



ARMENIA

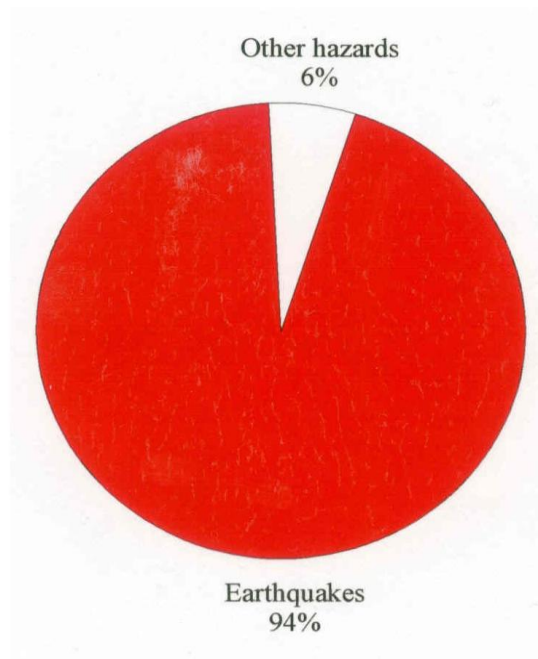
COUNTRY REPORT



1. Introduction

Armenia is one of the ancient countries in the world. Geographically, it is located in the northeast of Armenian Upland between the Caucasus and Southwestern Asia. The greater part of Armenia is situated on the southern flank of the Caucasian mountain range. The country covers approximately 29,800 square kilometers. The neighboring countries include: Turkey to the west, Georgia to the north, Azerbaijan to the east and southwest, and Iran to the southeast. Its territory is mostly mountainous, and the arable soil is very fertile. Its significant geographical features include Lake Sevan (elevation 2,000m.) and Mount Aragats (elevation 4,090m.). Most of Armenia lies between 1,000 to 2,500 meters above sea level. The climate in Armenia is continental with hot summers and cold, wet winters.

Located in one of the world's most active seismic zone, Armenia frequently experiences earthquakes. Armenia is one of few countries entirely located in the zone of high seismic risk. Among various types of disasters, main hazard for the territory of Armenia is the earthquake- 94%, and only 6% is another hazards.



Earthquakes - 94%

Mudslides - 3.15%

Transport accidents - 1.5%

Landslides and rockfalls - 1.2%

Floods - 0.15%

Irradiation - 0%

The loss caused by different types of disasters in Armenia

According to sociological data during last century for the territory of Armenia are peculiar about 110 types of natural dangerous phenomena and only 11 of them are considered to be more frequent and dangerous for human life and health, in that number are earthquakes, floods, landslides, rock-falls, mudflows, lightning, hail, ground subsidence and forests fire.

2. Disaster management system

The direct management of activities by state bodies in emergency situations is assigned to the Ministry of Emergency Situation (MES) in the Republic of Armenia. Ministry of Emergency Situations is a republican body of executive authority, which in line with such competences as is vested in it by laws and other legal acts, develops implements and coordinates RA government's policy in the area of civil defense and protection of the population in emergency situations. The MES is the management body responsible for prevention, reduction of the consequences and actions in case of natural and technogen disasters. Objectives of the MES:

- To establish and vest governmental policy in Civil Protection and enhance the country's preparedness level;
- the consequences of emergencies; prepare for possible consequences; establish, provide and implement Civil Protection programs;
- Co-ordinate and organize Civil Protection system activities;
- Organize governmental expertise in solutions and projects concerning objects and processes as possible causes of emergencies;
- Organize government control over the secured implementation of industrial activities concerning civil protection and the utilization of mineral resources;
- Organize and implement preparedness in government administrations, local self-government bodies and the administrative staff of organizations, to promote stable activities in the civil protection system in emergencies, and the training of professional personnel;
- Participate, organize and co-ordinate rehabilitation and rescue activities in emergencies and the invention of corresponding forces for that purpose. Promote co-operation between governmental, departmental (administrational) and public (volunteer) rescue organizations;
- Organize and provide resources for international co-operation in civil protection problems;
- Organize and certification of rescuers.

Civil Protection activities are regulated by a number of laws and legislative acts of the Republic of Armenia:

- The Law of the Republic of Armenia on Armenian Rescue Service, Adopted on July 8, 2005
- The Law of the Republic of Armenia on Rescue Forces and Status of Rescuers, Adopted on May 25 2004
- The Law of the Republic of Armenia on Population Protection in Emergency Situations, Adopted by National Assembly on December 2nd 1998
- The Law of the Republic of Armenia on Civil Defense, Adopted on March 5, 2002
- The Law of the Republic of Armenia on Fire Security, Adapted an April 18, 2001
- The Law of the Republic of Armenia on Seismic Protection, Adopted on June 12, 2002
- The Law of the Republic of Armenia on Protection, Adopted by the National Assembly on May 29, 1997
- The Law of the Republic of Armenia Legal Regime of Martial Law, Adopted by the National Assembly on 29 May, 1997

3. Seismic Protection

Armenian Upland is situated in most active segments of the Alpine-Himalayan seismic belt between the Arabian and Eurasian plates collision zone. This collision is responsible for the complex deformation and is associated with an intense earthquake activity affecting this region, including Active Mountain building in the Caucasus in general and the territory of Armenia in particular.

Practically all the territory of Armenia is situated in a seismic active zone. Strong earthquakes have occurred in Armenia beginning since 18-15 centuries A.C., such as in Vayk in 735 (M=6.5), in Vaiots-Dzor in 906 (M=6.5), in Garni in 1679 (M=7.0). One of the destructive earthquakes is the Spitak earthquake occurred on December 7, 1988 (M=7.0). About 40 % of the total territory affected; 25,000 people were killed, 530,000 became homeless.

The size of earthquakes ranges up to M=7.0 (according to instrumental recordings) and M=7.5 (according to historical and paleoseismic estimations). Focal depth is 10 km. on average. The average recurrence interval of large earthquakes (M>5.5) comprises 30-40 years both in the territory of Armenia and adjacent territories.

After the catastrophic Spitak earthquake of 1988 the government of Armenia starts to pay great attention to seismic protection in his policy. The first main step was the creation of National Survey for Seismic Protection under the Government of RA (NSSP RA), as a state responsible body for Seismic Risk Reduction Strategy development and implementation.

The Armenian National Survey for Seismic Protection (Armenian NSSP) was founded under the Government of the Republic of Armenia on July 17, 1991. The Armenian NSSP was given special governmental status and ministerial power. The President of the Armenian NSSP directly reports to the Prime Minister of the Republic of Armenia.

The main goal of the Armenian NSSP is multidisciplinary Seismic Risk Reduction.

The Armenian NSSP has developed two strategic National Programs on "Seismic Risk Reduction in Armenia" and "Seismic Risk Reduction in Yerevan-city". The Programs, adopted by the Government of the Republic of Armenia on 10th and 7th July 1999 respectively, are designed for period of 30 years. All the Ministries and other Governmental, non-Governmental and private organizations are participating and making their contribution to the National Programs under the general co-ordination of Armenian NSSP assigned by the Government as a responsible body for the Seismic Risk Reduction Strategy development and implementation, which includes:

- Seismic Hazard and Risk Assessment;
- Vulnerability reduction in urban areas, including strengthening and upgrading of existing buildings, design of new building codes and standards;
- Public awareness, people education and training;

- Early warning and notification;
- Partnership establishment involving public and private organizations;
- Risk management, including Emergency Response and Rescue Operations;
- Disaster relief and people rehabilitation;
- Insurance;
- State disaster Law and regulations.

The Armenian NSSP is divided into 3 administrative regional departments with appropriate centers organized according to main objectives and research directions. The Armenian NSSP carries out all seismic risk reduction related studies including geophysics, geology, geochemistry, geodesy and earthquake engineering, sociology, psychology, etc.

Armenian NSSP consists of several administrative departments and centers. Each administrative regional department has uniform subdivisions for solving the whole spectrum of issues on go seismic protection of the country (from seismic hazard and risk assessment to earthquake-engineering and earthquake-resistant construction code development, from seismic knowledge dissemination and training of the public to prompt response and rescue operations, etc.). The uniform subdivisions of the Armenian NSSP departments are connected with each other horizontally by the same issues and have strict vertical subordination to the Head of Department, who is under the Armenian NSSP President subordination.

The Armenian NSSP has significant achievements in the field of seismic risk reduction.

The main of them are the following:

- **Seismic Hazard Assessment.** The first probabilistic maps of Seismic Hazard Assessment (SHA) for the Crimea - Caucasus-Copet-Dagh Test site in the frame of the GSHAP Program, and for the Armenia within the framework of the National Program have been created.
- **Current Seismic Hazard Assessment.** A unique multi-parameter network has been established. It consists of 150 monitoring stations performing round-the-clock data acquisition and analysis via satellites. The particular software named as “Expert” for current seismic hazard assessment has been created. The state of the art technology for current seismic hazard assessment on the base of know-how, connecting to discovered (Balassanian, 1972-2001) highly sensitive energy-active points of the Earth (HEP) phenomena has been developed.
- **Seismic Risk Assessment.** The new methods for seismic risk quantitative assessment, based on the main seismic risk assessment factors (such as seismic hazard level, population density and buildings' vulnerability) have been elaborated.
- **Reinforcement of existing buildings and structures.** New methods for increasing the earthquake resistance of existing buildings and structures have been developed, successfully tested and implemented into practice.
- **New building codes.** The Armenian NSSP took part in creation of the first national building codes for Armenia, which are in good accordance with the international standards and requirements.

- **Early Warning Systems and Notification.** An Early Warning System based on the current seismic hazard assessment has been developed and is under the design. A project of Early Warning System based on automatic registration and determination of the parameters of destructive seismic wave propagations is under the development. A project of Early Warning System based on the fast determination of earthquake parameters and damage assessment, as well as human loss is under design.
- **State disaster Law and regulations.** The Law on Seismic Protection has been adopted by the Parliament in 2002.
- **Risk management including Emergency Response and Rescue Operations.** The multidisciplinary well-equipped Armenian NSSP Task Force including seismologists, earthquake-engineers, geo-technicians, communication engineers, medical staff, psychologists, rescuers with sniff dogs, has been created for prompt response to disaster. The Task Force has good experience in carrying out relief operations in earthquake-suffered countries, including recent Gujarat earthquake (January 2001) in India.
- **Public Education.** The Center for Public Education and Training has been established in Armenian NSSP. Educational system based on knowledge dissemination through mass media, TV and radio Programs have been developed.

In 2001 Armenian NSSP concluded more than 50 international agreements and memorandums in the field of seismic protection with all the leading centers of the world – France, USA, Italy, Greece, Iran, India, Germany, Russia, Georgia, Azerbaijan, China, Japan etc.

For 10 years Armenian NSSP has gained unique experience in seismic protection. In 1998 in Geneva, the Armenian NSSP has been awarded by the "Certificate of Distinction" of the United Nations Sasakawa Disaster Prevention Award in appreciation for its distinguished contribution to disaster prevention, mitigation and preparedness, and furthering the goals of the International Decade for Natural Disaster Reduction.

In February, 2001 after the destructive earthquake in Gujarat State the Government of Armenia rushed to India multi-profile well-equipped Armenian NSSP Task Force Unit consisting of seismologists, geologists, earthquake and communication engineers, a psychologist, instructor on interaction with population, physicians and rescuers which actions were highly appreciated by the Government of India and Gujarat State Administration. Armenian NSSP Task Force Unit enrolled into the staff of international formations acting under the aegis of UN.

The third essential event was acceptance in 2002 by the National Parliament of “The Law on Seismic Protection of the RA”. According to the law seismic protection is meant as a complex of legal, social, economic, educational, organizational, scientific and other measures directed to seismic safety and sustainable development of the state.

3.1. Strategy of seismic risk reduction in Armenia

The main goal of the Armenian NSSP is Seismic Risk Reduction in the territory of Armenia. The main purpose of seismic risk reduction is diminution of probable losses by increase of readiness, prompt and effective reaction to earthquake on the basis of improvements of a state system of risk reduction with involvement of all levels of authorities and society.

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The concepts of seismic risk reduction in Armenia include the following main positions:

- Seismic Hazard Assessment
- Current Seismic Hazard Assessment Seismic Risk Assessment
- Reinforcement of existing buildings and structures.
- New building codes creation
- Early Warning Systems and Notification
- State disaster Law and regulations
- Public Education. The Center for Public Education and Training has been established in Armenian NSSP. Educational system based on knowledge dissemination through mass media, TV and radio Programs have been developed.

Seismic hazard assessment

The rather reliable probabilistic map of seismic zoning of the territory of Armenia in scale 1:500000 (fig.2) is now compiled, and a number of maps of detail seismic zoning of 1:200000 scale (the territory of Armenian NPP, epicenter zone of Spitak earthquake etc.) are composed. For the main densely populated areas, especially in the Northern and Central Armenia, the seismic microzoning maps of scale 1:5000 to 1:10000 have been developed. Compilation of such maps is planned for other territories and cities.

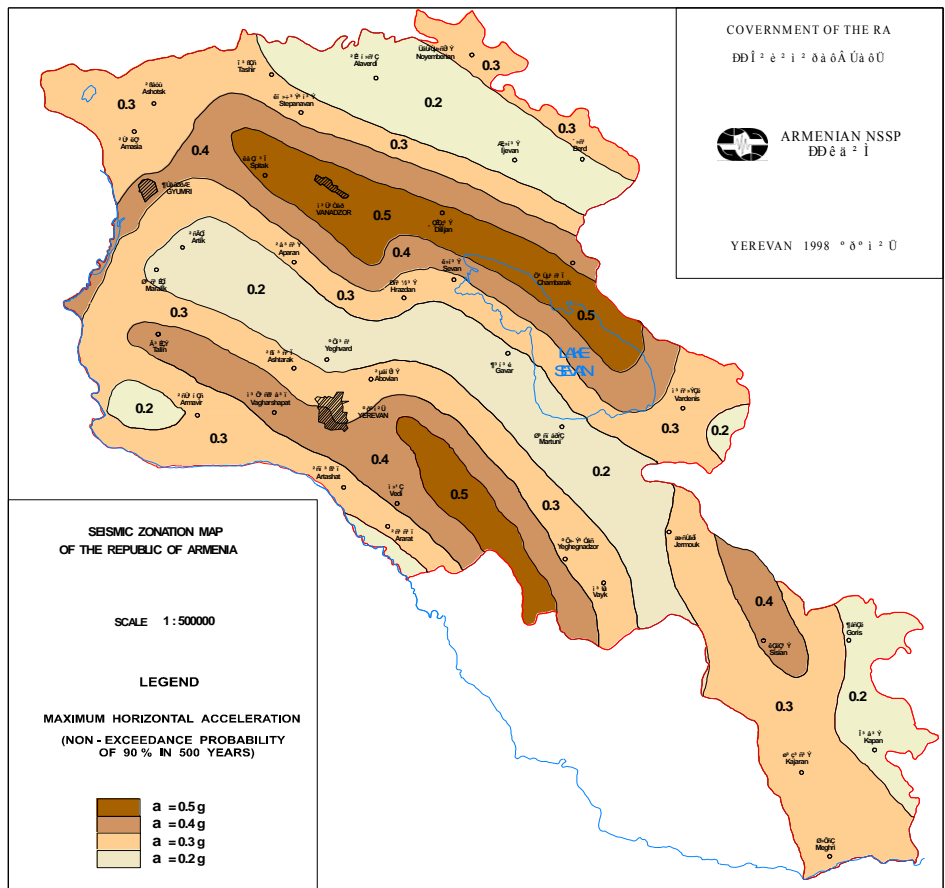


Fig.2. Seismic zonation map for Armenia

Seismic risk assessment is carried out both for separate objects, and for all the territory of Armenia. The schematic maps of seismic risk for the territory of Armenia, Yerevan and Gyumri cities are already composed.

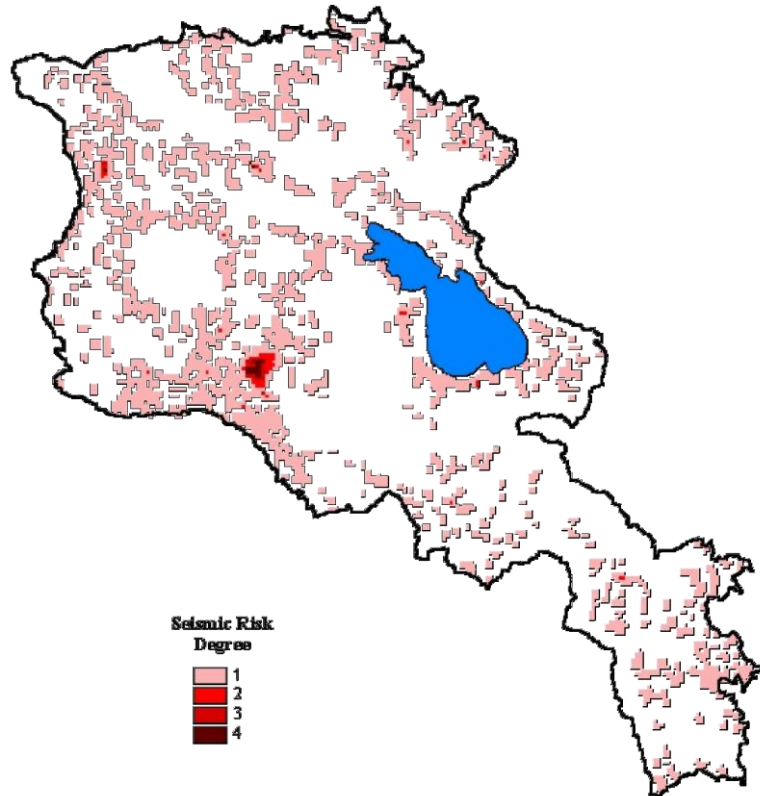


Fig.3. Seismic risk map for Armenia

Seismic risk reduction is carried out on the basis of two long-term Strategic National Programs accepted in 1999: a) “Seismic risk reduction in the territory of Armenia ”; b) “Seismic risk reduction in the territory of Yerevan city”. All the Ministries, other governmental, non-governmental and private organization, local state authorities (regional administrations), local government bodies (city administration, village administrations) participate in the program. Practically, all the important elements of risk reduction are taken into account in the program. The implementation schedule of the separate items of the program is composed; the expected outcomes on each item are indicated. Seismic Risk Reduction Strategy includes solution of a number of important problems, beginning with a development of law and regulation, finishing with the public awareness, people education and training.

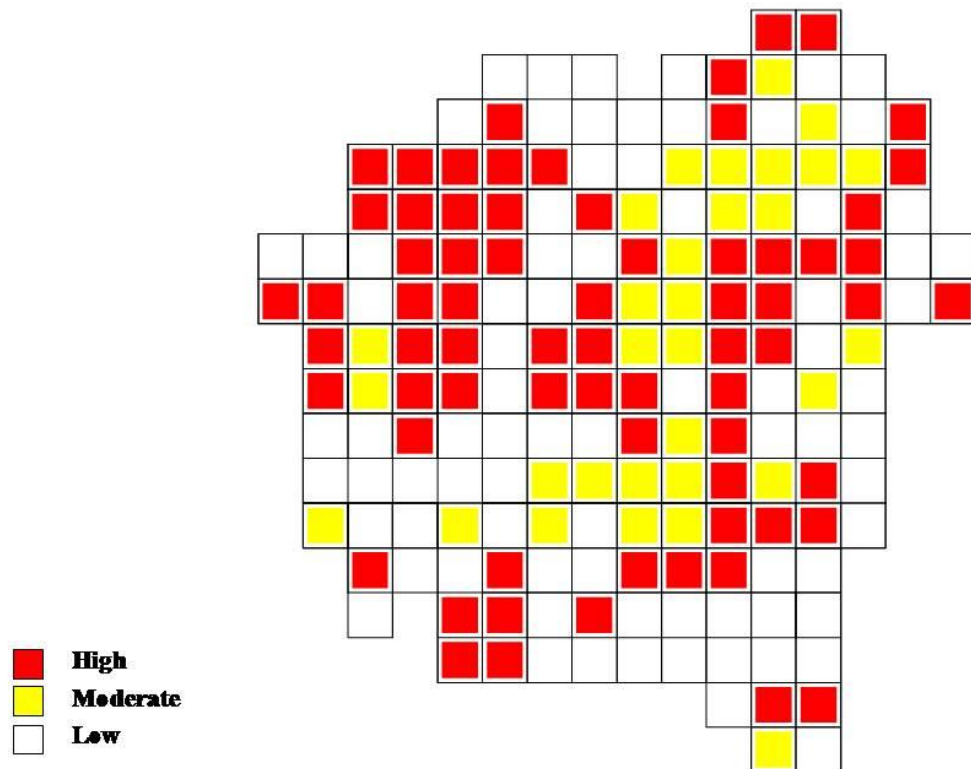


Fig.4. Seismic risk distribution for Yerevan-city

3.2 Laws and regulations

As a legal basis for organization of seismic risk reduction activities in Armenia serve two important laws:

- a) “The law on Seismic Protection of the RA”.
- b) “The law on Protection of the Population in Emergency Situations”.

Other normative documents, regulating organization of seismic protection have been also developed. Some of them are as follows: a) New seismic building codes; b) Principles of Seismic Microzoning; c) Instruction on conducting of observations in seismic, geophysical and other stations; d) The procedure of the expert analysis and providing the information about earthquake threat to the Government of RA.

4. Monitoring System in Armenia

The Armenian NSSP has a unique multi-parameter observation network consisting of 150 stations for real-time monitoring of geosphere.

4.1. Geophysical Observation Network

Basing on retrospective analysis of pre-, on and after seismic anomaly of the Armenian NSSP observation network, the expert system including DF and Expert software has been created for analyzing data from different stations of Armenian NSSP. DF program enables to outline short-term, medium-term and long-term seismogenic anomaly of various fields. The particular software named as “Expert” for current seismic hazard assessment has been created. Expert program enables to determine the site, time and magnitude of current seismic hazard based on the Armenian NSSP clearing house. Testing of seismic events occurred in the territory of Armenia and adjacent territories for current seismic hazard assessment have been performed. The Catalogue of earthquake-tested precursors including 167-test anomaly-precursor with 15 parameters has been compiled. The probabilities of precursor seismic realization have been determined. The everyday tests are used in operational activities of Armenian NSSP, enabling rapidly assess current seismic hazard and proved the information to the Government for undertaking the necessary counter-measures. Besides, earthquake testing enables to insure the quality of data obtained from the observation network. Network informativness as well as the station sensitivity to seismic event preparing and determination of features of different type of precursors create the methodological base for upgrading and developing of the Armenian NSSP multi-parameter observation network.

4.2. Seismic Observation Network

There are four types of seismic network in Armenia:

- Regional Seismic Network
- Local Telemetry Seismic Network
- Global Seismograph Network Station-IRIS GSN
- Mini-Array VAYK

Regional Seismic Network was established in late 1960's. Now it consists of 9 stations with instrumentation for visual recording on photo paper (fig. 9, table 1). This instrumentation allows to record oscillation with periods from 0.1 to 30 second.

Local Telemetry Seismic Network

With the purpose of increasing the level and accuracy of seismological observations, local networks of telemetry seismic stations were established in the territory of Armenia, with the centers of: "Gyumri", "Vanadzor", "Yerevan", "NPP", "Kapan" (table 2, figure 10).

These networks are equipped with short period three component sensors that cover a frequency band from 0.5 – 25 Hz. Dynamic range of the stations are 60dB. All four networks have their own acquisition and processing centers which are connected to the main processing center in NSSP (Yerevan). It was the first step to make early warning system around the capital of Yerevan.

These networks were established to find out quickly precise local earthquake locations and to conduct investigation on weak seismicity in the territory of Armenia. Due to these networks the

lower representation magnitude level in the National earthquake catalogue was reduced down to $M < 2.5$ during recent years.

International Cooperation

NSSP is in charge of the seismic protection and seismic monitoring system. NSSP has the following international monitoring systems:

- USGS-IRIS Project
- CTBT International Monitoring System
(Comprehensive nuclear Test-Ban Treaty)
- CEA/DASE VAYK seismic array

-The IRIS GNI station was installed in 1991 in the geophysical observatory Garni. It is broadband seismic station equipped with STS-1 VBB seismometers (fig 5). This station included in the IRIS Global Seismographic Network (GSN) and providing seismographic data to research earthquake hazard mitigation and the verification of a Comprehensive Test Ban Treaty (CTBT).



Fig.5. Seismic sensors installed in Garni

- The Vayk array was installed in cooperation with CEA/DASE.

In 2010 the construction of the new VAYK seismic array was finished and its operation began. The first seismic data were received from the array in January 2010. Vayk seismic array is located near to Vayk town. Seismic array consists of 6 observation points, located in two concentric circles with one central site. Five one-component short-period seismometers are installed. Besides, there is a broadband three-component station with STS2 seismometer. At present the station is mainly operating in testing mode.

5. NSSP Database and Seismicity in Armenia

For reliable hazard and risk assessment the following main tasks are applied:

- Creation of a reliable and comprehensive database for the territory larger, than the territory, for which the assessment is carried out.
- Assessment on the basis of modern advanced technologies.
- Seismic Hazard and Risk assessment for the territory of Armenia

NSSP has created the certain database for an assessment of hazard and risk for the territory of Armenia:

- Prehistorical and historical earthquake catalogues for Caucasus
- Earthquake catalogues for instrumental period (catalogues were checked and cleared from industrial explosions, parameters of the events should be recalculated)
- Focal mechanisms catalogue for earthquakes occurred in the territory of Armenia (focal mechanisms are determined for lower hemisphere)
- Macroseismic database for Armenia and adjacent territory. Epicentral maps, isoseismal maps for events with intensity $I > 7$ (EMS scale) have been compiled, peculiarities of attenuation of macroseismic field have been analyzed. Macroseismic information for this territory has been revised. It contains data on macroseismic intensity in each populated locality in the area.
- The waveform database consists of digital seismograms, strong motion accelerograms. The records of large industrial explosions and nuclear explosions have been digitized as well
- Database on geology, active tectonics, and geophysical parameters

The following maps were collected and their systematization has been carried out. All these maps are created in GIS format.

1. geological maps for Armenia and adjacent territories (1:100000, 1:200000, 1:500000)
2. tectonic maps (age of deformation and origination, faults, deep structure)
3. map of earth crust strain on the bases of fault plane solutions and GPS observations (map of compression, map of probable ruptures)
4. gravitational maps and maps of magnetic anomalies of 1:200000 scale

NSSP Database includes the Earthquake catalogue comprises 25000 earthquakes for all the observation period of time which is divided into three groups:

- Historical (2000B.C-1900A.D.)
- Early instrumental Period (1900-1961)
- Instrumental period (since 1962), which include
 - ✓ Date
 - ✓ Origin time
 - ✓ Epicenter Latitude
 - ✓ Epicenter Longitude
 - ✓ Focal depth (in km)
 - ✓ Magnitude value and scale type
 - ✓ Maximum macroseismic Intensity
 - ✓ The accuracy of the earthquake parameters solution
 - ✓ Region

The distribution of weak seismicity in our investigation area has diffused character. Due to block structure of the Earth's crust there are local tension zones on the background of regional

compressional stress-field. The largest one is located in the North of Armenia extending to the territory of Georgia. It is most seismically active zone in the region.

“Traditionally” active zones are: Tebriz-Balykgel fault zone, Erzurum-Sarikhamish area, Javakhet Highline, the South-Eastern part of Pambak-Sevan fault, Yerevan, Garni-Elpin fault zones, i.e. the zones of active faults. However, it should be noted that on long term scale the faults are active not the whole length. Activity is related to faults junctions and flanges.

6. Earthquake Early Notification System in NSSP

The data are received to the Data Center on a near real-time basis from whole stations homogeneously distributed in Armenia. Recorded data are transferred to Data Acquisition and Analysis Center through various means of communication including satellite, Internet, mobile and stationary phone, electronic etc (fig 6).

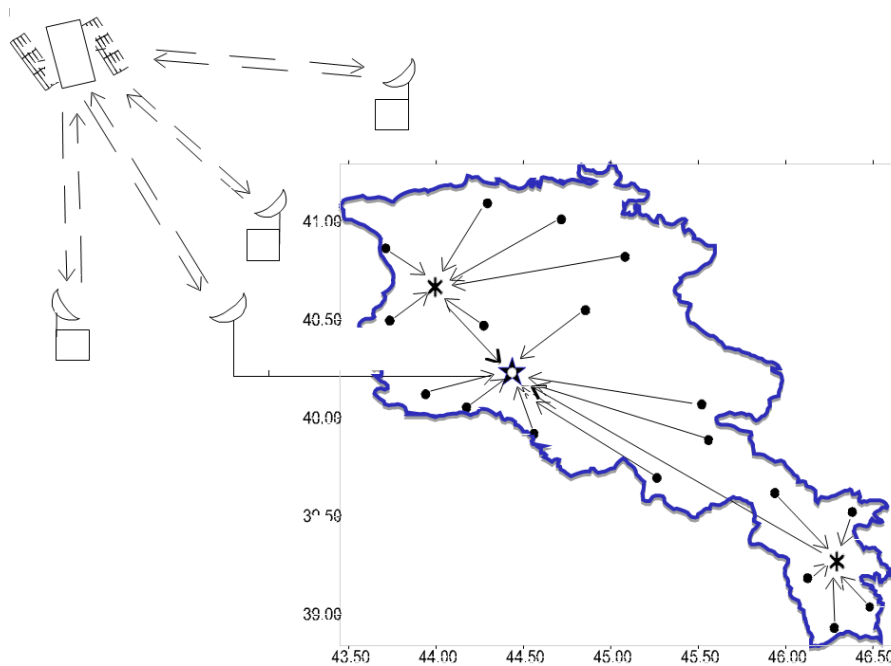


Fig.6. Scheme of internal and external information flows in NSSP's National Observation Network

When an earthquake occurs, NSSP immediately (for local earthquakes during 20 minutes) issues information on its hypocenter, magnitude and observed seismic intensity. The information is provided to disaster prevention authorities and reaches the public through local governments and the media. The data are archived at the Seismology Department and stored in database system: as waveforms, seismological bulletins and catalogues for research work and other activities. NSSP also provides data to international organizations such as ESMC, ISC est. as near real time information about earthquake and seismological bulletins.

- Current seismic hazard assessment and early non-urgent warning (preparation phase)
- Earthquake operatives prediction and Government notification emerged from expert evaluation
- Urgent warning (earthquake hit urban area and rapid information is essential)

7. ADRC Counterpart

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