurring in the region.

The CSHA approach was tested in Armenia for 11 years, from 1991 to 2002. The Expert Council of Armenian NSSP reported to Armenian Government in all the following cases:

1) after each earthquake, which was felt by public, when it was necessary to evaluate the scenario of further development of current seismic hazard, in order to answer the question “What is the probability of the next more strong seismic event during the next few hours or days?”.
2) after each strong seismic event in the Caucasus and adjacent regions, upon the request of Government and general public to inform “What is the probability of strong earthquake in Armenia now?”.
3) after each situation when the real time multidisciplinary monitoring data shows the pre-seismic anomalies similar to those, which were observed during past seismic events in Armenia.

From 1991-2002 the CSHA approach answered correctly to all the above mentioned cases:

- 17 times (from 17 events) for the first case;
- 17 times (from 14 events) for the second case;
- 5 times (from 6 alerts) for the third case, showing pre-seismic alert for the following seismic events that took place in Armenia in 1991-2002: Martuni earthquake (M=5.0, 1992), Elpin earthquakes swarm (consists of 25 small shocks with $M_{max}$=4.2), Ashotsk earthquake swarm (consists of 150 small shocks with $M_{max}$=4.1), Parakar earthquake (M=3.7, 1997), Noyemberyan earthquake (M=4.4, 1997).

On the basis of the CSHA reports, made by Armenian NSSP Expert Council, the Armenian Government undertook adequate countermeasures, including partial evacuation of inhabitants from the most vulnerable buildings in the above mentioned areas.

The Armenian experience shows that the CSHA technology might be a new step to sufficient approach for Earthquake Early Warning and Notification.