3.3 Country Good Practices

3.3.1 Armenia

Armenia

International Cooperation from Armenia: Emergency Response to the Gujarat Earthquake in 2001

The $M_w = 7.7$ earthquake occurred at 8:50 local time on January 26, 2001, in the northwest corner of India. The Government of Armenia, in coordination with the Government of India, rushed an 18-member multi-disciplinary Armenian National Survey for Seismic Protection (NSSP) Task Force team for relief operations to the earthquake-affected Gujarat state of India for two weeks. The team included seismologists, structural and communication engineers, geotechnicians, physicians, psychologist and rescuers with a sniffer dog. At the request of the Government of India the team was stationed in Ahmedabad, a city with a population of 5.74 million people.

Ground Motion Records in Ahmedabad City

The first ground motion studies through aftershock recordings of the Gujarat earthquake were conducted by the Armenian NSSP Task Force Mission. A temporary ground motion network, consisting of four portable strong SMACH instruments with three-component strong-motion seismometers, was placed in different parts of the city with various geologic conditions.

The comparison of the peak horizontal accelerations calculated by different attenuation models shows a good agreement between the data set and calculated accelerations on the base of the attenuation model for Europe.

Building Inspection and Performance of Engineered Structures and Soil Conditions

The Armenian NSSP Task Force inspected 140 buildings (of 4-12 stories) in total, and summarized data for 125 multistoried residential buildings.
Summary of results:
The seismic data show that the Bhuj earthquake intensity reached VII according to the European Micro-Seismic Scale (EMS - European 1993) in the area of Ahmedabad city.
The surveyed buildings were subject to differing degrees of damage: 5.3 % of buildings were collapsed or are subject to demolition; 48.2% of buildings required reinforcement; 46.5 % of buildings were subject to normal operation with cosmetic repairs.
Despite the location of Ahmedabad city 270 km from the epicenter of the main shock, the intensity of the earthquake here was estimated to have reached VII according to the EMS scale, and buildings have seriously suffered for the following reasons.

1. Buildings were designed and constructed with serious deviations from or ignoring basic rules of earthquake engineering; built with materials of poor quality; and subject to defects in the design and production of cast-in-place reinforced concrete constructions.
2. The area had a low level of mechanization and thus construction itself was of poor quality.
3. Damage had been caused to load-bearing elements of the structures during their use due to inadmissible changes made by residents.
4. The predominant period of ground motion was 0.3-0.5 s with the consequent high probability of the resonance phenomenon arising mainly in 4-6–storey buildings.

Major achievements
In line with the observations above, the following proposals are made:

1. To revise the Indian Seismic Building Codes taking into consideration analysis of the Bhuj earthquake.
2. To design in complete compliance with the requirements of the codes.
3. To undertake regulated quality control and assurance during construction.
4. To examine and certify building materials for mass construction.
5. To conduct complex investigations of buildings prior to restoration and strengthening work.

Rescue, Medical and Psychological Assistance to Demolition Teams and Earthquake Victims

The Armenian NSSP Task Force rescuers, physicians, social scientist and psychologist provided assistance with search and rescue activities and participated in demolition operations. Medical assistance was extended to demolition teams and earthquake victims. They also investigated the social impact through meetings and interviews with officials, victims, and emergency managers.

- **Background**
The Armenian NSSP is the initiator of many UN, EU, NATO and other international and regional programs and projects, aimed at regional cooperation in the field of seismic safety in the Caucasus and other earthquake-prone regions.

- **Objective**
1. To provide scientific and technical expertise and multidisciplinary assistance with respect to immediate post-earthquake relief efforts.
2. To gather data and information to assess the factors that contributed to the disaster, identifying knowledge gaps where focused efforts can contribute to seismic risk (loss) reduction in India, Armenia and other earthquake-prone countries.

- **Term/Time Frame**
Two weeks

- **Activities Undertaken**
1. Establishment of a temporary array of accelerographs to record strong aftershocks.
2. Engineering assessment of soil and structural performance.
3. Demolition of heavy damaged structures.
4. Rescue, medical and psychological assistance.

- **Major achievements**
1. Six strong aftershocks of the earthquake were recorded in Ahmedabad city, and ground geotechnical conditions were studied.
2. One hundred and forty buildings were inspected and tested.
3. Unique operations were implemented jointly with the Ahmedabad fire brigade for the deconstruction and demolition of 14 severely affected buildings.
4. Rescue, medical and psychological assistance was provided.
5. Sociological studies have been carried out through talking with local people.

- **Contact Details**
Armenian National Survey for Seismic Protection, Yerevan, Republic of Armenia

Risk Assessment in Case of Possible Facility Failure: The experience of Azat Reservoir in Armenia

Armenia is an entirely mountainous country with strongly featured relief. The average altitude of the territory is 1800 m above sea level.
Ridges account for nearly 14,000 km^2 (47%) of the territory. Some 40% of dwellings are located at an altitude of 1500-2000 m above sea level. The mountain areas of Armenia have a rich cultural heritage and are an attractive tourist destination.
Taking into consideration that the whole territory of Armenia lies within a seismically active zone, the seismic hazard value is 0.2- 0.5 g (an intensity of 8-10 on the MSK scale), and that in the past the seismic resistance of buildings and structures has not corresponded to the real seismic hazard, it is evident that there is a high seismic risk level for the territory of Armenia.
The seismic risk level of mountain areas with rugged topography increases sharply owing to seismically induced secondary hazards (landslides, reservoir failure, slope collapse, rock avalanches, etc) causing instability in slopes and rock masses.

The following steps are to be performed for risk assessment:
- reservoir site seismic hazard assessment and compilation of micro-zonation maps;
- reservoir seismic vulnerability assessment;
- risk evaluation of flooded areas in case of reservoir failure;
- preparedness of local authorities and population at the reservoir site and adjacent areas.

Azat reservoir is located at an altitude of 1650 m above sea level and a distance of 20 km from the capital city of Yerevan. General data for Azat reservoir are given below.
- Height of dam: 77 m
- Volume: 70 million.m^3
- Surface: 2.85 million m^2
- Date of construction: 1976

Reservoir site seismic hazard assessment and micro-zonation map compilation will include:
- earthquake catalogue and database preparation;
- distinguishing possible earthquake sources;
- establishing a ground strong motion attenuation model;
- seismic hazard computation.

Fault tectonics and earthquake epicenters in the area of Azat reservoir are presented in Fig. 1.
The level of seismic vulnerability of Azat reservoir has been assessed according to the following steps:
- estimation of parameters for regionally devastating earthquakes;
- definition of seismic characteristics of the ground at the dam site;
- estimation of ground acceleration at the dam site by altitude;
- visual and instrumental inspection of filtration

The dam risk is determined by the vulnerability (stability) of its construction, its filtration, the condition of outlets, mechanical equipment, availability of control–measuring instruments, as well as the most important factor, which is the size of the population in the zone of possible flooding and the possible property losses.

Some important parameters of seismicity for the Azat reservoir are shown below.
- Peak horizontal acceleration (foundation) share of g: 0.4
- Peak horizontal acceleration (dam) share of g: 0 331
- Leakage and suffusion: High
- Spillway and irrigation: High

Estimation of flooded areas in case of reservoir failure (collapse) is essential for risk evaluation and the amelioration of consequences. Special software program called "Wave2" (hereafter called The Program) was developed for operative estimation of the area that would be flooded by a possible failure of Azat reservoir and the consequences of the resulting wave. The Program allows the definition of extreme values of flooding parameters including the width of flooding and stream velocity as well as the arrival time for

the wave front, top and tail. The level of destruction of buildings and structures, bridges, roads and highways and industrial facilities has been estimated and relevant rescue and emergency actions have been planned.

On the basis of data obtained by using GIS technology a map of the borders of the Azat reservoir and the adjacent area in case of possible flooding has been compiled (Fig. 2).
It may clearly be seen that more than 10 settlements with a population of 90,000 would be flooded in case of the failure of the Azat reservoir. On the occasion of the International Day of Risk Prevention announced by the United Nations, the relevant state management organizations of the Republic of Armenia, together with national government organizations in the Ararat region, local governing bodies in cities and settlements of the region, and ministries, branches and establishments in Armenia, organized and implemented large-scale measures aimed at the protection of the population in case the dam of the Azat reservoir ever burst.

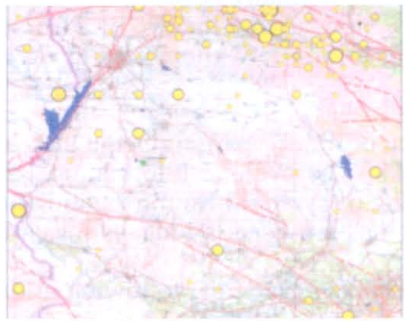

Figure 1: Fault tectonics and earthquake around the Azat reservoir

Figure 2: The region adjacent to the Azat epicenters in the reservoir adjacent case of possible flooding

Conclusion and Recommendations
Azat reservoir seismic risk assessment and reduction include the following:
- seismic microzonation map;
- vulnerability assessment;
- assessment of consequences;
- actions undertaken;
- preparedness of local people.

- **Background**
  Reservoir (dam) safety is an essential component of the sustainable development of mountain areas in Armenia.

- **Objective**
  Hazard and Risk Assessment in Case of Reservoir (Dam) Failure

- **Term/Time Frame**
  Two years

- **Activities Undertaken**
  Estimation of losses due to flooding, and population protection

- **Major Achievements**
  Operative estimation of losses and risk reduction in mountain area

- **Total Budget**
  1 million US$

- **Contact Details**
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3.3.2 Bangladesh

Cyclone Prediction and Forecasting, Weather Warning System and Dissemination Methods: The Bangladesh Perspective

Bangladesh is a deltaic land about 144,000 km^2 in area. The Himalayas are to the north and the Bay of Bengal to the south. Due to the concave shape of the Bangladesh coast and its peculiar geographic location, the weather system is complicated across the country. A tropical cyclone is a warm-core low-pressure system around which the air circulates in an anti-clockwise direction in the Northern Hemisphere. It consists of a rotating mass of warm and humid air, normally between 300 and 1500 km in diameter. The strongest winds, which may approach 200 knots, blow around the eye of a tropical cyclone, a central region of light winds and lightly clouded sky ranging from a few kilometers to over 100 km in diameter.

Prediction of cyclonic storm in the Bay of Bengal and issuance of timely warning is the task of the Storm Warning Centre (National Weather Forecasting Centre) Dhaka. The cyclone information issued by the Storm Warning Centre (SWC) requires detection and monitoring of cyclones from formation until landfall and forecasting the cyclone's future track. Modern technology has provided the means for early detection and constant tracking.

The cyclone warning system is well known in Bangladesh. Warnings include the following information.

a) Position of storm centre.
b) Direction and rate of movement.
c) Area likely to be affected specifying upazillas (administrative unit in Bangladesh) of the district if possible.
d) Approximate time of commencement of gale winds (speed more than 32 km/h or 52 km/h).
e) Maximum wind speed expected.
f) Approximate height of storm surge/tide and areas likely to be affected.

In order to produce a tropical cyclone warning, predictions of the following are required:

- Tropical cyclone location and motion
- Tropical cyclone wind field.
- Storm surge

Debsarma (STP Model 1994 & STEEPER Model 1998) developed one regression model and one steering-cum-persistence model for the track prediction of cyclones, which operates well in the Storm Warning Centre of Bangladesh Meteorological Department (BMD). It has been found that the upper air steering method plays an important role in the track prediction cyclones in the Bay of Bengal. For this purpose, a 200-hPa or 150-hPa level chart is carefully analyzed to obtain the circulation pattern and the movement of a cyclone is guided by the anti-cyclonic flow pattern at 200-hPa or 150-hPa level.

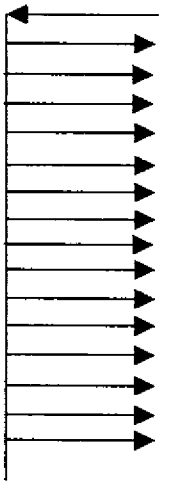
As per the Standing Order of the Government, Cyclone Warning messages are issued as follows:

a) Warning Stage: 24 hours in advance.
b) Danger Stage: Minimum 18 hours in advance.
c) Great Danger Stage: Minimum 10 hours in advance.

Charactenstics of Tropical Disturbances in the Bay of Bengal

Stages of Disturbances	Radius of Disturbances	Maximum sustained wind
Low pressure are or low	-	Less than or equal to 31 km/h (17 Kts)
Well marked low	-	32 km/h - 39 km/h (18 Kts - 21 Kts)
Depression	44 km (24 NM)	40 km/h - 50 km/h (22 Kts - 27 Kts)
Deep Depression	48 km (26 NM)	51 km/h - 60 km/h (28 Kts - 33 Kts)
Cyclonic Storm	54 km (30 NM)	61 km/h - 88 km/h (34 Kts - 47 Kts)
Severe Cyclonic Storm	64 km (35 NM)	89 km/h - 117 km/h (48 Kts – 63 Kts)
Severe Cyclonic Storm with a Core of Hurricane wind	74 km (40 NM)	118 km/h-219 km/h (64 Kts–118 Kts)
Super Cyclone	84 km (45 NM)	220 km/h or more (119 Kts or more)

There is a standing order for cyclones to be disseminated to all concerned Ministries, Divisions, Departments, and nongovernmental agencies and also to press the public to be ready to discharge their duties in a speedy and systematic manner to handle the situation efficiently. More frequent contact is maintained between BMD and Betar (radio), and television transmission hours are extended as and whenDanger Signals or Great Danger Signals are hoisted. The warning message dissemination system of SWC, the national weather forecasting centre, is as follows:



Storm Warning Centre (SWC)
Prime Minister's Secretariat
Bangladesh Betar (Radio)
Bangladesh Television (BTV)
Control Room, Ministry of Disaster Management and Relief
Control Room, Disaster Management Bureau (DMB)
Cyclone Preparedness Programme (CPP)
Coastal Volunteers
Media
General population
Armed Forces
Bangladesh Navy
Bangladesh Air Force
Maritime and Riverine Ports
NGOS
Flood Forecasting and Warning Centre

Only 5% of cyclones form in the Bay of Bengal, but loss of lives and property is about 85% of the global total. The cyclone of 1970 took the lives of 300,000 people but the cyclone of the same intensity of 1991 killed 138,000 people, and the cyclones of 1997 and 1998 resulted in only 127 and 6-7 deaths respectively. This is a definite development in saving lives and property.

Weather forecasting is difficult and will remain a challenging task. The BMD in collaboration with the CPP and other organizations related to disaster management will hopefully be in a position to handle natural disasters more efficiently and easily in the near future.

- **Background**
  Bangladesh is the most disaster prone area of the world. Most of its disasters are cyclones. It sometimes occupies the news headlines because of its extreme weather events.

- **Objective**
  Prediction of cyclonic storms in the Bay of Bengal and issuance of timely warnings are the main objectives of the Storm Warning Centre (National Weather Forecasting Centre) Dhaka.

- **Activities Undertaken**
  Cyclone prediction, forecasting and provision of weather warning signals.

- **Major Achievement**
  The cyclone of 1970 took the lives of 300,000 people but the cyclone of the same intensity of 1991 killed 138,000 people, while the cyclones of 1997 and 1998 resulted in only 127 and 6-7 deaths respectively.

- **Contact Details**
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On-Going Disaster Mitigation Practices in Bangladesh

In recent years, the Government of Bangladesh (GoB) has been placing increased emphasis on reduction of the human, economic and environmental costs of disasters, through enhancing the national capacity for disaster mitigation.
The programs on disaster management in Bangladesh focus equally on structural and non-structural practices intended for disaster mitigation:

Structural Mitigation: GoB has so far constructed 1,841 cyclone shelters and 200 flood shelters. During the last four decades 482 water and flood control projects have been implemented, through which flood protection embankments totalling about 8,200 km, drainage channels of total length 3,400 km and 9,000 sluice gates and regulators on different rivers and canals have been constructed as safety measures against inundation by tidal waves, storm-surges and flooding.

Non-Structural Mitigation: Non-structural mitigation practices pursued by the GoB focus on (1) preparedness and possibilities for action to reduce risks and losses, and (2) better coordination mechanisms between all actors involved (GoB, NGO and community people at the grass-roots level) during all phases of disaster. Such practical measures under the recently completed project: "Support for Disaster Management" involve the following.

i) Legislation, Policy and Planning
The Disaster Management Legislation (Act) and the Clear and Comprehensive National Policy on Disaster Management and National Disaster Management Plan have already been drafted and are now under consideration of the GoB.

ii) Training and Public Awareness
The Disaster Management Bureau (DMB) has conducted 447 training courses, workshops and seminars attended by government and semi-government officials of different levels, as well as various stakeholders. In addition, the DMB has developed Disaster Management training modules and has supported the arrangement of disaster management training workshops.

iii) Institutional Arrangements
The GoB has taken a number of significant steps for building up institutional arrangements from national to union levels for effective and systematic disaster management.
1. Naming of the Ministry of Relief and Rehabilitation as the Ministry of Disaster Management & Relief (MDMR)
2. Establishment of Disaster Management Bureau (DMB) in 1993
3. Establishment of Council and Committees at the national, district, upazilla and union levels
4. Establishment of Emergency Operations Centre (EOC)

iv) Warning Systems
In Bangladesh there are two warning systems: flood warning and cyclone warning.

Flood Warning System:
Flood warning has been in a state of continuous development since 1972. There was a significant improvement in the Flood Forecasting and Warning system (FFWS) with the introduction of the hydrodynamic super model MIKE 11 and an increase in the number of real-time monitoring stations to 30. With such modernization, FFWS yielded a successful result during the devastating flood of 1998.

Cyclone Warning System: The existing cyclone warning has two signal numbers inherited from British India. In line with growing need, the warning signals were simplified and made specific and easily understandable in June 2002. The modified system is now under consideration by the GoB.