

EARTHQUAKE DISASTER MANAGEMENT REQUIREMENT IN THE CONTEXT OF BANGLADESH

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INTRODUCTION

Bangladesh, by virtue of its geographical location, is a disaster-prone country. It is vulnerable to a wide variety of natural calamities like drought, tornado, floods, cyclones, tidal surge, river bank erosion etc. that cause immense damage to life, livestock, property, life support system and infrastructure. But this is not all as Bangladesh is also vulnerable to earthquake disaster. During the last hundred years several great earthquakes devastated cities and towns in some parts of the Indian subcontinent. Earthquake could be one of the most disastrous hazards for Bangladesh as the country is located near the Alpide-Himalayan earthquake belt. Fortunately, earthquake casualties in this region have not been significant till to date. But it should not develop a sense of complacency among the population and the policy makers of Bangladesh. During the last 80 years the world has lost about 20,000 lives per year due to earthquake. Though this figure may not look very impressive, but when one considers an earthquake of magnitude 8.3 on the Richter scale, such as the 1905 earthquake of Kangra wherein about 20,000¹ lives perished in a few seconds and hundreds of thousands houses collapsed or severely damaged, one can imagine the impact of an earthquake. So the questions to be asked are: *what would be the shape of things in Bangladesh if a severe earthquake occurs here and, have adequate precautionary measures been ensured in Bangladesh to mitigate or avoid the possible earthquake disaster in future?*

Even though seismic zoning map of Bangladesh was prepared in 1979, and the Bangladesh National Building Code was prepared in 1993, but the code has not yet been officially enforced. As a result, with rapid urbanization, thousands of buildings without seismic resistant feature have been built in the seismic risk zones of Bangladesh where a significant portion of its population are living under constant threat of earthquake disaster. Public awareness is an important factor for reducing earthquake hazards. But are the people of Bangladesh adequately aware of the consequence of existing construction practice in the country? It needs not be emphasized further that ignorance of the population about consequences of earthquakes in general may be fatal and disastrous. In a situation like this the question that needs to be asked is *"how to avoid or minimize the sufferings of people from the devastation of a probable major earthquake?"*

1. Bangladesh Meteorological Department, 'Earthquake Data'.

There may be different approaches for handling earthquake disaster, but the most logical approach is to face the challenge by adopting appropriate preventive measures so that disastrous effects are either prevented or minimized.² The economic consequence of this approach is minimal although it needs adequate infrastructures to incorporate resistance feature in construction and building up a national capability to combat such disaster. Though earthquake prediction studies help in defining the hazard and stimulating preparedness action before and after the event, but prediction alone, as a means of earthquake disaster mitigation is unreliable and, therefore, needs to be supplemented with comprehensive pre-disaster and post disaster measures. Today it is widely acknowledged that to build up a national capability to cope with earthquake disaster the focus needs to be shifted from post disaster measures to disaster mitigation aspects, with a greater involvement of govt. and non-govt. agencies. Therefore, the need of the time is to apply all the resources towards improving pre-disaster measures and simultaneously evolve a more responsive post disaster measures.

Scope

The aim of this paper is to analyze the vulnerability and risk of earthquake in Bangladesh and suggest pre and post disaster management measures integrating all resources available in the country. The paper concentrates on the earthquake disaster mitigation techniques and post earthquake disaster management measures in the context of Bangladesh. It will also focus on the present state of preparedness and the requirements for implementing the pre-earthquake measures.

EARTHQUAKE RISK IN BANGLADESH

Seismicity of Bangladesh

Geologic and tectonic information play vital role in earthquake risk analysis. The probability of earthquake occurrence within a region can be estimated using geological data combined with historical seismicity data.³ The geological map of Bangladesh, provides a brief account of geology and tectonics of Bangladesh and its adjoining areas. The tectonic evolution of Bangladesh is explained as the result of collision of the north moving Indian plate with the Eurasian plate, and the southeastern arm of the Burma sub-plate. The tectonic frameworks of Bangladesh indicate that the northeastern part of the country, with the presence of Dauki and Sylhet fault system, and proximity to the southeastern Assam with the Jafalong thrust and the Naga thrust, is a zone of high seismic risk. Northern Bangladesh comprising greater Rangpur and Dinajpur

2. Carter W Nick, Disaster Management A Disaster Manager's Handbook, Asian Development Bank, Manila, 1991

3. Development Design Consultant Ltd. Seismic Zoning and Earthquake Risk Analysis of Bangladesh, April 1993

district is also a region of high seismicity because of the presence of Jamuna fault, and the proximity to the active east-west running fault and the main boundary fault to the north in India. The Chittagong Tripura Folded Belt, experiences frequent earthquakes, as just to its east is the Burmese arc where a large number of shallow depth earthquakes originate. The southwestern part, relatively free from active faults and away from tectonically active areas of India, is the region of least seismicity. The central part of Bangladesh is relatively less susceptible to high earthquake hazards. The Bogra fault system and other suspected basement faults, however, add to the vulnerability to earthquake. The tectonic provinces both within and around Bangladesh, which have been identified as the major sources of earthquake⁴ that may affect Bangladesh are: Bogra fault zone, Sub-Dauki fault zone, Assam fault zone and Tripura fault zone.

Probable Future Earthquakes in Bangladesh

The earthquake data of Bangladesh from 1910 to 2002 shows that Bangladesh experiences frequent low intensity earthquake almost every month. The Bengal Basin, most of which has been slowly subsiding due to tectonic forces, is responsible for building the Himalayas. The tectonic process causes the strata under the Himalayas and the adjoining areas lying at their feet to be in a state of tension and the strata are yet to settle down to their equilibrium plane.⁵ This tectonic process and the consequential settling of these strata are mainly responsible for occurrence of earthquake in this region. Bangladesh lies between Latitude. 21° N and 27°N, and Longitude. 88°E and 92°E, within which few earthquake epicentres can be observed But most of the major earthquake epicenters lie in the east and northeast Indian regions, adjacent to Bangladesh's international border. These have, in the past, produced some shaking in the central part of Bangladesh.

Return Period (Years)	Earthquake Magnitude (Mb) for			
	Bogra Fault Zone	Sub-Dauki Fault Zone	Assam Fault Zone	Tripura Fault Zone
100	6.9	7.6	8.0	7.6
200	7.3	8.2	8.5	8.0

Table-1 Earthquakes for Different Seismic Zones

4. Goswami H C and Sarmah S K, Probabilistic Earthquake Expectancy in the Northeast Indian Region, 1982, Bull. Seism. Soc. Am. Vol-72, No.3, Pp. 999-1009

5. Geophysical Institute, Quetta, Pakistan, " Seismicity of Bangladesh"

A total of about 365 earthquakes of magnitudes ranging from 4 to 7.9 occurred at different observation periods from 1897 to 1991 in the tectonic province bounded by Lat 20° to 28° N and Lon 87° to 94° E. The Table 1 shows the magnitudes of earthquake in Bogra, Sub-Dauki, Assam and Tripura Fault zone in 100 and 200 years return periods. From this information and the fact that the earthquake of magnitude 8.7 and 8 occurred in Shillong and Kangra in 1885 and 1905 respectively, it can be presumed that an earthquake of this magnitude is overdue in this tectonic province where Bangladesh is located.

EARTHQUAKE PREDICTION AND MEASUREMENT

Earthquake Prediction

Since early 1960s lot of studies and research works have been carried out to understand the phenomenon of earthquake. It is now well established that when an earthquake occurs, it releases energy in the form of waves that travel through the earth at different velocities⁶ from the earthquake source in all directions. This has formed the basis of earthquake prediction technique in the present days. But one of the problems of earthquake prediction is that it is grossly inaccurate because it cannot indicate a precise geographical point within a precise time window with an acceptable probability. Therefore, forecasting earthquake like weather has not been possible till to date⁷ and geophysicists in countries like China are trying to correlate earthquake and behaviour of animals, birds and insects. Emission of radon gas from fault lines is seen before an earthquake. But it needs to be studied further for confirmation.

Measuring and Recording Earthquakes

Earthquakes are measured and recorded by a seismographic network. Each seismic station in the network measures the movement of the ground at the site. Magnitude is the most common measure of an earthquake's size. It measures the total energy released during an earthquake. The magnitude of an earthquake is determined from the logarithm of the amplitude of waves recorded on a seismogram at a certain period and expressed in Arabic numerals.

6. Internet: <http://www.earthquakes.bgs.ac.UK/hazard/faq1.htm> - Earthquake Frequently Asked Questions

7. Internet: http://www.pbs.org/wnet/SavageEarth/earthquake/htm/side_bar_2.htm, "Savage Earth: Quake Prediction"

Earthquake Description	Magnitude M Equivalent TNT Energy, Tons	Approximate	Remark
Great	M>8	1,010,000,00	Any earthquake of magnitude greater than 10 would be able to destroy the world civilization.
Major	7<M<7.9	31,800,000	
Strong	6<M<6.9	1,01,000	
Moderate	5<M<5.9	31,800	
Light	4<M<4.9	1,010	
Minor	3<M<3.9		
Micro	M<3		
Table 2 Earthquake Magnitudes (Source: Magnitude & Intensity, NEIC)			

The earthquake magnitude is classified as shown in Table 2. Intensity is a measure of the shaking and damage caused by the earthquake and this values change from location to location.⁸ The intensity scale or the Modified Mercalli scale has 12 levels of intensity expressed in Roman numerals.

Damage Profile

The extent of damage caused by earthquake depends on the intensity of earthquake, distance from the epicentre, soil condition, type of structure, design of building and quality of construction. An earthquake of magnitude 5 and above is likely to cause collapse of almost all kinds of structures, lifelines, sanitation, electric supply and communication system. Life and property can be damaged by fires originating from short circuits of power line and gas leaks from damaged gas lines. The most common failure will be the failure of stone masonry load bearing walls due to shear and tensile forces. Non-load bearing walls may fail by overturning, local crushing at the corners and diagonal cracking. Reinforced concrete framed structure may fail both due to buckling of columns under lateral force and the failure of joints. Shattering of gable walls and collapse of stone masonry walls may cause extensive damage to roofs.

8. Internet: <http://www.earthquakes.bgs.ac.uk/hazard/faq1.htm> "Earthquake:Frequently Asked Question."

EARTHQUAKE DISASTER RISKS FOR DHAKA CITY

Seismic Hazards for Dhaka City

According to a report published by United Nations, Dhaka and Tehran are the cities with the highest relative disaster risk (Cardona et al, 1999). Based on the historical data of major earthquakes that affected Bangladesh, it is conceivable that the Dhaka region may experience earthquakes with damage intensity greater than VIII. The following factors may explain the seismic hazards in and around Dhaka:

- a. **Movement of Major Lineaments.** The major faults and lineaments mapped in Dhaka are obvious. Movement of these lineaments, if happens, might pose significant seismic risk to the city (Hoque et al. 1994)
- b. **Ground Water Extraction.** There are concerns of increase in seismic hazard in and around Dhaka due to human activities. Recent research indicates that ground water extraction may trigger earthquakes in relatively stable regions (Prof Ansary M A, 2002).
- c. **Liquefaction Phenomena.** Liquefaction is a physical process that takes place during an earthquake and may lead to ground failure. Bangladesh including Dhaka is largely an alluvial plain consisting of fine sand and silts, which is susceptible to liquefaction, during earthquake.
- d. **Construction Technology.** Dhaka region has buildings of different categories including reinforced concrete frame buildings, brick masonry buildings with reinforced roofs, non-engineered brick masonry buildings and buildings made of other materials such as tin sheets, mud, wood etc. The non-engineered constructions are of lower strength. During the 1991 census, the Dhaka city was recorded to have a total of about 7, 43,480 dwellings which are now estimated to be over 12, 00,000. About 60% of these non-engineering constructions⁹ are likely to fall in a major earthquake.
- e. **Human Settlement on Surface Faults.** Dhaka city has been expanding in almost all directions. It is clearly evident from the **Micro-seismic Hazard Zoning Map of Dhaka city**, and the Tectonic Map of Dhaka region, that human settlements are growing on areas of faults and lineaments. These settlements are serious seismic hazards for Dhaka city.

9. Prof Ansary M A, Seismic Risk of Dhaka City and Role of the Insurance Community, Paper presented at National Sensitization Seminar on Response to Earthquake, Hotel Sonargaon, Dhaka, 6 March 2002

Earthquake Damage Scenarios for Dhaka City

On the basis of seismic hazard, structural vulnerability and building damage index the total number of buildings that would be damaged in Dhaka resulting deaths and injuries due to earthquakes of different intensities were studied by a committee of experts under a project funded by the Ministry of Science and Technology. The estimated number of building that would be damaged due to earthquake is shown in Table 3. The Dhaka census information, earthquake hazard, vulnerability data and the mortality information were combined to estimate the number of possible injuries, Table 4, and the corresponding deaths, Table 5 on the basis of the building occupancy

Item Description	EMS VII	EMS VIII	EMS IX
Reinforced Concrete Building	6,700	20,000	34,000
Engineering Masonry Building	81,000	171,000	250,000
Non-Engineered Masonry Building	82,000	145,000	200,000
Non-Engineered Constructions: Others	48,000	94,000	178,000
Fire	54,000	72,000	90,000
(Source: Prof Ansary)			
Table 3: Estimated Number of Buildings that would be Damaged in Dhaka due to Earthquake.			

Items Description	EMS VII	EMS VIII	EMS IX
Midnight	125,000	210,000	300,000
6 AM	100,000	170,000	240,000
12 Noon	65,000	110,000	160,000
(Source: Prof Ansary)			
Table 4: Estimated Numbers of Injuries (Residential) due to Different Maximum Earthquake Intensities Occurring in Dhaka.			

Items Description	EMS VII	EMS VIII	EMS IX
Midnight	52,000	86,000	119,000
6 AM	41,000	68,000	95,000
12 Noon	27,000	45,000	62,500
(Source: Prof Ansary)			
Table 5: Estimated Numbers of Fatalities (residential) due to Different Maximum Earthquake Intensities Occurring in Dhaka.			

EARTHQUAKE DISASTER MITIGATION PLAN FOR BANGLADESH

Priority in Disaster Mitigation Plan

To draw up plans for mitigation of earthquake disaster, the objects exposed to the hazards that need immediate attention may be placed in order of priority. All man-made heavy structures like dams, power plants, bridges etc. and places of assembly of people such as schools, hostels, auditoriums, mosques, etc. must be built with adequate safety margin. Emergency services like hospitals, fire stations, communications centers and lifelines of cities or even regions etc. should remain functional even after a major earthquake. Water and gas supply lines are to have in-built flexibility, with provisions for additional sub-zonal cross connections so that an affected zone may be isolated, while keeping the other zones functional. Power supply lines should be laid under ground, as much as possible. All private houses, including non-engineered houses are to be earthquake resistant. Industrial buildings and building in commercial areas should be built with earthquake resistance feature. The total disaster mitigation program that will reduce the impact of a major earthquake on the community can be divided into three phases¹⁰ discussed in the succeeding paragraphs.

Preventive Phase before Disaster. This phase should include the following actions:

- a. Preparation of earthquake catalogues, epicentre and geologic-tectonic maps for assessment of earthquake hazard, and preparation of seismic zoning maps.
- b. Development and enforcement of anti-seismic codes of building design and construction.

10. Arya A S, "Action Plan for Earthquake Disaster Mitigation", Proceedings of Disaster Management Training Country Workshop.

- c. Education and training of engineers and architects in earthquake engineering principles and use of building codes.
- d. Retrofitting of important existing building.
- e. Earthquake insurance for the buildings and structures.
- f. Installation of seismological observatory network.

Emergency Phase after Earthquake. This phase includes the following actions:

- a. Maintenance of law and order.
- b. Evacuation and medical care of stranded people and recovery of dead bodies and their disposal.
- c. Providing shelters, food and water.
- d. Restoring damaged lifelines, communication and transport routes
- e. Quick assessment of damage, cordoning and temporary shoring of severely damaged structures liable to collapse during the after shock period.
- f. Immediate actions to prevent certain chain reactions from developing.
- g. Collection of data from the observatories to monitor the after shock phase.

Consolidation and Reconstruction Phase. This phase should include the following actions:

- a. Survey of buildings and structure for assessment of damage.
- b. Repair or demolition of buildings.
- c. Selection of sites for new settlement.
- d. Adoption of strategy for new construction.
- e. Execution of reconstruction program.
- f. Reviewing of existing seismic zoning maps and seismic codes.
- g. Training of engineer/technical personnel based on lessons learnt.
- h. Statistical studies regarding the occurred earthquake.

EARTHQUAKE DISASTER MANAGEMENT PREPAREDNESS AND REQUIREMENT IN BANGLADESH

Seismic Zoning

In 1977, the Government of Bangladesh constituted a committee of experts for preparation of seismic zoning map of Bangladesh. Based on the analysis and interpretations of the earthquake occurrence data and the seismic tectonic setup of the country, the committee prepared a seismic zoning map, in 1979 under the aegis of the Geological Survey of Bangladesh. This zoning map was reviewed and a revised zoning map was prepared in 1993. On the basis of re-analysis of old and newly acquired data Prof Ansary M A, Department of Civil Engineering, BUET made a proposal in 2001 to revise the zoning map implying increased seismic risk.

Assessment of Earthquake Hazard

The data on earthquake occurrence in and around Bangladesh were collected by the Bangladesh govt appointed committee from the Catalogue of the Indian Society of Earthquake Technology¹¹ starting from the historical period up to 1978, and from Earthquake Data Files of the National Oceanic and Atmospheric Administration, USA from 1979 to 1992.¹² The Geological Map of Bangladesh, was prepared by Alam et al in 1990 under the Geological Survey Department of Bangladesh.¹³ But till to date the micro-seismic hazard zoning map of Dhaka city only has been prepared. The micro-seismic zoning maps of other cities in the seismic risk zones of Bangladesh i.e. Chittagong, Sylhet, Mymensing, and Rangpur are yet to be prepared.

Structural Mitigation

Structural mitigation is one of the major pre-disaster initiatives to minimize damage during earthquake. For buildings coming up in seismic zone 2 and 3 if appropriate design and construction codes are followed, it will reduce the damage during earthquake. Quality materials such as steel, stone, cement and other building materials in construction can make buildings stronger to withstand severe earthquake shocks. Bangladesh Standard and Testing Institution (BSTI) and House Building Research Institute (HBRI) have important role to play in this regard.

11. Catalogue of Earthquake in India and Neighborhood 1983, Indian Society of Earthquake Technology, Roorkee, India.

12. Earthquake Data File (1992), National Oceanographic and Atmospheric Administration, USA

13. Alam M K, Hasan A K M S, Khan M R, and Whitney J W (1990), Geological Map of Bangladesh, Geological Survey of Bangladesh.

Town Planning and Implementation

Lack of awareness in people about earthquake disaster has caused a very detrimental impact on the construction practice followed in the country and implementation of town plans. The Master Plan of Dhaka City, for example, was prepared in 1959 and was revised in 1995, but it has not been properly implemented. Individual houses and buildings have been built filling up ponds, ditches and surface fault lines without seismic strengthening. Presently, the building permit granting authorities do not have any mechanism for inspection and supervision during construction phase of private buildings. Consequently, almost all private owners temper with the approved design incorporating harmful changes in the design. To avert such problems town planning must be carried out taking the micro-seismic hazard zoning map into consideration and the plan be implemented through legal means. There is a serious lack of cooperation and coordination among city administrative bodies in implementing town plans and laying lifelines for cities. Lifelines should be centrally planned and laid through proper coordination.

Enforcement of Building Code

The outline of a “Code for Earthquake Resistant Design” of construction was prepared in 1979. In 1993, a team of consultants, appointed by the Government of Bangladesh, prepared the National Building Code for Bangladesh (BNBC 93). But this Code has not yet been enacted as law and hence the Code could not be enforced officially. In 1997, the Ministry of Works constituted a committee to develop a mechanism for its enforcement but it could not make any progress. Presently, the Ministry of Works is considering to accept BNBC 93 as annex to the Building Act 1952. Enforcement of building code should be the function of the government to assure uniformity and prevent conflict. Investigation should be the responsibility of a single institution, such as RAJUK. A branch or department of the same institution should constitute a court to carry out hearing and impose necessary penalties. Necessary laws and byelaws, in this regard, are to be passed and promulgated to ensure enforcement of the National Building Code after its enactment. Appropriate mechanism for inspection at all phases of building construction must be developed.

Retrofitting of Existing Building

Essential facilities such as hospitals, communication centres, fire stations, powers plants, water supply and treatment plants etc. play vital roles in the post disaster phase. Many old buildings in Bangladesh under these categories were not designed to withstand the shock of earthquake. Presently, there is no government policy to undertake retrofitting of such essential facilities. However, the retrofitting techniques of existing buildings and structures have already been developed. Therefore, programs may be taken up for retrofitting of important buildings that accommodate essential facilities. Effort may also be made to study the behavior of non-engineered houses during an earthquake and technology is to be developed for strengthening of such houses and buildings.

Education, Training and Research

The present level of education and training on earthquake technology available in the country is inadequate. Recently, the BRAC University organized an international training program titled "Earthquake Vulnerability Reduction in Cities". The National Center for Earthquake Engineering has been set up and engineering courses have been started in BUET. Bangladesh Institute of Technology, Chittagong has also set up an Earthquake Research Centre. Moreover, BUET has carried out a project to develop an earthquake database from historical period to recent past for seismic hazard analysis. It also created a database of civil engineering structures in selected areas of Dhaka city to develop a damage scenario of structures in the event of a probable earthquake. But still there are a lot more to be done to educate and train engineers and professionals on earthquake engineering principles and effective use of codes. Computer hardware and software may be acquired for carrying out analytical modeling and simulation studies different types of buildings and structures.¹⁴

Public Awareness

Public should be made aware of earthquake hazards and consequences and be motivated to take appropriate preventive actions in advance without developing a sense of complacency at any stage. In this regard the electronic and printed media must play their role effectively. Recently, the Institute of Engineers, Bangladesh (IEB) has organized few seminars in Dhaka, Sylhet, Chittagong, Katmandu and Agartala in co-operation with Nepal Engineers Association and Institution of Engineers, India. Bangladesh Earthquake Society has been formed drawing members from all disciplines of profession.¹⁵ But the general mass is still unaware of the likely consequences of a major earthquake, which demands special attention.

14. Dr Ali M H , 'Earthquake Hazard and Seismic Zoning Of Bangladesh'.

15. Dr J R Chowdhury, "Some Recent Development in Earthquake Disaster Mitigation and the Bangladesh Scenerio "

Observatories

To locate an earthquake correctly, a dense network of observatory is essential. In 1986 a project was started, with UNDP's contribution, for setting up a 4-station network with the existing one at Chittagong and three new stations namely at Dhaka, Rangpur and Sylhet. But the project was finally abandoned due to shortage of fund from the Government of Bangladesh, and UNDP withdrew its fund. The Government of Bangladesh took up another similar project in 1991 but this was also abandoned due to financial constraint and now it is waiting for funds from foreign donor.¹⁶ However, the need for setting up an observatory network in the country cannot be emphasized further as the lone observatory in Chittagong is now partially operational and unable to locate earthquake epicenter due to its operational limitation.

Instrumentation of the Seismic Stations

Bore Hole seismometers are required to be installed in Dhaka and Rangpur, which will cover the alluvial soil, whereas, broadband seismometers are needed in Chittagong and Sylhet, for their hilly terrain. Recently, it was decided that to collect information on ground motion a number of strong motion accelerograph will be installed on and in the vicinity of the Jamuna Multipurpose Bridge and four district headquarters (Bogra, Natore, Mymensingh and Gazipur) close to the bridge. Installation of seismic monitoring equipment in important structures may be made compulsory, for vital information in determining seismic design criteria in new structures.

Preparation at Government Level

Recently the Disaster Management Bureau (DMB) has taken a number of steps, such as preparation of list of essential vehicles, tools, equipments, possessed by different organizations, organizing training, seminars, meetings and workshops. But to face the challenge of a major earthquake detailed action plans are yet to be prepared. Very recently, a program has been initiated by the Ministry of Disaster Management and Relief for drawing up comprehensive action plans for facing the challenges of earthquake disaster. It involves all government agencies/departments including Army, Navy, Air Force and NGOs. The DMB has published a book titled "Earthquake Awareness Programme," and the same has been distributed to different authorities in Zilla, Upozilla and Union Parishod.¹⁷ Such book may be included in the syllabus of secondary school certificate curriculum.

16. Bangladesh Meteorological Department, Dhaka, "Position in Connection with Establishment of a Four Stations Seismic Network in Bangladesh "

17. Mir Fazlul Karim, " Earthquake and Public Awareness in Bangladesh " Proceeding of National Disaster Preparedness Day- 2002, Disaster Management Bureau.

EARTHQUAKE DISASTER MANAGEMENT IN BANGLADESH

Post Disaster Operations

Resource Management. Since it is impossible to maintain an exhaustive stock of all resources and facilities that would be required to face the catastrophe of a major earthquake, actions to face such challenges are to be initiated utilizing all available resources and facilities through organized and coordinated efforts. There has to be provision of specialists to assist in the coordinating activities of various government departments and liaise with outside agencies for emergency support.

Damage and Need Assessment. Immediately after an earthquake the whole devastated area is to be surveyed to assess and determine the extent of damage and requirement of rescue and relief operations.

Establishing Communication. Military type communications within and outside the disaster areas are to be established. Mobile/cellular telephone would play vital role in providing post earthquake communication links and search and rescue operations. Many of the cellular telephone antennas, now existing on building top, may collapse in the event of earthquakes. Therefore, the damaged antennas are to be repaired with due priority.

Collapsed Building and Debris Clearance. Provisions of earthmoving equipment including other special equipment for search and rescue operations and operators are to be made to clear debris and collapsed building/structures from the affected areas and roadways to ensure quick access to the trapped survivors.

Evacuation. Provisions of ground evacuation for large number of people and provisions of helicopter evacuation of casualties with in-flight medical treatment facilities are to be made.

Search and Rescue. Coordinated wide ranging search and rescue services are to be provided using both fixed and rotary-wing aircraft and ground and water transport to find out and remove affected/injured persons to safe areas and rescue centers.

Food and Water. Provisions of military type field messing facilities and

issue of military subsistence rations are to be arranged where authorized. Provisions of portable water for emergency drinking and cooking purposes are to be made. Assistance to be provided to the governmental departments and bodies in supervising the storage, transportation and distribution of consumer goods and commodities supplied by the armed forces and other agencies.

Temporary Housing and Shelter. Housing at military camps having facilities in excess of operational requirements may be provided, if possible. Camps and temporary shelter for public administrative offices may be erected utilizing military engineers.

Protection of Life and Property. Active military police units and military forces may be deployed, when authorized, in maintenance of law and order, and in prevention of looting and plundering within the disaster areas. Local fire services are to be assisted in suppression of fires by providing fire fighting equipment, operators and troops.

Repair of Roads and Bridges. Emergency repair of streets, roads, bridges and replacement of damaged bridges with temporary types of bridges utilizing engineer troops are to be arranged. Specialists' support is to be provided to assist the local government in supervising operations of Public Works Department within the disaster areas and in coordinating the utilization of resources provided by other agencies.

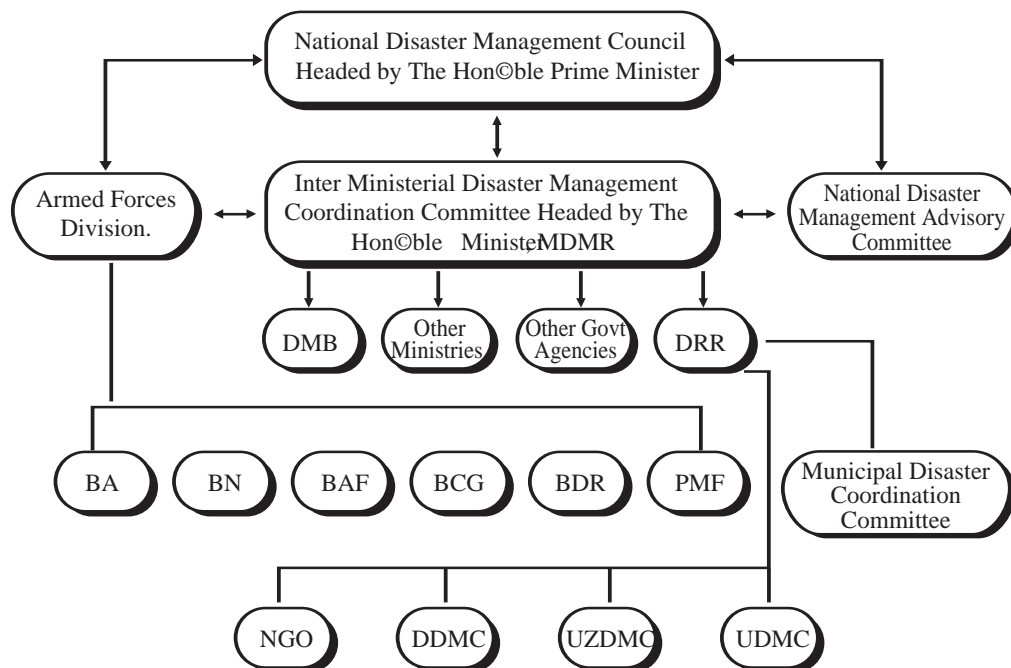
Restoration of Lifelines. Specialists to assist and advice government departments in restoring lifelines and sanitation system in the affected areas are to be provided. Emergency repair of these systems utilizing military engineers and troops is to be arranged as necessary.

Post Disaster Operation Management Plans

The Directorate of Relief and Rehabilitation (DRR), under the Ministry of Disaster Management and Relief (MDMR), mainly implement the relief and rehabilitation policies through its field organs and NGOs. But in case of an earthquake, neither the govt. bodies nor any corporate body alone can cope with the multitude of problems that would be left in its wake. Therefore, the responsibilities for execution of the rescue, relief and rehabilitation are to be shared by all the specialist departments of government and non-government agencies.

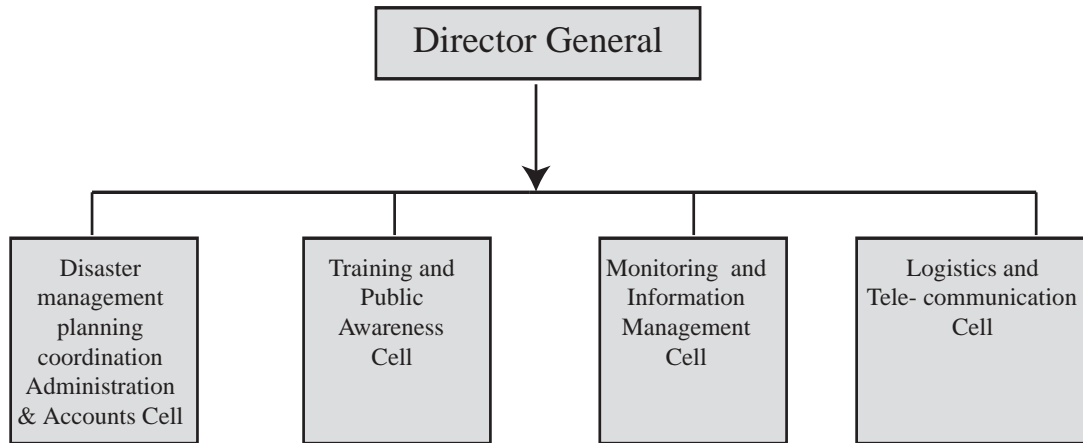
To conduct post earthquake disaster management activities the affected city/town/locality may be divided into sectors. The sector-wise area of responsibility may be distributed among the different government agencies. The operations are to be conducted under the National Disaster Management Council headed by the Hon'ble Prime Minister. The Inter-Ministerial Disaster Management Coordination Committee headed by the Hon'ble Minister, MDMR, is to implement the policy and decisions of the National Disaster Management Council.¹⁸ The committee will monitor the execution of the rescue; relief and rehabilitation related plans and keep the council informed of the progress. The committee is to coordinate and evaluate the activities of the line ministries, concerned, Armed Forces Division, Disaster Management Bureau, Directorate of Relief and Rehabilitation, all Para Military Forces, other government and non-government agencies concerned. The National Disaster Management Advisory Committee is to advise the National Disaster Management Council and MDMR on technical management, emergency response and development. The Armed Forces Division is to conduct all the post disaster activities, assigned by the government, through the services headquarters, which in turn, will execute action plans through formation/area headquarters and units/bases. The proposed organograms of the different disaster management organizations at the national and local levels including the DMB, Armed Forces, Para Military Forces and NGOs are shown below:

NATIONAL LEVEL DISASTER MANAGEMENT ORGANIZATION

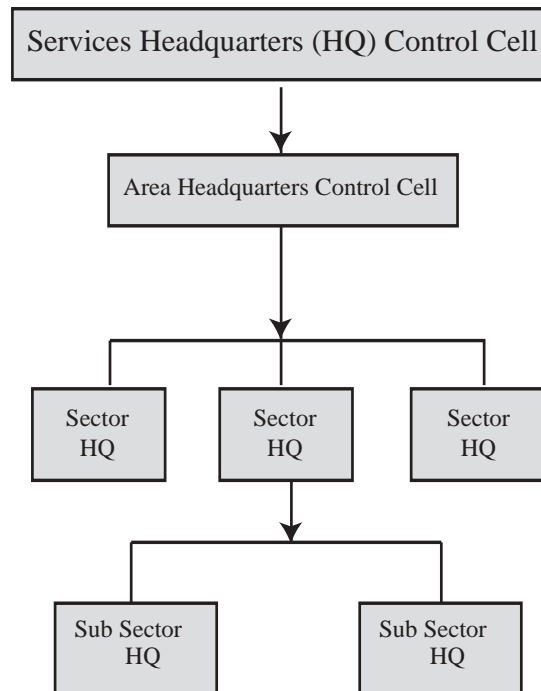


18. Ashraf M, " Role of the Government in Relief and Rehabilitation" Paper presented at National Workshop on Disaster Management and Media, CIDRAP Auditorium, Dhaka 12 Aug 2002.

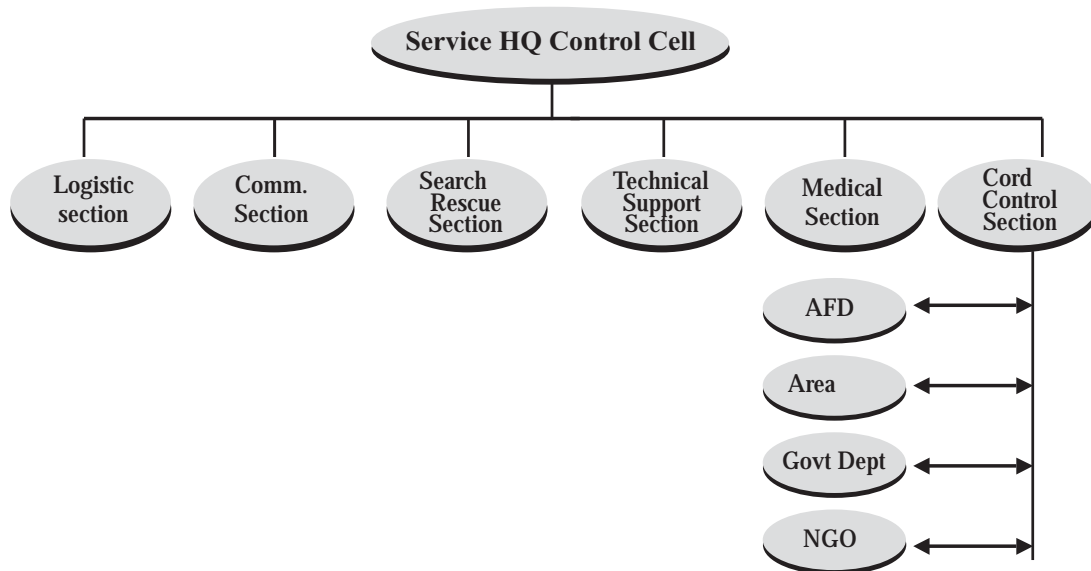
CORE STRUCTURE OF DMB



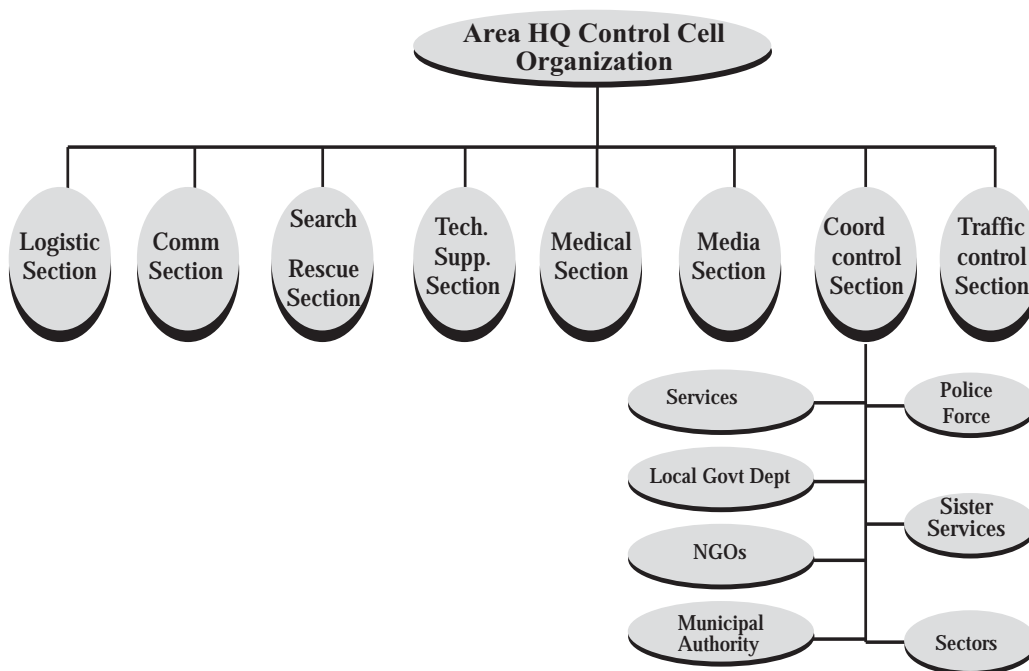
ARMED FORCES DISASTER MANAGEMENT ORGANIZATION



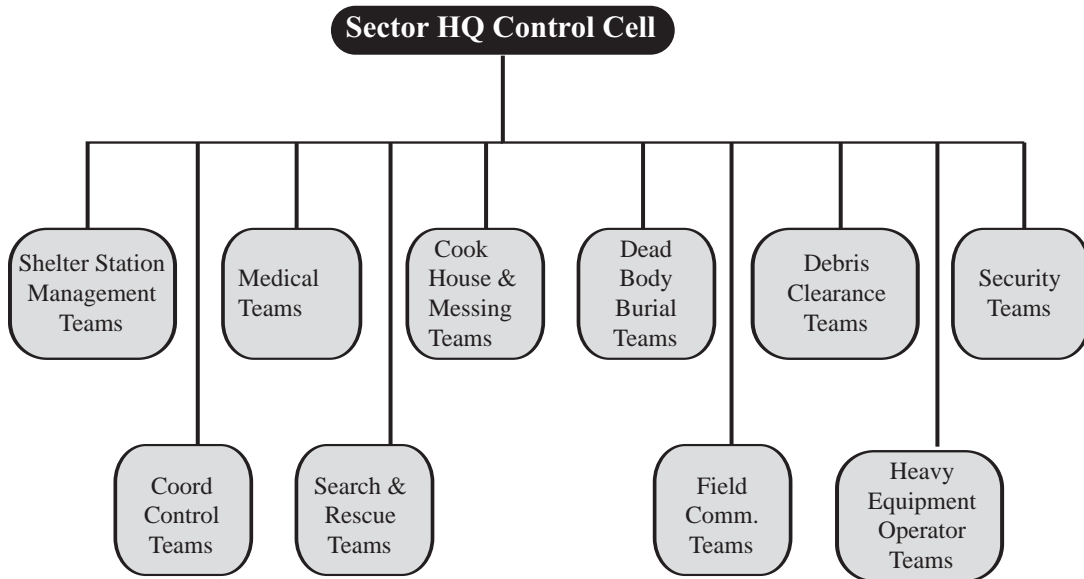
SERVICES HQs CONTROL CELL ORGANIZATION



AREA HQ CONTROL CELL ORGANIZATION



SECTOR HQ ORGANIZATION



Management of Special Tools and Equipments

An inventory of heavy vehicles, tools, special equipment and sensors available with different agencies/department that would be required for handling earthquake damages is to be maintained with DMB. Foreign assistance with appropriate tools, equipment and know how will be vital for post disaster operations. Such technical assistance may be called for immediately after an earthquake from different resourceful countries.

Earthquake Website. Earthquake website may be launched as it would be very helpful in collecting information in post-disaster situation. Departments and agencies, concerned, may then continuously update the information logging on to the website as and when required. This will enable international communities to assess special technical assistance needed for any particular operation and extend necessary support accordingly.

ROLE OF DIFFERENT AGENCIES IN EARTHQUAKE DISASTER MANAGEMENT

Role of the Ministry of Disaster Management and Relief

The Ministry of Disaster Management and Relief is to play its role to perform the following tasks with regard to relief and rehabilitation activities in the post earthquake situation:¹⁹

- a. Approach the Armed Forces Division to provide support for search and rescue operations and assessment of loss and damage.
- b. Request the civil authorities to assist the Armed Forces in carrying out search, rescue, relief and rehabilitation activities.
- c. Arrange meetings of the National Disaster Management Council and Inter Ministerial Disaster Management Coordination Committee.
- d. Coordinate rescue and relief work with NGOs.
- e. Assess requirement of funds, material and International support for rescue, relief and rehabilitation works.
- f. Arrange house building grants and food for works program.
- g. Coordinate overall rehabilitation program.

Role of the Directorate of Relief and Rehabilitation

The DRR is to perform the following tasks to ensure relief activities during post disaster period:²⁰

- a. Ensure adequate stock of relief and rehabilitation materials.
- b. Allocate and utilize relief and rehabilitation material received under the food for works program for various post earthquake disaster management activities.
- c. Ensure quick dispatch of relief material to the affected areas.
- d. Instruct field officers for helping the local administration in evacuation and rescue operation.
- e. Setup temporary shelter and feeding center at the affected areas.

Role of Specialist Department

Different specialist departments of the government are to take part in their specialized fields to carry out the following activities:²¹

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19. Ashraf M, " Role of the Government in Relief and Rehabilitation " Proceeding of National Workshop on Disaster Management and Media "
 20. Ashraf M, " Role of the Government in Relief and Rehabilitation " Proceeding of National Workshop on Disaster Management and Media "
 21. Ashraf M, " Role of the Government in Relief and Rehabilitation " Proceeding of National Workshop on Disaster Management and Media "

- a. Fire services are to work for mitigation of fire accidents and rescue operation as necessary.
- b. Power Development Board is to restore power supply.
- c. Gas distribution authority is to ensure safety, repair damaged pipelines and restore supply.
- d. Water supply authority is to restore water supply to affected area and repair damaged pipelines and pump houses.
- e. Roads and High Ways, Water Development Board and LGED departments are to repair damaged infrastructure, embankments and roads and keep these useable.
- f. Public health department is to supply pure drinking water to the affected areas.
- g. Health department is to provide medical teams and check outbreak of epidemics.
- h. Telecommunication authorities are to restore communication network.

Role of the Armed and Para Military Forces

The Armed Forces (Army, Navy & Air Forces) and the Para Military Forces of Bangladesh can play vital role in the post earthquake disaster management activities because of their effective organizational and command control structure. The Bangladesh Armed Forces may perform the following operational tasks to assist the civil administration:

- a. Mobilize available resources to the affected areas for search and rescue of the trapped persons.
- b. Assess the damage and needs as per priorities.
- c. Provide transportation facilities by land, water and air for evacuation of stranded people and carrying relief material.
- d. Employ field medical teams and establish mobile hospital.
- e. Assist fire services in fire fighting.
- f. Restore lifelines in the affected areas.
- g. Ensure security of the distressed people.

- h. Remove and clear debris and collapsed building/structures to ensure accessibility to the affected areas.
- j. Remove dead bodies, animal carcasses and bury/dispose the same.
- k. Provide temporary shelter, cooking and sanitation facilities and supply drinking water and other needs.
- l. Establish emergency communication.
- m. Provide support in rehabilitation efforts.
- n. Besides all these, the Armed Forces can be deployed at any places, for any difficult task to meet the needs of the time.

Role of the NGOs

The NGOs in Bangladesh can play important roles in earthquake response both at national and local level. Following are the major tasks that NGOs may carry out in response to earthquake:

- a. Appropriate assessment of damage and needs in the aftermath of earthquake.
- b. Appropriate targeting of the affected population to ensure accountability and optimal use of limited resources.
- c. Respond in coordination among the involved agencies in the aftermath of earthquake.
- d. Exchange ideas and experience, in response of earthquake, with other involved agencies.
- e. Involve in post earthquake disaster response such as search, rescue, relief and rehabilitation work together with government departments/officials.

Role of Insurance Community

In mitigating the impact of earthquake, the insurance industries can play two major roles. The first relates to the mitigation of cost to the insured by bearing part of the cost of damage. The second role involves harnessing market forces to drive long-term improvement in seismic risk. By charging higher rates

for structures having poor or no seismic strengthening feature and for construction of structures at poor location, the insurance industry would encourage the private property owners to demand that the architects and engineers build structure that can be insured at reasonable rates.

CONCLUSION AND RECOMMENDATIONS

The aim of this paper was to analyze the vulnerability and risk of earthquake in Bangladesh and to suggest pre and post disaster management measures integrating all resources available in the country. The paper tried to concentrate on the earthquake disaster mitigation techniques and post earthquake disaster management measures in the context of Bangladesh with its focus on the present state of preparedness and the requirements for implementing the pre-earthquake measures.

From the findings of this paper it is evident that Bangladesh lies in an active tectonic province, and the history of earthquakes in and around Bangladesh, indicate that an earthquake of magnitude 8 is already overdue in the region. In case of a major earthquake in Sub-Dauki, Assam and Shillong Fault Zone, Dhaka City has all the possibilities of being severely affected. Depending on the time of occurrence, between 45000 to 86000 people may perish due to structural collapse. The number serious injuries may range from 1,10,000 to 2,10,000. About 60% of the existing non-engineered structures may collapse. Therefore, there is a need for extensive detailed risk assessment of different areas for formulating realistic mitigation policies.

There is a serious lack of awareness among the public and the govt. policy makers about the earthquake risks and hazards. Construction of non-engineered buildings is increasing frantically in the absence of a National Building Code. Human settlements are growing on seismically hazardous areas. There is a need for close cooperation and coordination among city administrative bodies in implementing town plans.

But unfortunately, there is no effective mechanism for implementing a new-effective town plan, and earthquake observational facility available in the country is absolutely inadequate. There is a lack of realization among the authorities at national level about the necessity of establishing a seismic network in the country as Micro-seismic hazard zoning map for cities in the seismic risk zones i.e. Chittagong, Sylhet, Mymensing and Rangpur are yet to be prepared.

In view of the seismic risk in Bangladesh, resources available in the country, existing construction practice and the present level of preparedness the following immediate measures are recommended:

- a. The Bangladesh National Building Code (BNBC93) is to be enacted as law and the mechanism for enforcement of the code is to be developed. Laws and byelaws are to be passed and promulgated for preventing construction of non-engineered structures and buildings.
- b. Town plans are to be implemented through more cohesive interactions and coordination among the city administrative bodies.
- c. The adequacy of important existing buildings and structures to withstand earthquake is to be evaluated and retrofitting is to be carried out as necessary.
- d. Standing orders detailing emergency action plans to be executed during and after earthquake are to be prepared and incorporated in the overall Disaster Management Plan under the DMB.
- e. Public awareness building program is to be undertaken. Private building owners are to be encouraged to insure their building /house to mitigate the cost of damage due to earthquakes. Insurance industries are to harness market forces to drive long-term improvement in seismic risk. The printed and electronic media are to be effectively utilized for this purpose.
- f. The government policy makers' awareness building would be an important step to be taken for overall earthquake disaster preparedness.
- g. General instructions on dos and don'ts before, during and after earthquakes should be included in the school curricula in the high-risk zones.
- h. Earthquake drills in the high-risk zones are to be organized on regular basis.
- i. Simple guidelines for strengthening of existing non-engineered constructions are to be developed and disseminated widely.

- j. Equipment held with different agencies may be earmarked to ensure their ready availability at the time of need.

With a view to building up a national capability for facing the challenges of a major earthquake the following long-term measures are recommended:

- a. Collection and analysis of earthquake related information to identify its sources and updating seismic zoning maps.
- b. Preparation of liquefaction potentials maps of major urban centers of the country.
- c. Micro-seismic hazard zoning of major cities in zone 2 and 3 starting with Chittagong, Sylhet, Mymensing and Rangpur.
- d. Development of planning guidelines to be used in locating major structures based on micro-seismic hazard zoning map and liquefaction potentials.
- e. Reviewing and updating of the building code at regular intervals.
- f. Development of facilities for research and education/ training of professionals specialized in earthquakes, seismology and geophysics.
- g. Development of analytical modeling and simulation facilities for carrying out studies for various types of structures subjected to earthquake excitation.
- h. Setting up of Seismic Network (at least 4-station) with fully equipped observatories and instrumentation of selected important structures to acquire strong motion data in zone 3 and 2.
- j. Arranging seminars and workshops on earthquake disaster management to identify shortcomings and develop capabilities.
- k. Simulation exercises involving the Armed Forces, NGOs and public.

In conclusion it can be hoped that Bangladesh Government and its people will wake up to the realities of a possible earthquake disaster in this region, and with the right kind of planning and awareness, together we can face such problem successfully.

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