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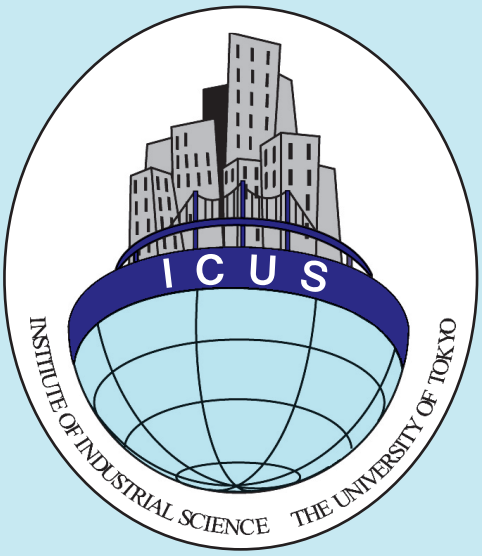

INTERNATIONAL CENTER FOR
URBAN SAFETY ENGINEERING

INSTITUTE OF INDUSTRIAL SCIENCE
THE UNIVERSITY OF TOKYO

BNUS ANNUAL REPORT - 2008

Edited by

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BANGLADESH NETWORK OFFICE FOR URBAN SAFETY

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BUET, DHAKA, BANGLADESH

Prepared by:

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PART-I

POST DISASTER SURVEY SIDR (NOV 15, 2007)

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared by: Afifa Imtiaz
Mehedi Ahmed Ansary

ABSTRACT

Bangladesh is prone to several natural disasters such as floods, cyclone, landslide, earthquake etc. while the Southern coasts are prone to severe cyclones. One of the recent major events is the super cyclone SIDR. This was a category 4 storm that reached the coast on the night of 15 November 2007 causing a severe damage over several south western coastal districts and central areas of Bangladesh. The accompanying storm surge reached maximum heights of about 10 meters in certain areas, breaching the coastal and river embankments, flooding low lying lands and causing extensive physical destruction. The cyclone's winds of up to 220 kilometers per hour caused further destruction to buildings and uprooting of trees that in turn destroyed housing and other infrastructure inland. According to the Government reports Bagerhat, Barguna, Patuakhali and Pirojpur have been classified as 'worst' affected and eight Khulna, Madaripur, Sariatpur, Barisal, Bhola, Satkhira, Jhalakathi and Gopalganj have been classified as 'badly' affected out of the total 30 affected districts (Figure 1). Total damage has been estimated to be 1.6 billion US dollars. To perform a survey on the post disaster situation and activities and to collect the finalized damage assessment information a team from Bangladesh Network Office for Urban Safety (BNUS), Bangladesh University of Engineering and Technology (BUET) visited two worst affected Districts Patuakhali and Barguna (Figure 1) from May 5 to May 12, 2008. Afterwards BNUS Continues Interview Survey to selected authorities and policy makers in Dhaka regarding Cyclone SIDR Management and Standing Order of Disasters (SoD) for Bangladesh. This report provides the detailed description of the survey.

INTRODUCTION

An ideal Disaster Management System needs to support the activities related to the various phases of disaster management including the pre-disaster planning, warning and emergency relief and post-disaster recovery. Having been accustomed to a long history of fighting with cyclones, Bangladesh still suffers from the deadly affect of such events like SIDR. The improved Early Warning as well as the Warning Dissemination System along with cyclone preparedness programs could save loss of lives significantly. But the death toll over 3406 and massive destruction due to SIDR indicates that there needs improvements or modifications in the coping mechanism. Thus the principle objective of this work is to address the entire cyclone management system and to elaborate the damage and vulnerability assessment of the affected communities based on two particular case studies, Barguna and Patuakhali. Since, the Standing Order of Disasters (SOD) is the basic tool that is supposed to be followed for guiding the disaster management activities for the concerned authorities, now it is high time to analyze on the role of SOD. It should be assessed that in present times how functional the SOD is and what kind of modifications are needed in the existing SOD for better guidance in disaster action plans. BNUS performed interview survey from November 26 to December 07, 2008, in Dhaka on the role of Standing Orders of Disaster (SoD) of Bangladesh and the Cyclone SIDR Management Operations. The interviews were conducted to the policy makers and personnel associated with cyclone management activities in some organizations such as Disaster Management Bureau (DMB), Directorate of Relief and Rehabilitation (DRR), Bangladesh Red Crecent Society (BDRCS), Cyclone Preparedness Programme (CPP), Comprehensive Disaster Management Programme (CDMP). The interview surveys in Dhaka were performed jointly with Taiki KOU, an undergraduate student of Meguro Lab, doing a

study on "Disaster Management Operation by the governments in case of Cyclone SIDR in Bangladesh", from the Department of Urban Earthquake Disaster Mitigation Engineering, International Center for Urban Safety Engineering (ICUS), The University of Tokyo. Through the interviews discussions were held on various issues such as Historical Changes of Disaster Management Plan and SoD in Bangladesh, Cyclone Management Operations' Flow of Ministry of Food and Disaster Management, Information Flow and Sharing, Maintenance of Logistics, Efficiency of Cluster approach during the disaster stage, Current Action Plans, CPP and BDRCS Activities, Relief Works, Plans and Activities regarding Cyclone Shelters and so on.

OBJECTIVE OF THE STUDY

The principle objectives of this Case Study Survey are as follows:

- To visit Two Worst Affected Areas by SIDR : Patuakhali & Barguna
- To collect Damage Data of the areas
- To share experience of the Local Responsible Authorities in Cyclone Management
- To have a look on the Key-Roles played by the Local Authorities and compare with the Standing Order on Disaster, Bangladesh
- To collect information on Roles played by the Non Govt. Organizations
- To perform survey on Local People on Overall Disaster Situation
- To visit Cyclone Shelters and Killas
- To share the experience of authorities involved in SIDR management in Dhaka, to link up the information sharing and work flow network and to analyze the role of SoD in overall Disaster Management.

VISITED AUTHORITIES

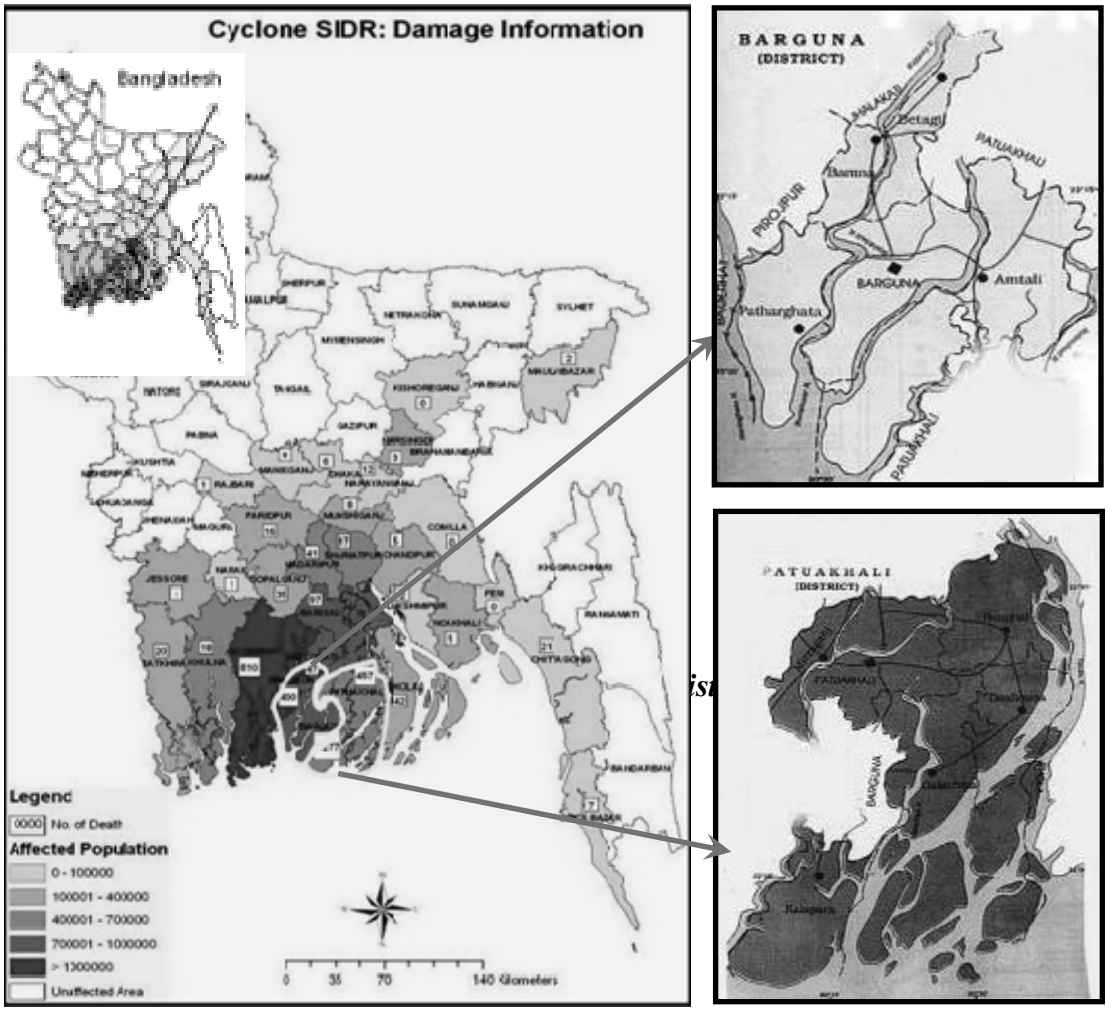
The survey in the affected areas was conducted by interviewing the following key personnel and also by visiting their respective offices for which they are considered to be the responsible representatives:

- Deputy Commissioner (DC)
- Upazila Nirbahi Officer (UNO)
- District Relief & Rehabilitation Officer (DRRO)
- Executive Engineer, Water Development Board (WDB)
- Executive Engineer, Local Govt. Engineering Department (LGED)
- Assistant Engineer (WDB)
- Assistant Engineer (LGED)
- Upazila Engineer
- Bangladesh Red Crescent Society (BDRCS)
- Cyclone Preparedness Program (CPP)

The interview surveys conducted in Dhaka incorporated the following personnel

- Professor Jamilur R. Choudhury, Vice Chancellor, BRAC University
- Director (Admin), Disaster Management Bureau (DMB)
- Director, Directorate of Relief and Rehabilitation (DRR)
- Communication Media Specialist, Disaster Management Bureau (DMB)
- Deputy Director, Cyclone Preparedness Program (CPP)
- Deputy Chief Coordinator, Cyclone SIDR, Bangladesh red Crescent Society (BDRCS)
- Shelter Coordinator, Cyclone SIDR Operation, BDRCS
- Relief Coordinator, Cyclone SIDR Operation, BDRCS

- Monitoring & Evaluation Expert, Comprehensive Disaster Management Programme (CDMP)



(Source: Ministry of Food and Disaster Management (MoFDM) Relief Control Cell (RCC); Date: November 29, 2007)

Figure 1: Damage by Cyclone SIDR

THE CYCLONE SIDR

The Super Cyclone 'SIDR' was first observed on 9 November 2007 near the southeast of the Andaman Islands with a weak low-level circulation near the Nicobar Islands. It showed indication of the formation of a tropical cyclone on 11 November while located a short distance south of the Andaman Islands. On 13 November, the depression turned into a cyclonic storm with a core of hurricane force winds. It moved northwards and was centred at 9 p.m. on 14 November 2007 about 670 km South of Mongla port. Cyclone SIDR hit Bangladesh's offshore islands at approximately 18:30 hours on the evening of 15 November and made landfall across the Barisal coast at 21:00 hours local time during ebb tide. Wind speeds reached up to 240 km per hour (JTWC) affecting 15 districts with 15 others partly affected. Figure 2 shows the track of Cyclone.

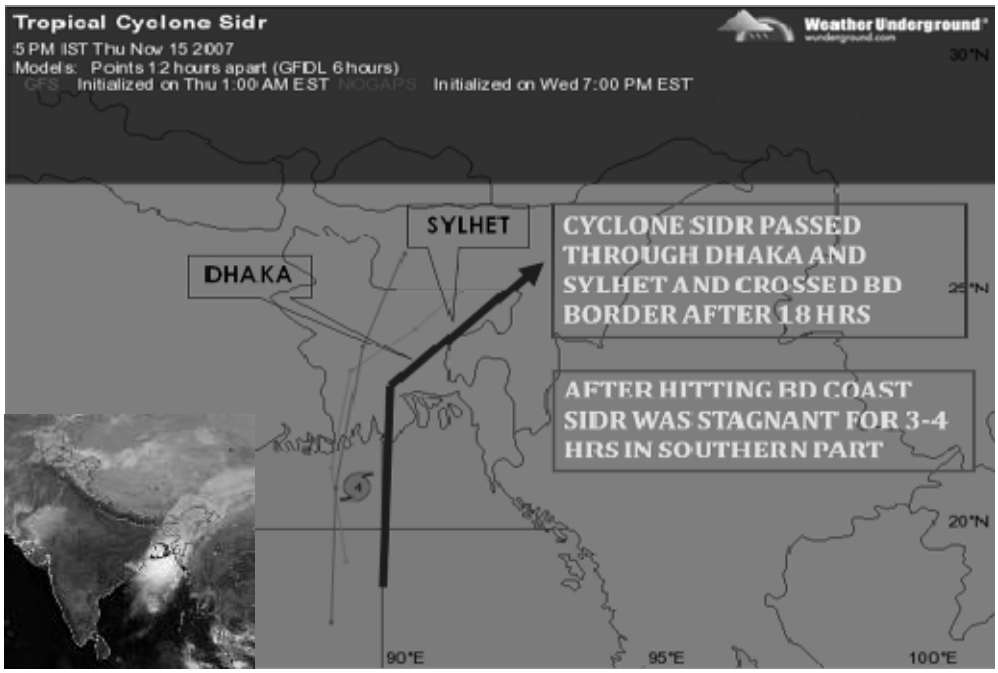


Figure 2: Track of Cyclone SIDR

WARNING ISSUED & PREPAREDNESS

The cyclone SIDR was monitored from its generation time to progress towards Bangladesh. Technology for monitoring tropical cyclones has significantly improved in the country over the last decade. Nowadays it is possible to observe cyclones and forecast about their strength and destined landfall. The authorities in Bangladesh first got news of the impending crisis 72 hours before the category four tropical cyclone, which was then still forming over the Bay of Bengal, made landfall. The World Meteorological Organization, WMO's global cyclone observatory started feeding data to its regional outpost at the Indian Meteorological Office in New Delhi, which in turn triggered Bangaldesh's government to sound the alarm [5]. Tropical Cyclone Formation Alert was issued on November 11 while located a short distance south of the Andaman Islands. The warning was disseminated by emergency response authorities in Bangladesh, prompting massive evacuations of the low-lying coastal areas. When the message was relayed to the local administrations of probable affected districts, a network of 40,000 CPP trained volunteers, were mobilised. They cycled around the country, using megaphones to order residents into the 1,800 cyclone shelters and 440 flood shelters. A total of 2 million people were sheltered before the cyclone hit. In spite of the warning, thousands of people were stranded on small and remote islands, with no place to go because of its low elevation above sea level. However, the early warning system, preparedness and massive evacuations, resulted in a much lower death toll than that caused by the 1991 cyclone.

OVERVIEW: DAMAGE AND LOSSES

More than 8.9 million people in 1,950 unions of 200 Upazilas under 30 districts were affected by Cyclone SIDR. Official reports indicated a total of 3,406 Bangladesh

nationals perished during this event with 1,001 missing and 55,282 sustained physical and psychological injuries as a result of the disaster. Total damage is estimated to 2.3 billion US Dollars [3]. Total 3,319 people died in 12 affected districts, which is 97% of the total death reported as of 21 January 2008. Highest death toll was reported in Barguna district (1,335) followed by Bagerhat (810),
Patuakhali (457) and Pirojpur (400) [3]. The MoFDM Official report indicates that 1.75 million families were affected in 12 districts, which is also 84% of the total affected families in 30 districts. Over 564,967 houses are fully damaged and 957,110 houses are partially damaged. Bagerhat suffered the most in terms of fully damaged housing (118,899 houses, 22%), followed by Barguna (95,412), Jhalakathi (69685), Pirojpur (63,896) and Patuakhali (53,291) [3].
The extensive destruction and resulting social and economic losses are summarized in Table 1to 2 [3], Table 3 and Figure 3 to 5 [3].

Table 1: Summarized information on damage & loss (as of January 21, 2008)

Sl. No.	Item	Quantity (No./km)
1	Affected District	30
2	Most Affected District	12
3	Affected Upazila	200
4	Affected Union	1,950
5	Affected Households	2,064,026
6	Affected People	8,923,259
7	Crops Damaged (ha)	
	7.a Fully damaged (ha)	300,940
	7.b Partially damaged (ha)	700,533
8	Damaged Houses	
	8.a Fully damaged house	564,967
	8.b Partially damaged house	957,110
9	Death Toll	3,406
10	Injured persons	55,282
11	Missing persons	1,001
12	Dead livestock & poultry	1,873,694
13	Damaged Educational Institution	
	13.a Fully damaged (No.)	4,231
	13.b Partially damaged (No.)	12,723
14	Damaged roads (km)	
	14.a Fully damaged (km)	1,714
	14.b Partially damaged (km)	6,361
15	Damaged bridge/ culverts (No.)	1,850
16	Damaged embankment (km)	1,875
17	Damaged Trees (No.)	4,065,316

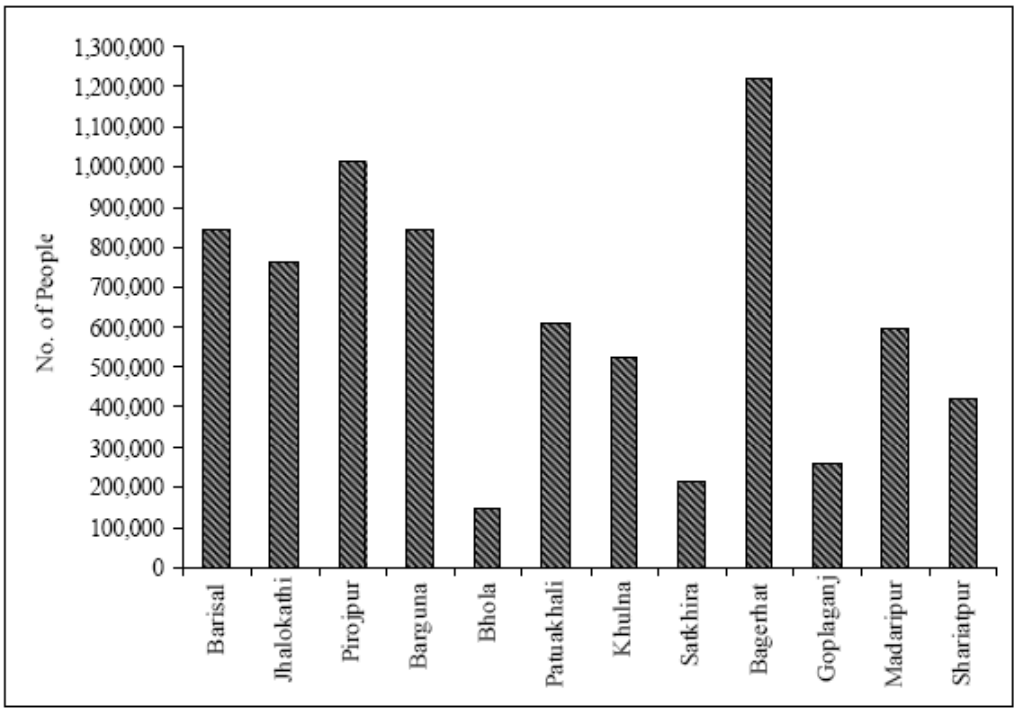


Figure 3: No. of people died at worst affected & badly affected districts

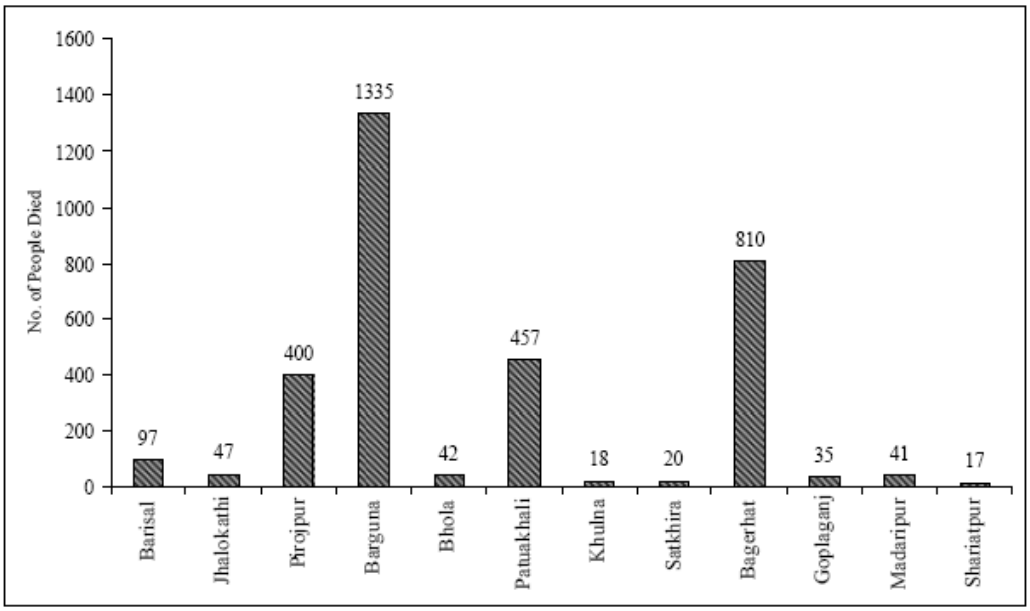


Figure 4: No. of people affected at worst affected & badly affected districts

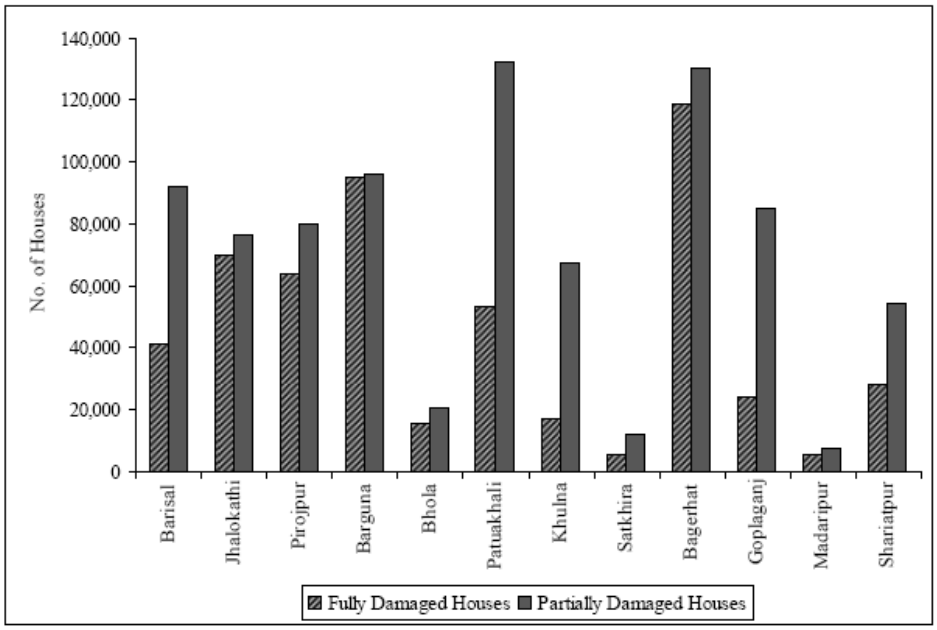


Figure 5: House damaged at worst affected & badly affected districts

Table 2: Information on damage and loss in Barguna and Patuakhali districts

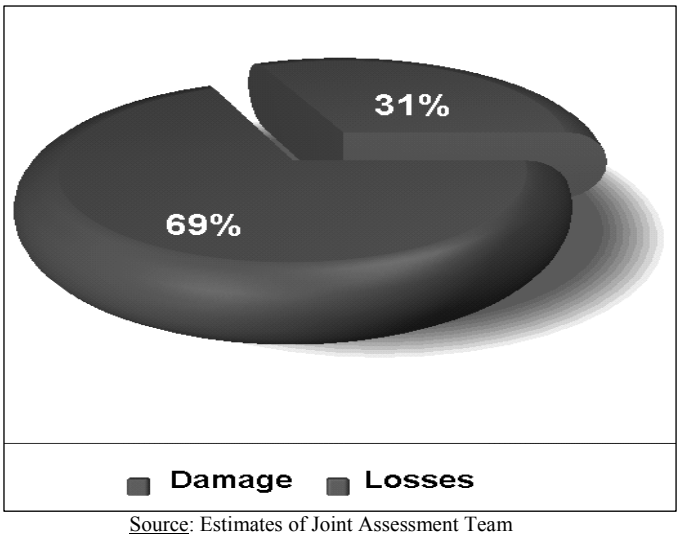
District	Affected Upazila	Affected Union	Affected Household	Affected Population	Damaged Crop (ha)		Damaged Houses (No.)		Death Toll	Injured People	Missing People	Livestock and Poultry	Damaged Institutions (No.)		Damaged Roads (km)		Damaged Trees
	(No.)	(No.)	(No.)	(No.)	Fully	Partially	Fully	Partially	(No.)	(No.)	(No.)	(No.)	Full	Partial	Full	Partial	(No.)
Barguna	5	42	217,270	843,669	92,066	33,685	95,412	96,245	1335	16,310	156	688,758	423	649	614	1,294	1,000,000
Patuakhali	7	72	252,300	611,125	24,470	103,172	53,291	132,369	457	8,500	221	17,184	351	1,022	0	838	175,000

(Source: Ministry of Food and Disaster Managemnet (MoFDM), Relief Control Cell (RCC): Updated on 21 January 2008)

Table 3: Damage and loss summary for Barguna and Patuakhali districts
(Information collected from field survey)

	Total Area (Affected) Sq. Km	**Total Population (Affected)**	**Dead (Injured)**	**Damaged Houses (Partial)**	**Shelters (Used)**
BARGUNA	1,831.31 (1,831.31)	942,083 (831,029)	1,345 (28,050)	77,754 (112,031)	181 (170)
PATUAKHALI	3,225.91 (2,845.49)	1,478,269 (996,470)	467 (11,719)	50,237 (97,000)	251 (180)
	Total Cattle (Death)	**Total Cropland (Full+Partiallly Damaged) ha**	**Total Carpeted Road (Full+Partiallly Damaged) Km**	**Total Embankment (Full+Partiallly Damaged) Km**	**Total Educational Institute (Full+Partiallly Damaged)**
BARGUNA	411,946 (30,499)	116,685 (96,715)	397.54 (330.38)	851 (484.68)	1,266 (1,235)
PATUAKHALI	899,460 (31,124)	220,692 (188,179.7)	781.41 (164.45)	762 (564.92)	1,630 (1,622)

A comprehensive analysis undertaken by a team of Bangladesh Government and international experts, using state of the art assessment methodologies, estimated the total damage and losses caused by the cyclone to be BDT 115.6 billion (equivalent to US$ 1.7 billion). The effects of Cyclone SIDR are equivalent to 2.8% of Bangladesh's GDP. The damage and losses were notably concentrated in the private sector, rather than in the public sector (Figure 6 and 7, Table 4) [2]. This has significant implications in the strategy that must be adopted for recovery and reconstruction.



Source: Estimates of Joint Assessment Team

Figure 6: Ownership of damage and losses

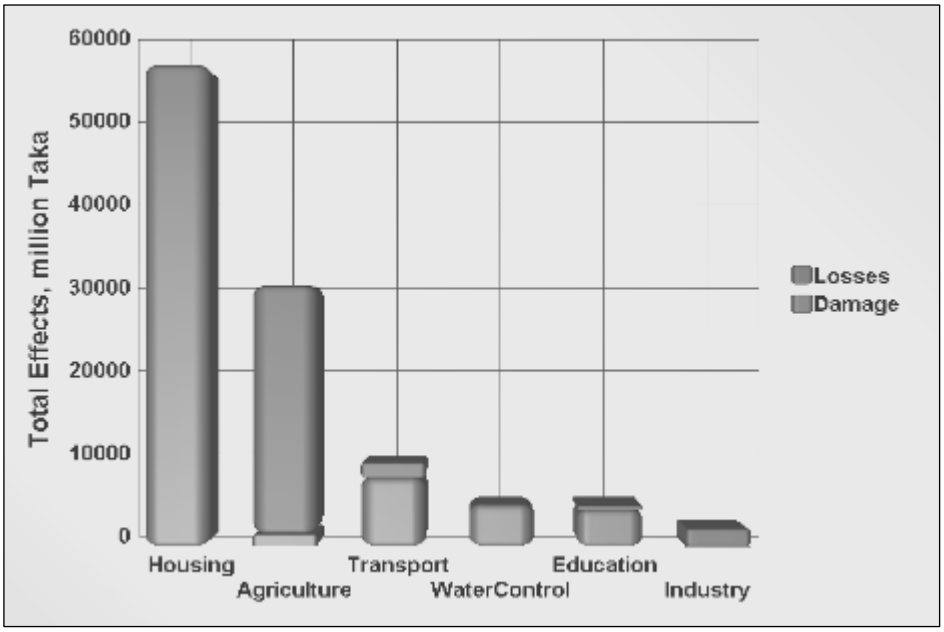


Figure 7: Damage and losses caused by cyclone SIDR in most affected sectors

Damage and losses were concentrated on the housing sector (57.9 BDT billion, or 50% of the total), productive sectors (33.8 billion or 30%), and on public sector infrastructure (17.5 billion or 16%). Most affected sectors were, in decreasing order,

housing, agriculture, transport, water control structures, education and industry (Figure and Table).

Table 4: Summary of damage and losses (BDT million)

		Disaster Effects			Ownership	
		Damage	Losses	Total	Public	Private
Social Sectors		**4,482**	**1,453**	**5,934**	**5,485**	**449**
	Health and Nutrition	169	1,038	1,206	1,188	18
	Education	4,313	415	4,728	4,297	431
Infrastructure		**71,064**	**2,130**	**73,194**	**15,758**	**57,436**
	Housing	57,915		57,915		57,915
	Transport	8,006	1,725	9,731	8,006	1,725
	Electricity	576	359	935	935	
	Water and Sanitation	157	46	203	203	
	Urban and Municipal	1,696		1,696	1,696	
	Water Resource	4,918		4,918	4,918	
Productive Sectors		**1,734**	**32,083**	**33,817**	**19**	**33,798**
	Agriculture	1,472	28,725	30,197	19	30,178
	Industry	262	2,035	2,297		2,297
	Commerce		1,258	1,258		1,258
	Tourism		65	65		65
Cross-Cutting Issues		**420**	**0**	**420**	**420**	**0**
	Environment	420		420	420	
TOTAL		**79,904**	**35,665**	**115,569**	**21,682**	**93,888**

Source: Estimates by Joint Assessment Team

The effects of the disaster were highly concentrated in the Districts of Bagherat, Borguna, Patuakhali, Pirojpur and Barisal, where – according to a 2005 survey of household data – poverty levels range between 35 to more than 50 per cent of the population (Figure 8). It is estimated that about 2 million persons have lost income and employment in the more affected Districts, and that they have seen their income for this year reduced to about a third of the average.

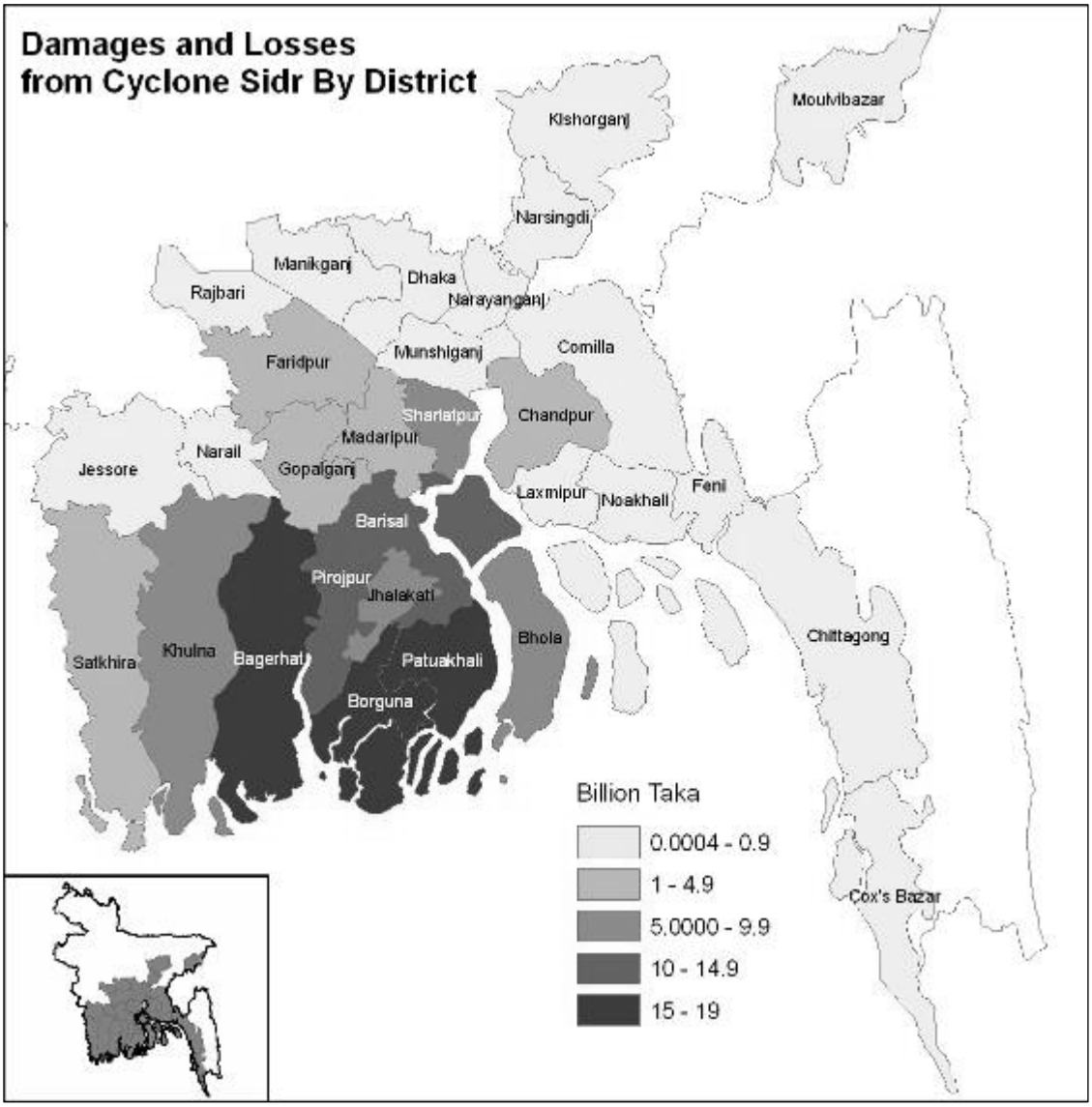


Figure 8: Most affected districts in damage and loss Terms [2]

SIDR MANAGEMENT BY THE ARMED FORCES DIVISION

Armed Forces Division (AFD) of Bangladesh played a significant role in SIDR Management. AFD involved its own workforce and logistics in damage assessment and relief and rehabilitation activities. They immediately launched a massive search and rescue and early relief operation as well as assisted in the burial of dead bodies and removal of debris and dead livestock.

The roles played by the AFD were basically as follows [1]:

- Maintaining the Standing Order for Disaster Management (SOD)
- Delineating the Role and Responsibility of Concerned Agencies
- Coordinating the Employment of Armed Forces
- Coordinating the Relief Work of Three Services
- Identifying the Worst Affected Areas and Setting Priority
- Monitoring Air Movement and Collecting Feedback

There is an established disaster management committee system of the Government of Bangladesh that involves the National Disaster Council from top to Union Disaster Management Committee at bottom. AFD followed the national response and recovery co-ordination system which has been described schematically in Figure 9 [1]:

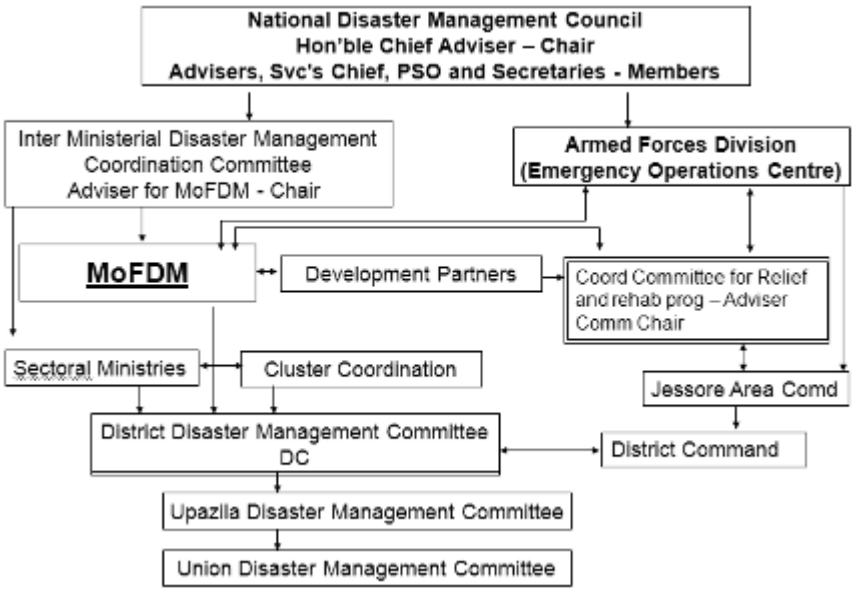


Figure 9: Response and recovery coordination of AFD

The Damage Statistics provided by AFD have been summarized in Table 5 to 7 [1]:

Table 5: Response and recovery coordination of AFD

DAMAGE STATISTICS	
Event	**No.**
Area	
Worst Affected Districts	08
Moderately Affected Districts	07
Less Affected Districts	15
Total Affected Districts	30
Affected Upazilas (Sub-Districts)	200
Affected Unions	1,880 **
Population	
Death Toll	3,406 *
Missing	873
Wounded	55,282
Affected People	8.9 Million
Affected Families	20,64026**
Shelter Less Population	1572495**
Properties	
Crops Damaged Area	2.47 Million Acres
Loss of Livestock	1.7 Million
Lost Boats And Trawler (Water Crafts)	137**
Infrastructure	
Roads/tracks	648 km (Completely)** 88,550km (Partially)**
Affected Educational Institution	16,954
Bridge/Culverts	1654**
Embankment	581 Km **
Estimated Damage (In Terms of Money)	**2.18 Billion USD**
Until 8 April 2008 * Until 31 January 2008 ** Until 28 December 2007	

Table 6: Comparison of damage

COMPARISON – CYCLONE 1991 AND SIDR 2007			
Sl. No.	Event	1991	2007
1.	Death Toll	1,38,882	3,406
2.	Missing	20,000	873
3.	Crops Damaged Area	0.35 Million Acres	2.4 Million Acres
4.	Areas Affected	15,000 Sq km	30 Districts

Table 7: Summary of damage assessment (in terms of money)

Ser	**Sector**	**Damage Assessment**		**Remarks**
		BDT *	**US $***	***Million**
1.	LGED	4622.774	67.00	
2.	WDB	4920.00	71.304	
3.	DPHE	186.418	2.701	
4.	BRDB	1688.713	24.474	
5.	BREB	358.571	5.197	
6.	Forest and Environment	10420.00	151.011	
7.	Education	4660.10	67.537	
8.	Health Service	1206.00	17.478	Death- 3406, Injured- 12979
9.	Agriculture	56906.00	824.724	
10.	Households	47390.55	686.819	
11.	Livestock	8892.53	128.877	
12.	Transport	9731	141.029	
Total		**150982.556***	**2188.153***	**2.188 Billion US $ (Approx)**

Notes: Until Feb 2008

1. Commerce, Tourism and Industrial sectors are not included in the calculation.
2. Calculation depends on updated data.

AFD listed the priority of most affected districts as follows and planned their further activities based on this list [1]:

- BORGUNA
- PATUAKHALI
- BAGERHAT

- PIROZPUR
- JHALAKATHI
- BARISAL
- BHOLA
- SHATKHIRA

For recovery and rehabilitation programs, AFD assessed the needs of the communities based on the severity of damage and losses and giving priority to most vulnerable groups. The entire supply coordination approach was considered in four stages (Figure 10) based on the needs of the essential and life saving material and services [1].

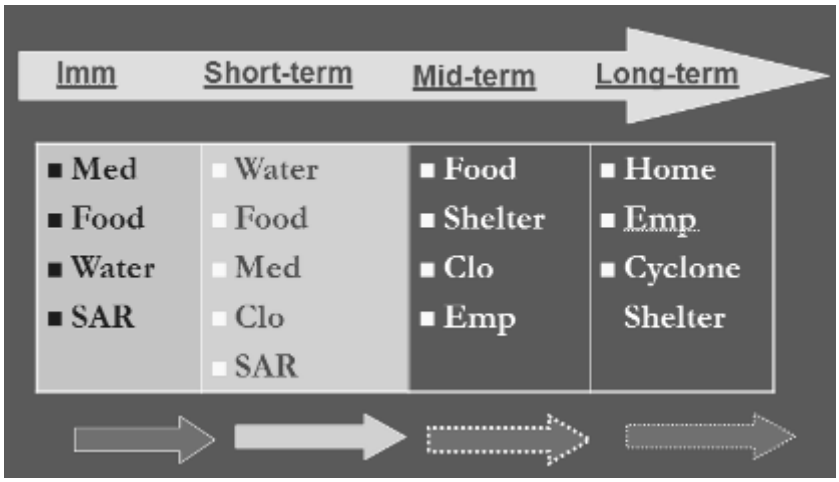


Figure 10: Need assessment flow

For smooth operation of emergency recovery and responses and post SIDR activities, AFD emphasized on the restoration of essential services in the affected areas. The efforts turned into quickest restoration of the services in the most affected areas which has been presented in Figure 11.

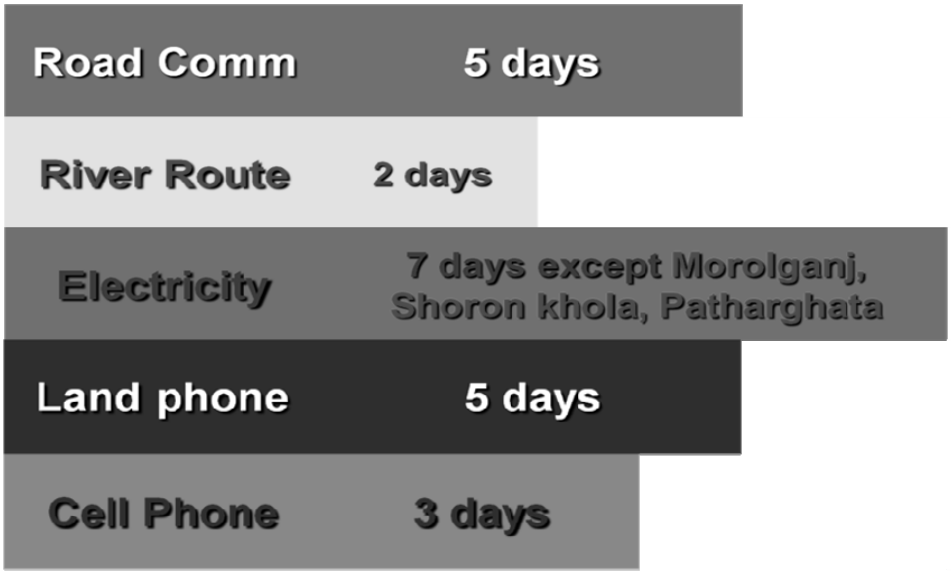


Figure 11: Restoration of services

For coordinating the relief works AFD worked together with the Coordination Committee of Government emergency responses. The Post-SIDR Relief Coordination Centre in Barisal was responsible for coordinating the national relief operations. It was operational since 17 November 2007. Its functions were to:

• Coordinate deployment of relief
• Coordinate volunteer efforts
• Coordinate information on relief transport (e.g., helipads)
• Ensure equitable allocation and distribution of relief material

Figure 12 shows the flow chart of the relief work.

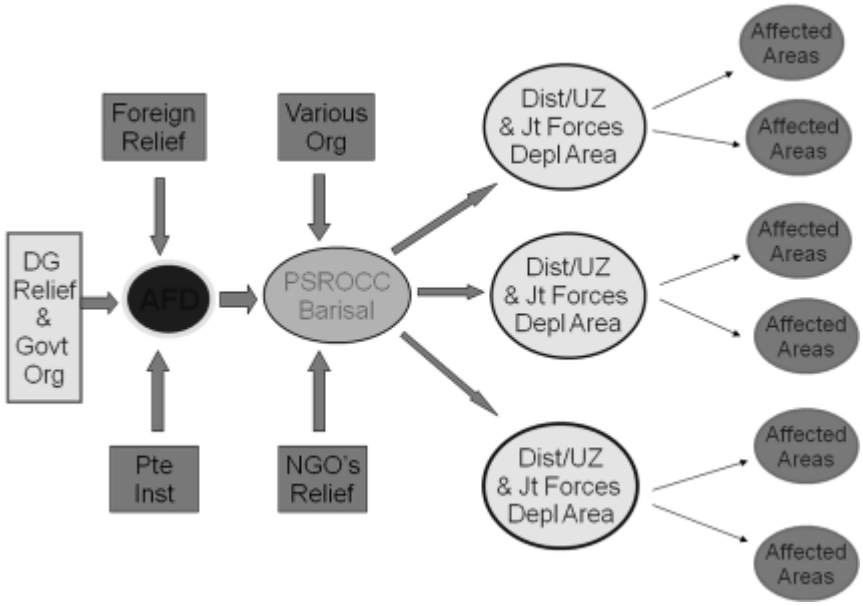


Figure 12: Relief work flow chart

The emergency relief work involved 1,000 Tons of supplies through Air Lift from 16 November 2007 to 12 December 2007 and 10,000 Tons through Sea Lift until 15 January 2008. Rehabilitation programs in different sectors were taken for the affected areas which involved short or mid term to long term supports. The Long Term rehabilitation plans involved:

- Rehabilitation of the people in their original homes
- Construction of Multipurpose Cyclone Shelters
- Rehabilitation for farmers and the fishermen
- Creating employment opportunities
- Reconstruction of embankments

The rehabilitation in terms of monetary efforts has been shown in Table 8.

Table 8: Rehabilitation Short/Mid/Long terms (monetary)

Ser	Sector	Short (3 – 6 Mon)		Mid (6-9 Mon)		Long (9-18 Mon)		G total	
		BDT M	US$ M	BDT M	US$ M	BDT M	US$ M	BDT M	US$ M
1.	LGED	4107.19	59.52	-	-	28150.00	407.980	32257.19	467.50
2.	WDB	8010.00	116.086	-	-	12590.00	182.463	20600.00	298.550
3.	Forest & Environment	-	-	-	-	11751.00	170.304	11751.00	170.304
4.	Health Service	-	-	-	-	946.496	13.717	946.496	13.717
5.	BREB	-	-	-	-	510.946	7.405	510.946	7.405
6.	BRDB	538.51	7.804	520.00	7.536	630.201	9.134	1688.711	24.474
7.	DPHE	-	-	-	-	1102.10	15.973	1102.100	15.972
8.	Education Engineering Directorate	359.400	5.2	-	-	5838.30	84.613	6197.70	89.813
	TOTAL	13015.1	188.61	520.00	7.536	61519.04	891.575	75056.13	1087.735

STANDING ORDERS OF DISASTER (SOD)

The Standing Orders have been prepared with the avowed objective of making the concerned persons understand their duties and responsibilities regarding disaster management at all levels, and accomplishing them. According to the SOD, all Ministries, Divisions/ Departments and Agencies shall prepare their own Action Plans in respect of their responsibilities under the Standing Orders for efficient implementation. The National Disaster Management Council (NDMC) and Inter-Ministerial Disaster Management Coordination Committee (IMDMCC) are responsible to ensure coordination of disaster related activities at the National level [4]. Coordination at district, Upazila and union levels are supposed to be done by the respective District, Upazila and Union Disaster Management Committees. The Disaster Management Bureau is responsible for rendering all assistance to them by facilitating the process.

The SOD suggests the Ministries, Divisions/Departments and Agencies to organize proper training of their officers and staff employed at District, Upazila, Union and village levels according to their own Action plans so that they can help in rescue, evacuation and relief work at different stages of a disaster. The local authority shall arrange preparedness for emergency steps to meet the disaster and to mitigate distress without waiting for government help. The Standing Orders shall be followed during Normal times, Precautionary and Warning stage, Disaster stage and Post-disaster stage. There are definitions of these terms in the SOD which are described as follows for better understanding:

(i) Disaster: An event, natural or man-made, sudden or progressive, that seriously disrupts the functioning of a society, causing human, material, or environmental

losses of such severity that the affected community has to respond by taking exceptional measures. The disruption (including essential services and means of livelihood) is on a scale that exceeds the ability of the affected society to cope with using only its own resources.

(ii) Disaster Management: Disaster management includes all aspects of planning of and responding to disasters. It refers to the management of both the risks and the consequences of disasters, and includes both prevention and preparedness measures taken in disaster-prone areas in anticipation of the known hazards – often referred to as "pre-disaster" and long-term rehabilitation (sometimes referred to as "reconstruction").

(iii) Normal Phase (Normal Time): A period when there is no immediate threat but long-term actions are required in anticipation of the impact, at some unknown time in the future, of known hazards.

(iv) Alert and Warning Phase: The period from the issuing of an alert or public warning of an imminent disaster threat to its actual impact, or the passage of the threat and the lifting of the warning. It is the period during which pre-impact precautionary, or disaster containment measures are taken.

(v) Disaster Phase: The period during which direct impact of a natural calamity is felt. Disaster phase is long in case of slow on-set disasters (draughts, normal monsoon flood) and short in case of rapid on-set disasters (flash flood, cyclone, earthquake, fire, industrial accident, landslide etc).

(vi) Recovery Phase: The period, following the emergency phase, during which actions are to be taken to enable victims to resume normal lives and means of livelihood, and to restore infrastructure, services and the economy in a manner appropriate to long-term needs and defined development objectives. Recovery encompasses both rehabilitation and reconstruction, and may include the continuation of certain relief (welfare) measures in favour of particular disadvantaged, vulnerable groups.

To collect and verify statistics relating to loss according to instructions issued by Disaster Management Bureau and other national authorities from Upazila officials and Upazila Disaster Management Committee and to determine priority and requirement through emergency survey by officials or any other competent persons.

STANDING ORDERS FOR CYCLONES

The Standing Orders for Cyclone (SOC) proclaimed by the Government of Bangladesh (GOB) as of November, 1985 and updated thereafter constitute the basic plan for coping with cyclone disasters. SOC laid down the guidelines for action at various stages of disaster by all government agencies to cope with situation arising out of cyclone havoc. Within the framework of SOC, concerned authorities are required to deal with unforeseen and complex situations swiftly using initiative and imagination. The local authorities are required to take necessary action to prevent or reduce loss or damage to life and property by making maximum use of local resources instead of waiting for external assistance. The guidelines for disaster preparedness and management under SOC are organized into 5 stages as follows [4]:

(a) Pre-Disaster Stage (Off-cyclone season)
(b) Alert Stage (Signal No. I, II and III)
(c) Warning Stage (Signal No. IV)
(d) Disaster Stage (Signal No. V, VI, VII and VIII, IX, X)
(e) Post-Disaster stage (Immediately after the cyclone till normalcy is attained)

INSTITUTIONAL ARRANGEMENT IN SOD

Being a disaster prone country, elaborate institutional arrangements are in place to deal with disasters, including cyclones. There are three committees and three institutions at the apex level namely National Disaster Management Council, headed by Prime Minister, Inter Ministerial Disaster Management Committee headed by Minister, Ministry of Food and Disaster Management (MoFDM), National Disaster Management Advisory Council, MoFDM, Disaster Management Bureau and Directorate of Relief and Rehabilitation. There are broad based Disaster Management Committees in the field levels at district, upazilla and union headed by deputy commissioner, upazilla nirbahi officer and chairman at respective areas.

However, the most dedicated agency for cyclone disaster information dissemination and mobilization at the coastal level is the Cyclone Preparedness Programme (CPP). The CPP is an organization of large contingent of volunteers at the field who carry out the important function of mobilizing people at the community level to cope with cyclones. In the mode of CPP, Bangladesh has evolved a model organization for cyclone warning dissemination in the coastal belt. The CPP is located in the Bangladesh Red Crescent Society (BDRC) under the MoFDM of the government. The CPP is staffed by a small number of permanent officers at the headquarter in Dhaka and 8 coastal districts and comprises of 44000 volunteers, organized in teams of ten, which undertake specified cyclone emergency preparedness and post impact tasks. The volunteers disseminate the warning signals, alert the people, evacuate them to safe places, rescue marooned people after the cyclone, provide the injured with first aid, report on the losses and damages after preliminary assessment within twelve hours of the cyclone, etc. Each CPP team is provided with warning equipments like transistor radio, megaphone, siren, signal light, first aid kit, etc. Teams are also provided with cycles for communication and signal flags for hoisting in poles in cyclone shelters and other points to communicate warning signals to people in the coastal area.

After the formation of a cyclonic storm in the Bay of Bengal, the Storm Warning Centre of BMD issues special weather bulletins from time to time till the landfall. The volunteers are provided with Depression Tracking Map and they receive instruction from the CPP Control Room in Dhaka over wireless to plot the track in the map as bulletins are received from BMD. The tasks of the volunteers include the arduous responsibility for wide dissemination of warnings by bicycle and foot and using megaphones and sirens, public address equipment, signal lights, signal flags, search and rescue, first aid treatment, evacuation and shelter, and welfare. Many communitites have significant number of illiterate population and they can be best reached through symbols. In Bangladesh, this is achieved through hosting of coloured flags. The warning flags are hoisted in port, cyclone shelters, public buildings, community centers, local government organizations in coastal area following warning by BMD to communicate impending cyclone. The CPP volunteers ensure hoisting of flags. One flag is hoisted for caution, two flags for danger and 3 flags for great danger. Such displays can serve as medium of warning dissemination and at the same time prepare the community for appropriate response which will in turn increase the effectiveness of warning.

SIDR MANAGEMENT IN THE SURVEYED AREAS

There are specified responsibilities for the different institutions under the Government at different stages of disasters, especially for cyclones, in the SOD. In this particular survey, the local government authorities in Barguna and Patuakhali districts were interviewed in the light of the responsibilities defined in SOD. The objective of such interviews was to assess the most recent cyclone management activities and to see how far the SOD is followed in the responsible institutions. On the other hand, there must be some difficulties or controversies along with suggestions regarding the SOD among the personnel involved. Therefore, to pick up some guidelines from practical field experiences for improvisation of the SOD was also another target of the survey.

The issues based on which the questionnaire survey was made and the information retrieved from the personnel has been listed in the following tables (Table 9 to 15).

Table 9: Interview of Deputy Commissioner

Issues	Patuakhali	Barguna
Normal Times		
Review the overall disaster preparedness level in the District every three months and try to remove the weaknesses	No such activity is ever performed or practiced	-do-
Identify (unprotected) important places, the highly risky cyclone/flood prone areas and prepare maps showing important places of the Upazila and Union, population, detailed preparedness facilities	There is no such activity. No population census made locally.	-do-
Form team of volunteers at Upazila, Union, Ward and Village level and ensure their responsibilities like publicity of signals, rescue, evacuation and relief operations etc.	These activities are performed by the CPP, BDRCS and few local NGOs	No activities are performed by the DC office regarding forming teams of Volunteers
Ensure effective training and orientation of the volunteers formed for cyclone preparedness programme drawn through CPP and other agencies	There is no such activity. Sometimes few NGOs provide such trainings	-do-
Ensure supply of related implements to the volunteers for improvement of communication for publicity of cyclone/flood warning signals.	There is no such activity	-do-
Ensure that all officials of different departments and agencies are aware of Standing Orders related to disaster.	There is no such activity	-do-

Issues	Patuakhali	Barguna
Arrange tree plantation at shelter places and proper maintenance of ponds, village roads, embankments and sluice gates	There is no such activity. Roads, embankments and other infrastructures are maintained by the respective authorities such as LGED, WDB etc.	-do-
Form District Disaster Management Committee in the light of government notification	District Disaster Management Committee is already formed and active in disaster management programs	-do-
Prepare local contingency plans for disaster response	There is no local contingency plan	-do-
Conduct mobilization drills in April and September every year to know the nature and effectiveness of preparedness	There is no such activity	-do-
Conduct population census in every newly formed chars and if possible encourage/assist people in constructing strong house. Otherwise, prepare plans for their evacuation to safer place	The approximate population is estimated in a newly formed char but there is no activity taken regarding housing or evacuation plan	Population is estimated approximately but evacuation is not planned. Again during a storm it is very tough to find any volunteers, risking their own lives for evacuating the people of char. During the landfall of SIDR the waterways linking the chars became very rough and those areas became totally inaccessible for evacuation
Keep ready updated list of important information like population, transport, water transport, food storage, stock of relief materials etc.	The lists are made always especially keeping a disaster preparedness program in mind but not updated	-do-
Keep cyclone/flood shelter and fortified earthen mounds fit for use and ensure availability of sufficient water.	Periodic repair works are done when funds are available but no regular maintenance is done for strengthening the shelters.	-do-

Issues	Patuakhali	Barguna
Prepare a list of buildings, schools, colleges, establishments etc. by conducting a regular survey annually so that people can use them during emergency as relief camp.	No regular annual survey is performed.	-do-
Ensure extensive publicity among people about cyclone/flood warning signals and their importance.	There is no such activity in normal times	DC office does not conduct such activities directly. CPP, BDRCS and NGOs have such programs, DC office assist them sometimes if needed
Encourage and ensure implementation of coastal afforestation programmes	Occasionally such activities are encouraged but there is no regular program if not instructed by the Government	-do-
Ensure preparation of Disaster Action Plan (contingency plan) by Upazila Disaster Management Committee and Upazila Nirbahi Officer	There is no such activity	
Conduct, with the assistance of DMB, orientation courses of all Upazila level officers and staff on preparedness for cyclone	There is no such activity	
Ensure calling of meetings now and then for proper formation of District Disaster Management Committee and evaluation of District Disaster Management Action Plans.	Generally meeting is called on emergency situations to instruct on emergency responses only	
Keep updated list of non-government agencies that are able to work on disaster management and coordinate their activities.	Yes	
Alert Stage		
Issue warning notice to all concerned for preparedness	Notice was issued immediately after getting information from BMD	1st signal issued 3 days before and notice was issued immediately
Ensure that the endangered people have been warned through wireless arrangement of police, BDR and CPP and other communication system.	The concerned agencies were instructed to do so	

Issues	Patuakhali	Barguna
Establish a Control Room and keep contact with the EOC at the Ministry of Food and Disaster Management and Divisional Control Room.	Control room was established in DC office building	Control room was established in the DC's conference room. 24 hr operated. Closed on 15th December
Warning Stage		
Call a meeting of the District Disaster Management Committee	yes	District meeting on preparedness activity held after #3 signal.
Instruct concerned agency to hoist appropriate warning signal at specified place.	yes	CPP and BDRCS were instructed to do so
Keep contact with the EOC at the Ministry of Food and Disaster Management, Divisional Control Room and the control room at the concerned Upazila headquarters.	yes	yes
Arrange wide publicity of cyclone danger/great danger signal among people of the area and ensure that the disaster signals are received by people of disaster prone areas	Miking was held among the communities. Local volunteers from BDRCS mainly conducted the publicity	Miking was held on 14th. Local representatives disseminated miking. Information. But it was not possible to announce everywhere especially in few inaccessible and remote areas. The previous Tsunami warning misled people. Evacuation order was issued on 14th. In some places shelters are scarce. CPP BDRCS acted as volunteers but local admin was more relied on for voluntary services. Warning flags were lifted at remote areas like Nishanbaria, Patharghata, and all places chosen by BDRCS, CPP
Disaster Stage		
Gather all necessary materials (manpower, transports, water	Necessary materials were gathered as much	On the 14th evening DC went to visit the

Issues	Patuakhali	Barguna
transport, equipment and relief materials) and send to disaster affected area	as possible. But there was only one rescue boat which was not sufficient to cover the affected areas. The allotment of carrying cost is insufficient	areas. There was some storage of dry food. Transport was speed boat, rescue boat (large enough, 10MT capacity). But fuel price is high. So it becomes tough to continue operation in all areas
Arrange requisition of necessary transports and water transports through appropriate authority	Requisition is not possible always as there are not enough water transports	On the 15th November night, flood started at 11pm. At 7.30 pm telecom disrupted. No wireless was in DC office. Communication was maintained by staffs through landlines.
Ensure supply of drinking water to disaster affected areas	No such activity conducted at the disaster stage. Only drinking water supply was ensured in few Shelters	
Call emergency meeting of District Disaster Management Committee.	yes	After getting #3 signal meeting was called
After receipt of evacuation order, ensure evacuation of people and materials through volunteers	Volunteers and Police force were involved in evacuation. People did not believe the warning and did not want to leave their houses. The police forced the people in some places	
Rehabilitation Stage		
Visit affected areas on emergency basis, arrange for appropriate survey to determine loss/damage and necessity for help/assistance.	Visit was made on the next morning	On the 16th morning DC visited the areas. Initial damage assessment, rescue work done. Telecom of police super, DC reinstalled first. On the 16th morning team went with stored dry food. Transport was

Issues	Patuakhali	Barguna
		speedboat.
Send a report of loss and damage in prescribed form and request for help and assistance.	Survey was performed in prescribed forms. But since Surveyors are mainly chaukidars (local guards) assigned by the members of the union, the damage assessment might not be reliable. Duplication with other agencies were avoided through coordination	Damage Assessment was performed through the teams appointed by the union parishads and other respective agencies like LGED, WDB etc.
Establish relief centers at appropriate places and operate them	Initially relief work was not very much planned. Reliefs were distributed by visiting the affected areas. NGOs helped a lot but sometimes they were partial to their people	
Conduct rescue operation of stranded or affected people in the islands	No govt. volunteers were involved in such operations	
Conduct emergency and normal medical services and supply of food and drinking water.	1 doctor+ 1 medical team were appointed for each union. Foods were supplied by DC office, NGOs. Purification tablets were also supplied.	Public Health Engg, AFD, Save the Children, American force served bottled water, packet water. Continued up to 4 months Purifier tablet was served immediately. Program finished in April. 58 medical teams came on 18th for 42 unions. Local teams also worked. German team and NGOs also worked
Arrange for the repair of damaged tube-wells and sinking of new tube-wells. Arrange for making the pond water suitable for use for drinking purpose.	Most of the tube wells were ok	Number of tube wells is not more. Normally municipality supply, PSF, deep tube wells are sources of drinking water

Issues	Patuakhali	Barguna
Arrange assistance for repairing of residential houses of affected people and temporary shelters for them	Money was provided for repairing/building houses through AFD and Chairman – 5000 tk/house	Money was provided
Take steps for burial of dead human bodies and carcasses and ensure prevention of epidemics	Dead bodies of Human and Animals were buried with the help of local agencies, volunteers	From 17th, govt officers from DC office, fire brigade, local people, volunteers, ansars worked for removing wastes and debris and burial of dead bodies of human & animal. One officer from DC office was involved. Continued for 3 days.
Render essential services through appropriate steps	The fallen trees were removed early as it was announced that those who will remove a tree will be owner of that.	People were ordered to remove trees with their own responsibilities. Restoration was possible within 3 weeks
Arrange for repair of roads, culverts, bridges etc and for their rehabilitation, if necessary.	AFD played a significant role here	On 17th foreign NGO help started. When help from outside was available, the restoration process accelerated
Prepare appropriate rehabilitation programmes in coordination with housing, agriculture and livestock officers and take steps for their quick approval and implement rehabilitation programmes quickly.	Rehabilitation programmes prepared and sent to the higher authority for approval	After SIDR, workshop, trainings held with the help of DMC members, scout, BNCC, rover scout, DMB. Sharing Knowledge started. Plans have been proposed for Reserve fund, vehicle for quick response, high frequency telecom (wireless). Education- rehabili-taion program proposed in ministry.

Issues	Patuakhali	Barguna
Take steps for drawing out polluted saline water from areas inside roads and embankments.		
Coordinate activities of non-government agencies engaged in rehabilitation work	yes	yes

Table 10: Interview of District Relief and Rehabilitation Officers (DRRO)

Issues	Patuakhali and Barguna
Normal Times	
Were materials and implements of relief preserved and their fitness assured?	In normal times there is no activity regarding relief materials or implements.
Were Upazila and Union Disaster Management Committees (DMC) formed and trainings arranged for them?	No trainings were arranged due to lack of fund
Alert and Warning Stage	
Where was control room arranged?	Control room was arranged in the office of Deputy Commissioner.
Were the DC and TNO informed of the condition of the areas likely to be affected by disaster?	The information on the probable vulnerable areas is provided by the central authorities through the weather bulletin. No other activities are performed locally to identify vulnerable areas.
What kinds of activities were performed for strengthening the stock of relief materials and to transfer the materials of the store houses likely to be affected to safer places?	Some local grocery shops were contacted and dry foods were bought from them immediately to stock as relief material. No proposal was submitted to Relief and Rehabilitation Department regarding this issue
How the coordination of the Voluntary and other agencies at the District and Upazila levels were assisted?	Voluntary and other agencies have to report on their activities in DC office and they are assisted according to their needs.
Was there any provision to keep vigilance on the security of water transports engaged in relief work or to inspect the identified relief centers and send reports to DMB?	The water transports are kept on the compounds of respective authorities. But in normal times relief centers are neither inspected nor any reports prepared.
Disaster Stage	
When the arrangement for sending the relief materials to destinations was finalized?	The relief materials were sent on the day after the storm, that is on 16th November morning

Issues	Patuakhali and Barguna
What was the role in rescue operations?	The activities of DMC were merged with the DC office. Trees, wastes and dead bodies were removed from the roads to establish the transport network. Local teams were organized and sent to the affected areas for rescue operation.
Was the primary assessment of loss of lives and properties done and report sent to TNO and DC?	Loss and Damage assessment was performed under the supervision of DC office.
Is there any routine chart on distribution, supervision and monitoring of relief materials according to approval?	The accounts are kept on the distribution of relief material.
Rehabilitation Stage	
Was any detailed report of loss and damage sent to DC, Relief and Rehabilitation Department and DMB?	Loss and Damage assessment was performed under the supervision of DC office and sent to the DMB.
When the disbursement of house building grant, gratuitous fund and other relief materials to the affected people were made?	
Was any report of relief and rehabilitation activities sent to Relief and Rehabilitation Department?	Reports are sent from the DC office.
Was any evaluation accounts of relief activities kept ready for audit?	NO
Was disaster affected people were employed through test relief?	Not initially

Table 11: Interview of field offices of Executive Engineer of the Bangladesh Water Development Board

Issues	Patuakhali	Barguna
Normal Times		
Construct embankment in disaster prone coasts and islands according to designs approved by the government.	Embankments are constructed according to the availability of fund.	-do-
Monitor continuously the condition of the embankment and repair the breaches and weak points in adequate manner	Monitoring and small repair works are done regularly especially in the disaster season	-do-
Was special weather bulletins/news collected and all concerned at field level informed and directed for security steps in embankments and	yes	yes

Issues	Patuakhali	Barguna
other installations?		
Was any meeting called by local Disaster Management Committee? Who attended the meeting?	Yes. Executive Engr attended.	Yes.
Was any Liaison Officer appointed by The Chief Engineer at field level for communicating with the local Disaster Management Committee?	No	No
Coordinate and cooperate with civil administration for rescue, evacuation and relief operations and make available implements, materials, transports and technical assistance to them.	Not enough workforces to be involved in rescue, relief and evacuation operations. Only supports can be provided by water transport	Speed boats are provided on demand, but the number is not sufficient
Was there any effort to repair leakage, breaches, holes, weak points in the embankment in the area before disaster season?	Through Yearly Watch	Depends on Fund. In 2006-2007 5 miles' repair work carried out in Mirzagonj
Are the materials kept ready at suitable place for repair purpose?	All the required materials are not available. Only sand sacks are kept ready some times	
Are guards appointed for protecting the polders?	There is a Committee including local admin and beneficiaries to ensure the security, but local musclemen dominate	No
How many protecting embankments are constructed this year?		Funding couldn't be managed
Are reports submitted at regular intervals to higher authority stating the condition of sluice gate, embankment and other works and progress of repair and reconstruction? How often reports are submitted?	Yearly reports are provided	
Alert and Warning Stage		
What type of precautionary steps were taken for protection of the lives of the employees of Water Development Board and secure Board assets, machinery, transports etc?	No	No
How link was maintained with the local Disaster Management	Coordination maintained through	Coordination maintained through

Issues	Patuakhali	Barguna
Committee and other agencies?	DC office	DC office
Was there any activity performed for emergency construction of physical infrastructure and repair and maintenance?	No	No
Disaster Stage		
How long the information centre was operated and was any liaison officer sent to the local Disaster Management Committee?	No information center	No information center
Were the information centre of Bangladesh Water Development Board and Control Room of the local administration informed about the disaster?	Control Room was operated in DC office	Control Room was operated in DC office
How the local administration was assisted for rescue, evacuation and relief activities?	Through providing logistic support	
Was there any requirement identified to repair any damage, unserviceable installations and supply source by organizing technical persons and materials?	No	No
After how long of the disaster the damage/loss was assessed?	Damage Assessment started on 16th	Damage Assessment started on 17th
When the action plan for repair, reconstruction and reinstallation was initiated for short term?	After completion of damage assessment	After completion of damage assessment and restoration of essential services
What preventive actions were taken on emergency basis through tours in the affected area?	There were no sufficient funds or logistics to take any preventive measure in disaster stage	-do-
Was there case of any difficulty or any exceptional circumstances, the solution of which is beyond the control of own office and needed request the local civil administration or Disaster Management Committee to help?		
Rehabilitation Stage		
Is the loss/damage assessed? Are plan and designs prepared for repair, reinstallation and reconstruction of physical infrastructure, embankments, and sluice gates at required places? After how many days of disaster,	Damage Assessment done. Detailed plans and requirements have been submitted for approval. After 3 or 4 days of disaster, planning started	Detailed plans and requirements have been submitted for approval. After a week of disaster, new planning started People died where

Issues	Patuakhali	Barguna
the planning has been started?		embankment failed. In reality Earthen embankments are constructed 2/3 ft lower than design height. So raising embankment might be needed. Proper maintenance can be a solution
What was the role in assisting and cooperating the civil administration in relief activities?	Logistics Support was provided	Logistics Support was provided
Are places for the construction of embankments as protective measures against future disasters have been identified? Are the plans and request for approval and sanction of funds from the concerned authorities prepared?	DPP submitted for 110 crore in planning commission	DPP submitted

Table 12: Interview of Upazila Nirbahi Officer

Issues	Patuakhali	Barguna
Normal Times		
Ensure formation of Upazila Disaster Management Committee according to government notification.	Yes	Yes
Ensure formation of Union Disaster Management Committee according to government notification.	Yes	Yes
Ensure constitution of team of volunteers at upazila/union/ward and village level for publicity of cautionary signals and rescue, evacuation to shelters/safe places and relief operations.	No.	No. CPP and BDRCS are responsible
Ensure cooperation with CPP for making warning signals fruitful through volunteers and orienting them with the situations.	No direct coordination with CPP at normal times	-do-
Ensure appropriate publicity of cyclone warning signals	No such activity at Normal times	No such activity at Normal times

Issues	Patuakhali	Barguna
through volunteers.		
Ensure awareness of concerned people of different departments about Standing Orders on Disaster related issues and encourage them to perform tasks in the light of these orders.	Concerned people know about SOD but not followed always	
Ensure appropriate maintenance of embankments of the Bangladesh Water Development Board and their raising at level higher than flood level for use as safe shelter places	WDB is assisted if required	-do-
Ensure implementation of coastal afforestation programme		
Maintain lists and maps of those areas which are generally affected by cyclone/floods.	Not done at normal times	Not done at normal times
Prepare Upazila Disaster Action Plans consistent with the Standing Orders on issues like warnings, shelters, rescue, health care, evacuation, relief and rehabilitation, security and law and order etc and ensure their implementation at union level.	No	No
Ensure cyclone rehearsals and drills in April and September every year so that people concerned can implement the preparedness plans after proper training.	No	No
Undertake survey of new settlements and ensure disaster preparedness of the people living there.	No	No
Arrange construction of fortified earthen mounds, helipads and cyclone shelters at necessary places especially like char areas and keep them effective.	Cyclone Shelters are constructed if fund available	-do-

Issues	Patuakhali	Barguna
Maintain list of all those voluntary organizations which will be called upon to participate in emergency and relief works during pre-disaster, disaster and post-disaster periods and keep coordination with various agencies.	Lists are maintained	-do-
Maintain list of manpower and transports which can be used in emergency work.	Not done at Normal Times	Not done at Normal Times
Ensure stocks of food, medicines, insecticides and tube-wells before flood/cyclone season.	Food stocks are preserved if there is any alert or warning	No such activity at Normal Times
Ensure operation of Upazila Control Room with the cooperation of wireless facilities	Upazila Control Room is operated but basically DC office maintains control room	Control room was operated in DC office
Ensure appropriate repair and maintenance of community centres, cyclone shelters and fortified earthen mounds.	Repair and Maintenance depends on Fund. Sufficient fund is not available	-do-
Ensure stock of warning signal flags at Upazila/Union Office/CPP units	Yes	Yes
Implement the orders of Deputy Commissioner about cyclone preparedness	Yes	Yes
After examining the condition of embankments submit proposals for repair, if necessary	Proposals are submitted but Fund is not sufficient	-do-
Take steps for popularising by publicity through cinema shows, leaflets and posters distribution and programmes regarding cyclone warning signals and preparedness programmes.	No	No
Identify and select places in cooperation with Union Parishad Chairmen/CPP, Union team leader for taking shelter by people in flood and tidal bore.	No	No
Alert and Warning Stage		
Operate the Control Room	Control Room operated	

Issues	Patuakhali	Barguna
round the clock (24 hrs). One gazetted officer/one member of Upazila Disaster Management Committee will be in charge of Control Room.		
Keep manpower and transport ready for immediate movement.	yes	yes
Send warning signals to Unions through special messenger/telephone and alert Union Parishad Chairmen.	Yes	yes
Caution people by establishing quick communication in char areas.		Messengers are sent to the char areas for warning dissemination in initial stages
Keep link with the District Control Room.	Yes	yes
Advise for opening of the Union Control Room.	Union level control room is not always possible	
Call emergency meeting of the Upazila Disaster Management Committee.	Meeting was held including DC, UNO, Union Parishad Chairman, DMC. Instructed for miking. Handmiking and announcements in mosques held. Police was enforced	Meeting held
Ensure hoisting of warning signals at all warning centres.	Warning signals are hoisted basically by BDRCS and CPP	-do-
Disaster Stage		
Ensure publicity of danger and great danger signals to the people through volunteers of CPP and other officials and NGO workers.	Yes	yes
Arrange evacuation of human beings and livestock to safer places. Arrange for supply of food and clothing etc.	Evacuation order was announced. But previous Tsunami warning misled people. Police was enforce to compel people to leave their houses and got to shelters. Supply of dry	Evacuation order was announced. In some places Police forced people to go to shelters

Issues	Patuakhali	Barguna
	food was ensured. Local shopkeepers were instructed not to sell groceries.	
Arrange special messengers to warn the population and advice to wrap up drinking water, safety match, dry food, green coconut and utensils etc with plastic sheet and stock them under earth.	Only evacuation and caution instructions were disseminated	
Requisition transports, water transports etc for rescue and relief operations. In addition to this request Deputy Commissioner for supply of required type of transports, if necessary.	Yes	yes
Rehabilitation Stage		
Arrange for rapid survey of the affected areas and determine the extent of loss/damage	Rapid damage assessment was performed and the DC was informed	Damage Assessment performed
Arrange for quick moving water transports for rescue operations.	Speedboats were arranged	-do-
Arrange emergency expenditure for relief work from Upazila Development Fund.	Yes. This fund was fully utilized in relief works	yes
Send emergency relief materials to affected Unions.	Immediately rice-dal (peas)-match provided from TNO fund. The shops were instructed not to sell goods. 15 Nov morning 10 am meeting held at DC office. Then TNO himself went with speed boat and bought some goods. Dry food. Within 2/3 days outside help came. Lots of grants came.	Dry foods were sent immediately as much as possible. But the whole area was so much affected that real relief work could not be started until the help from outside came
Arrange for supply of sufficient number of tube-wells in affected areas.	Flood did not remain longer, maximum tube wells remained functional	The water supply is not dependent on tube wells here
Arrange necessary steps	Union medical team	The supply of pure drinking

Issues	Patuakhali	Barguna
relating to health	had purified tablets, worked through civil surgeon.	water, food, primary medical supplies, tents and etc. could be ensured after getting help from outside
Divide affected areas into relief regions and declare. For the purpose of conducting relief work entrust the work of the region to one officer.	Good co-ordination. Local govt. assessed the need and directed the relief as per need within 24 hrs. Distribution Principle- population, area damage. Food, cloths, moshari, blanket, house building expenses etc. were sent. Limitations- govt fund, relief transport & handling cost lacking.	yes
Prevent mismanagement in relief work. Ensure quick distribution of relief materials, house building fund, cash relief and house building grant. Ensure proper management of emergency hospitals, relief centres and gruel kitchens etc.	As this year admin had freedom to work, relief to chairman, management was satisfactory.	
Arrange for the burial of dead bodies and dumping of carcasses under earth	For burying animals there were payments	Burial of dead bodies were performed in cooperation with local administration, NGO, Volunteers Army, Police, Ansars etc.
Submit proposals for necessary demand, through appropriate authority, for various grant, loan and relief materials for undertaking relief operations.	Proposals submitted for New shelters, embankments	Proposals submitted
Coordinate relief activities of voluntary and non-government agencies.	Coordination with NGOs were maintained	Coordination with NGOs were maintained
Arrange for the rehabilitation of people of the affected areas through Test Relief/Food for Works Programme/VGF etc and ensure successful implementation of these programmes.		People were not interested in Food for Work programs, rather they liked to get reliefs

Table 13: Interview of field level CPP
(No CPP office exist in Patuakhali Sadar)

Issues	Barguna
Normal Times	
Yearly Simulated Drill	No
Yearly monitoring of Simulated Drill (Apr & Sep)	No
Volunteers' Training before April	Trainings are conducted at regular intervals, nothing conducted especially before April
Grouping of families for evacuation planning	No specific plan, there are teams responsible for specific areas
Physical verification of equipment to facilitate volunteers	There are Megaphone, Radio, Flag, Hand Siren. But the equipments are very old.
Examine the wireless system and keep it running	The wireless system is not satisfactory
Educate and create awareness amongst the local people	The teams work with local people for awareness raising
Earmark shelter places, Killas and safe raised land to keep them fit for use and to publicise the people about the evacuation plan	No such activity
Make the people and the volunteers aware of the dangers	Through regular training works
Alert Stage	
Set up Control Room and maintain contact	Control Room at CPP office, operated more than 7 days
Maintain close link with the Meteorological Department	Information received regularly through HQ
Receive special weather bulletins from CPP Headquarters	Yes
Alert different local authorities and organizations	No significant works with the authorities
Advise the CPP volunteers to listening to radio broadcasts	Yes
Warning Stage	
Was the DC/TNO/UP Chairman requested to call emergency meeting of the respective Disaster Management Committee	At #4 signal, meeting was called and plan made
How CPP assisted in the implementation of the decisions taken in the emergency meeting	CPP assisted through the volunteer activities
Were the CPP volunteers deputed for shifting the livestock, poultry and other domestic animals to raised land, Killas? In Which stage of Warning?	CPP volunteers started their activity after getting instruction from HQ
When the people were warned about the disaster?	After #4 signal, Flags were raised at unit offices, bazar, schools. Warning dissemination was community based, not house to house
When the people were advised to go to shelter place? When the evacuation order was received? To what extent	After getting #10 signal. All the CPP volunteers were devoted

Issues	Barguna
people were assisted in the process?	and dared to take life risks to assist the people
When the final warning using megaphone, light signals and flash lights was given and to which areas?	After #10 signal. Megaphone could not be used, batteries unavailable. Super Megaphone needed. Lacking in equipments, flags, dress. No hand siren (needed in windy weather). Only mic was used. On 14th people came to shelter Cyclone did not come, many people went back and did not return on 15th
How often the Upazila and District administration, CPP Central Headquarters and DMB and others concerned were kept informed about the field level disaster situation report? How the situation report were prepared and sent?	Within one hour of getting any instruction
Which other agencies and NGOs were assisted in the implementation of their programmes and to what extent?	Co-ordination were maintained with the NGOs.
Disaster Stage	
Were the wirelesses in operation? Who maintained communication with CPP Central Office?	Wireless were active, but the equipments are old, problematic Not very much effective in worst conditions. One Staff in the office maintained communication
How the loss and damage statement was received and sent to concerned authority (whom)?	The teams participated in gross loss and damage assessment and sent to HQ and DC office
To what extent volunteers participated in rescue work and first aid and how/with whom the activities were coordinated?	Teams assisted the local administration in rescue works and first aids.
How and which of the local authorities were assisted in relief distribution?	Local authorities were assisted in relief distribution
Rehabilitation Stage	
Were data on loss and damage due to cyclone collected, and report sent to CPP HQ, UDMC, Upazila and District administration? Within how many days after disaster?	From 16th November assessment started and upto 7 days full reports were sent
What was the role in assisting local administration in burying the dead bodies and dumping the carcasses under the earth? How many volunteers participated?	Participated in burial of dead bodies and removal of debris
What was the role in assisting in inoculation-vaccination drive and other health measures?	No
Did volunteers participate in the rehabilitation programme with NGOs and other agencies?	Co-ordination with NGOs One unit, 15 members, 10 male, 5 female

Table 14: Interview of Bangladesh Red Crescent Society

Issues	Patuakhali	Barguna
Normal Times		
How BDRCS takes steps for disaster preparedness at all the levels and prepare plans?	Training, Awareness Programs, Mock Drill, First Aid Training, in selected schools and colleges	Vilage committee, to lessen damage awareness build-up, signal explanation. For awareness, training, workshop, gathering, how to work in disaster, how to respond, prepare
How many teams of volunteers are engaged in the area and how often their trainings are arranged?	15 member executive team. Volunteer teams School n College. Almost 1800 volunteers in the district. Not very often, at the convenience of the institute	13 HS, 2 Colleges, life member 700, women's forum 11 member committee 50/55 members
Do any educational and awareness raising programmes are taken for the people to combat disaster? What are they?	Not for general people. School/College students, teachers and guardians participate. No awareness program in mass level	First aid, health, search and rescue, missing people tracking
How often seminars, workshops and meetings for earning special efficiency and skill in disaster management are arranged?	No plan for seminar before SIDR. No, planning depends on HQ	
Which concerned bodies (e.g. Ministry/Department/office/Agency interested in disaster/relief work, United Nation Organizations and non-government organizations) are kept in contact?	DC, Pouroshova, BDRCS, local govt	Ministries- defense, health, social welfare, disaster management, education. Local admin, NGO 9to avoid overlapping), social and political leaders
How road communication for stocking and receipt of relief materials are ensured and water transports maintained?	No stock for normal times	Buffer stock for natural and manmade disaster Self water transport Cyclone shelter construction
Do BDRCS participate in the construction work of fortified earthen mound and flood shelter, cyclone shelter and linking them with various socio-economic and	No social development works	

Issues	Patuakhali	Barguna
social development programmes?		
What other steps are taken in connection with preparedness programme of the people to meet any emergency situation?	No	
Alert Stage		
When the warning notice was issued to all concerned including the CPP and relevant Red Crescent Unit?	From initial stage. After #4 signal	After #4 signal
How warning signals were disseminated?	Supply info in newspaper, inform other volunteers of branch offices about alert/warning. No participation in dissemination	Through volunteers
How contact with CPP and the Control Room of Storm Warning Centre (SWC) BMD was kept?	No mobile network, only AKTEL. After 9 pm no network	No mobile network
Who maintained link with the EOC at the Ministry of DMR and the Control Room of DMB?	Relief Dept., CPP, HQ, SWC	HQ
When instructions were issued to Survey Assessment Team to be on standby?	No such activity at alert stage, the volunteers are informed about warning dissemination only	-do-
What other steps were taken?	Be alert, spot affected areas	
Warning Stage		
How long the Control Room was operated?	No separate control room	24 hours
To whom officials warning signals were disseminated?	DC, branch offices, BIWTA office, Save the Children, Islamic Foundation. DC called meeting. Associated with DC	Local administration and NGOs
How the efficiency of CPP activities at field level was ensured?	No coordination	No coordination
How liaison with the EOC at the Ministry of Food and Disaster Management was maintained?	Headquarter maintained these communications	Through Headquarter

Issues	Patuakhali	Barguna
What was the preparation of the Survey and Relief Team of Headquarters?	No preparation at warning stage	-do-
Was there any meeting held with the CPP Implementation Board?	No	Yes
Were any employees, volunteers and materials sent to disaster affected areas from less disaster prone areas?	The volunteers were distributed on the basis of needs and severity of the affected community	Yes, in some cases
How the danger/great danger signal was explained during dissemination to all concerned?	House to house. No miking held by the volunteers, no leaflet, Not explained	Miking held
How BDRCS participated in evacuation?	Volunteers went house to house	Volunteers went house to house
Disaster Stage		
Did BDRCS performed any survey of loss and damage in affected areas	Damage Assessment for relief cards only	Participated in damage assessments
What was the role in dispatch of relief/medical teams?	Single Medical team, No first aid	
How the local authority was assisted to determine loss and damage and requirement and supply information?	Damage assessment started from 17th and Relief work started from 20th , BDRCS participated actively	The local admin was assisted in the loss and damage and need assessments
What type of emergency assistance was provided to the affected people, especially in the following cases. (i) Help in rescue and evacuation work. (ii) Assist the local administration in organising shelter places. (iii) Give first aid to injured persons. (iv) Arrange complementary food according to the need of distressed people. (v) Arrange preventive and limited curative treatment. (vi) Arrange for the necessary household materials and clothing to be dispatched to the seriously affected people.	The local unit not well equipped and sufficiently funded. Volunteers participated in rescue works and relief works mainly	Volunteers participated in rescue works and relief works mainly

Issues	Patuakhali	Barguna
Was appropriate authority informed about the specific requirement of affected people of that particular area?	Basically HQ was informed	
Was any request sent for requirement of relief and rehabilitation operation after informing about loss and damage due to disaster to the International Federation of Red Cross and Red Crescent Societies (IFRCS)	Information was sent through HQ	
Rehabilitation Stage		
Did BDRCS participate in reconstruction and rehabilitation programmes and to what extent?	Participated in Reconstruction, British Red-Cross & local chairman involved	Participated in Reconstruction
What steps were taken for correct and effective evaluation of preparedness work and for correcting errors/weakness in such work?	Nothing mentionable	
How BDRCS is associated with the National Disaster Management Council (NDMC) and the Ministry of Disaster Management and Relief in the preparation of list of disaster affected people and the requirement and probability of rehabilitation?	BDRCS sends its reports and recommendations	

Table 15: Interview of field offices of Executive Engineer of the Local Government Engineering Department (LGED), Bangladesh

(Role of LGED is not included in SOD, though interviews were conducted based on the roles of WDB)

Issues	Patuakhali	Barguna
Normal Times		
Construct cyclone shelters in disaster prone coasts and islands according to designs approved by the government.	Shelters are constructed according to the availability of fund.	-do-
Monitor continuously the condition of the shelters and repair them in adequate manner	Maintenance and Repair works are performed on the basis of needs rather than routin-basis.	-do-
Was special weather bulletins/news collected and all concerned at field level informed and directed for security steps?	Weather bulletins are collected but LGED is not assigned to inform	yes

Issues	Patuakhali	Barguna
Was any meeting called by local Disaster Management Committee? Who attended the meeting?	Yes.	Yes.
Was any Liaison Officer appointed by The Chief Engineer at field level for communicating with the local Disaster Management Committee?	LGED has no such role.	No
Coordinate and cooperate with civil administration for rescue, evacuation and relief operations and make available implements, materials, transports and technical assistance to them.	Coordination related activities are operated by the Headquarter	-do-
Are the materials kept ready at suitable place for repair purpose?	Repair is not a regular task.	No
Are reports submitted at regular intervals to higher authority stating the condition of the shelters?	Reports are submitted yearly	-do-
Alert and Warning Stage		
How link was maintained with the local Disaster Management Committee and other agencies?	LGED has no active role in DMC.	-do-
Was there any activity performed for emergency construction of physical infrastructure and repair and maintenance?	No	No
Disaster Stage		
How long the information centre was operated and was any liaison officer sent to the local Disaster Management Committee?	No information center	No information center
How the local administration was assisted for rescue, evacuation and relief activities?	Workforce was employed to remove trees from roads within 2/3 days.	LGED has no role in relief and rehabilitation activities.
Was there any requirement identified to repair any damage, unserviceable installations and supply source by organizing technical persons and materials?	The roads were repaired where possible for emergency activities	Disconnected roads were repaired immediately
After how long of the disaster the damage/loss was assessed?	Damage Assessment started on 16th and continued for 15 days	Surveying for damage assessment started on the next day, continued for month.
When the action plan for repair, reconstruction and reinstallation was initiated for short term?	Instant repairing continued for 2/3 months. Long term plans and works started after 3 months.	After completion of damage assessment and restoration of essential services

Issues	Patuakhali	Barguna
Rehabilitation Stage		
Is the loss/damage assessed? Are plan and designs prepared for repair, reinstallation and reconstruction of cyclone shelters at required places? After how many days of disaster, the planning has been started?	Need assessment performed at the end of the financial year and long term plan for construction was made. Helipad is constructed in each union	-do-
What was the role in assisting and co-operating the civil administration in relief activities?	No	No
Are places for the construction shelters future disasters have been identified? Are the plans and request for approval and sanction of funds from the concerned authorities prepared?	Plan submitted	Plan submitted

DISCUSSION & CONCLUSION

Bangladesh has got a well organized network for cyclone early warning system and preparedness at alert stage which contributed significantly in reducing human causalities due to SIDR. The cooperation of Armed Forces Division along with the Government Authorities was also very effective in managing post disaster response and recovery activities efficiently. Still the disaster preparedness and management operations of the country lacks in active and long term plans during normal times as well as the implementation of the action plans taken after recovery of a disaster. This is the basic reason behind the huge damages and losses of properties as well as significant number of death toll caused by SIDR. The Standing Orders of Disasters is not yet well absorbed in the local administrative levels and the related personnel are not aware of their roles in spite of the knowledge that there exists such a document in the country regarding disaster. The SoD itself also needs some modification and clarifications of the roles of the personnel and organizations. It needs to be updated at regular interval by including the newly formed or role playing organizations close to disaster related activities and through taking feedbacks from the experience and suggestions of existing active groups or communities involve. Special plans should be incorporated for the remote islands. Regular repair and maintenance of the existing shelters and embankments, mock drills among the communities as well as the local administration are needed to be followed properly before the beginning of the Cyclone Season. The format and procedure of existing damage assessment activities are found to be every much rough. In most of the cases the authorities, themselves, have admitted that the damage assessment done in the union level by the illiterate guards are not actually reliable. For instance, there is no specific definition on what is meant by “fully” or “partially” damages and the guards appointed for surveys put the figures on the assessment form simply form their assumptions. Therefore, the authorities should train teams of volunteers at normal times on damage assessment. Moreover, most of the tasks performed from alert stage to response even recovery stages, are in fact, the response of the personnel or organizations based on the demand

of the situation by remaining in the jurisdiction of their individual formal assigned responsibilities. These activities are not performed following the SoD or any other formal documents. On the other hand there is no provision of monitoring and keeping accounts of how much work done by whom during the disaster operations. So there should be a preformatted reporting practice on assigned responsibilities and work done for the individuals as well as the organizations or authorities.

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4. Government of People's Republic of Bangladesh, "Standing Orders on Disasters", Ministry of Food and Disaster Management. (http://www.dmb.gov.bd/Standing Order.pdf)
5. http://www.irinnews.org/Report.aspx?ReportId=75470 (accessed on February 1, 2008)

APPENDIX-I

Overall Damage Assessment from AFD

DAMAGE ASSESSMENT-LGED

Ser	Sector	Cost BDT M	Cost USD M
1.	Rural Infrastructure	3382.446	49.02
2.	Urban Infrastructure	1174.9	17.03
3.	Small Scale Water Resource Infrastructure	65.428	0.95
Total		4622.774	67.00

DAMAGE ASSESSMENT-WDB

Affected Districts	Affected Coastal Dam (km)	Damaged Irrigation and Drainage Project (Nos)	Damaged River Embankment (km)	Loss BDT M	Loss USD M
15	**2382**	**1007**	**49**	**4920**	**71.304**

DAMAGE ASSESSMENT- DPHE

Ser	Affected Components	Qty	Damage BDT M	Damage USD M
1.	Districts	12	-	-
2.	Water Sources(Tube well, Psf, Reservoir Etc)	13009	16.469	0.24
3.	Flooded Safe Drinking Water Pond(Psf)	7155	21.465	0.331
4.	Infrastructure Related to Safe Drinking Water	-	5.625	0.08
5.	Sanitary Latrines	55279	88.446	1.30
6.	Infrastructure And Factories –Sanitary Empty & Products	-	03.00	0.05
7.	Indirect Affect On Health, Sanitation And Such Related Sectors	-	46.10	0.70
G TOTAL			**186.418**	**2.701**

DAMAGE ASSESSMENT- BRDB

Ser	Sector	Qty	Unit Loss	Total Loss BDT M	Total Loss USD M
1.	Crops (0.232 M Acre)	0.43 M ton	-	172.0	2.492
2.	Live Stock	ANIMAL- 2 0000	5000	100	1.450
		POULTRY- 516000	100	51.6	0.748
3.	Plantation	3.03 M	-	606.0	8.782
4.	Fisheries	0.090 M ACRE	-	704.531	10.210
5.	Infrastructure			54.582	0.791
G TOTAL				**1688.713**	**24.474**

DAMAGE ASSESSMENT - BREB

Ser	Affected Components	Cost BDT M	Cost USD M
1.	Districts - 30 in number	-	
2.	Broken Poles	85.206	1.235
3.	Damaged Meters	39.943	0.579
4.	Transformers	35.515	0.515
5.	Conductors	141.504	2.051
6.	Poles Replaced Against Damaged Tower	2.310	0.033
7.	Sub Station Materials(ACR)	11.963	0.173
8.	Cross Arm	3.60	0.052
9.	Insulator	6.334	0.091
10.	Other Materials (Armour, Rod, Fuse Link Etc)	32.196	0.468
G TOTAL		**358.571**	**5.197**

DAMAGE ASSESSMENT – FOREST AND ENVIORNMENT DEPARTMENT

Ser	Damaged component		Loss in BDT M	Loss in USD M
1.	Sunderbans	Forest resources	10000	144.927
		Infrastructure	200	2.898
		Subtotal	10200	147.825
2.	Coastal Forestation	Forest resources	83.031	1.203
		Infrastructure	16.969	0.245
		Subtotal	100	1.448
3.	Social Afforestation	Forest resources	110.465	1.600
		Infrastructure	9.535	0.138
		Subtotal	120.00	1.738
G total			**10420.00**	**151.01**

DAMAGE ASSESSMENT- EDUCATIONAL INSTITUTES

Ser	Sector	Number of Damaged Institutes	Average Unit Cost BDT M	Cost BDT M	Cost USD M
1.	Fully Damaged	4231	0.5	2115.50	30.659
2.	Partially damaged	12723	0.2	2544.60	36.878
Total				**4660.10**	**67.537**

APPENDIX J
(Acknowledgement for Photographs: LGED, Patuakhali)

 Damaged caused due to overflow of tidal water during SIDR on Galachipa-Kalagachia road under Galachipa Upazila.	 RDP-16, Phase-II roads (few damaged photographs by SIDR on 15 Nov.'07)	 Damaged due to overflow near Hazirhat Market on Boga-Hazirhat Road under Bauphal Upazila.
 Full washed out section on Galachipa-Kalagachia road developed under RDP-16 near Dakua at Chainage approx. 3+500 apart from Galachipa Upazila.	 The above washed out section are temporarily filled by earth for emergency communication with Galachipa Upazila.	 Pavement and shoulder washed out due to overflow on Galachipa-Badnatoli road at Chainage approx. 7.70km. RDP-16,Phase-I, Galachipa Upazila, Patuakhali.
 Shoulder settled due to overflow on Kalagachia-Galachipa road.	 Damaged due to overflow by the tidal water on Kalagachia-Galachipa road.	 Edge failure and erosion caused by overflow on Kalagachia-Galachipa road.

119m long Iron Bridge was constructed during the Phase-I of RDP-16 for the FY 1995-1996 on Nishanbaria-Faryghata Kheya ghat road under Kalapara Upazila, District Patuakhali. This bridge collapsed at about 2.00pm on 24 November 2007 during the distribution of relief goods among the SIDR affected peoples. A huge number of peoples were standing on the bridge waiting to collect the relief. Suddenly 2 spans about 7m each at the Chakamaya end fell down into the water. One person died, four people were not traced out yet and about 200 peoples were injured. Additional Chief Engineer (Planning) LGED visited the bridge on 25 November, 2007.

77m long Iron Bridge near Chiknikandi Bazar at approx. 8.00km from Galachipa Upazila on Galachipa- Chiknikandi-Patabunia road. This bridge was Constructed during the Phase-I of the RDP-16 Project for the FY 1995-1996. As per local people's opinion this damage was caused by the striking of a loaded Berge and a floating big tree during the SIDR on 15-11-'07. Additional Chief Engineer (Planning) LGED has visited the site on 25-11-'07.

Summary of damaged Infrastructure under LGED, District- Patuakhali due to Cyclone "SIDR" on dated-15/11/2007

Sl No.	Type of damaged component	Type of damaged	Actual damaged Quantity			Tentative Estimated cost to repair/ Rehabilitation (in lakh)
			KM	M	No	
1	Paved Road	Full/Partial	182.64	--	--	1205.00
2	HBB road	-do-	56.44	--	--	326.15
3	Earthen road	-do-	231.50	--	--	403.75
4	Bridge/Culvert	-do-	--	877.00	--	791.50
5	Primary School	-do-	--	--	467	2470.00
6	Growth Centre	-do-	--	--	17	186.00
7	Union Parishad	-do-	--	--	7	19.00
8	Cyclone Shelter	-do-	--	--	14	116.00
Total			**470.58**	**877.00**	**505**	**5517.40**

APPENDIX K

(Acknowledgement for Photographs: Upazila Engineer, Barguna)

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<tr><td colspan="3">  </td></tr>
<tr><td colspan="3">Barguna- Fujihari Road</td></tr>
<tr><td colspan="3">  </td></tr>
<tr><td colspan="3">Ghulshakhali Bazar to Bawalkar via Dema Sluice</td></tr>
<tr><td>  </td><td>  </td><td>  </td></tr>
<tr><td>Kakchira Bazar</td><td>Kakchira Bazar</td><td>Nali Bazar (Nali Iron Bridge)</td></tr>
<tr><td>  </td><td>  </td><td>  </td></tr>
<tr><td>Nishanbaria Ghat</td><td>Nali Bazar (Nali Iron Bridge)</td><td>Rotten Animals at Khakdon River</td></tr>
<tr><td>  </td><td>  </td><td>  </td></tr>
<tr><td>Barguna – Nishanbaria Road</td><td>Barguna – Nishanbaria Road</td><td>Relief Works at Nishanbaria Ghat</td></tr>
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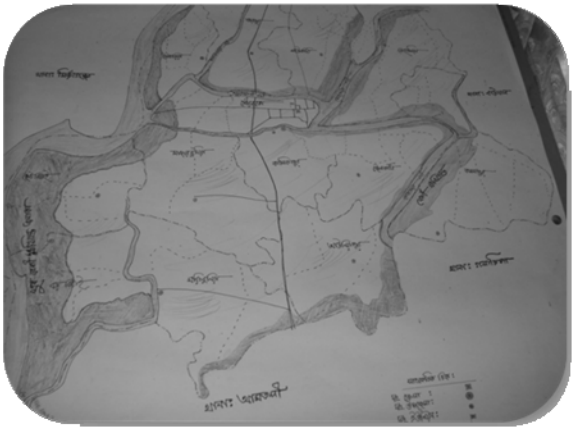
APPENDIX K

Photographs of Interview Surveys

Visiting Patuakhali District

DC & Survey Team



Upazila Damage Map

UNO, Patuakhali Sadar

Executive Engineer, WDB

Asst. Engineer, LGED

BDRCS Members

Visiting Barguna District

DC Office

Magistrate, DC Office

Executive Engineer, LGED

Upazila Engineer

Deputy Director, BDRCS

Deputy Director, CPP

Visiting Barguna District

Survey among Local People

Cyclone Shelter, Patharghata

Killa, Patharghata

Interview Survey in Dhaka

	
The interviewers from BNUS and ICUS with Prof. M.A. Ansary	Interview with Professor Jamilur R. Choudhury, VC, Brac University
	
Interview with G. M. Mansur Rahman, Director, DRR	Interview with Md. Khairul Anam Khan, Deputy Chief Coordinator, Cyclone SIDR Operation, BDRCS

BANGLADESH NETWORK
OFFICE FOR URBAN SAFETY

PART-II

RAIN INDUCED HILL-SLOPE EROSION/ LANDSLIDE AND PROBABLE CONTROL MEASURE IN CHITTAGONG HILLY AREAS

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared by: Afifa Imtiaz
Mehedi Ahmed Ansary

ABSTRACT

Rain induced hilltop erosions or landslides have become a common phenomenon in greater Chittagong and the adjacent rolling areas including the Chittagong Hill Tracts in recent years. Hill leveling in the Chittagong region continues unabated despite frequent mudslides during the monsoon. A total of 11 persons were killed and more than 30 were injured in a landslide in Motijhorna area at Lalkhan Bazar in the port city of Chittagong on August 18, 2008. Heavy downpour caused the landslide. A total of 128 persons were killed in another massive landslide in Chittagong City on June 11, 2007. Raincut erosions occur mainly due to man-made denudation and cutting of the hills. If vegetations (grass and plants) with deep roots can be grown on these stripped hill surfaces, the problem would be either totally eliminated or at least significantly reduced. To investigate the causes of the recently occurred landslides and find a probable solution to this problem, Bangladesh Network Office for Urban Safety (BNUS) arranged a field visit for the experts/researchers to some landslide areas of Chittagong district from September 10 to 11, 2008. The team was formed by Dr. Abdul Jabbar Khan, Professor and Dr. Raquib Ahsan, Associate Professor from the Department of Civil engineering, Bangladesh University of Engineering and Technology (BUET). Later, Prof. Khan presented his findings as well as a couple of recent projects implemented by 16 Engineering Construction Battalion (ECB) at Rangamati area using geojute for raincut erosion control under his guidance. He showed that these two project areas protected by geojute have performed surprisingly satisfactorily against the recent high intensity rainfalls of the similar magnitude that caused erosion at Motijhorna of Chittagong.

INTRODUCTION

Recent occurrences of raincut erosion in Chittagong hilly areas of Bangladesh have added yet another challenge to the engineering know-how, administrative decisiveness and mass awareness in the country. Many geologists and local sufferers have reiterated in many news columns that these raincut erosions occur mainly due to man-made denudation and cutting of the hills. The technical understanding is that due to denudation or deforestation of the hills the top soils get loosened by the impact energy of the short duration high intensity rain drops. These loose soils are then carried down the hill by the unintercepted runoff of rainwater. Such form of raincut erosion occurs almost everywhere in the world. It should be appreciated that if vegetations (grass and plants) with deep roots can be grown on these stripped hill surfaces, the problem would be either totally eliminated or at least significantly reduced. The question is how to inhibit erosion of the top soils until the vegetations grow. Geojute – a special type of woven type open mesh jute geotextiles has been employed in Germany, Italy, USA and Australia to cater for this intermediate stage. It is worth mentioning here that geojute is produced in abundance in local jute mills in Bangladesh and every year more than twelve million square meters is exported. Unfortunately, there was no case study of using geojute for raincut erosion control until a couple of recent projects implemented by 16 Engineering Construction Battalion (ECB) at Rangamati area under the guidance of Prof. Abdul Jabbar Khan of the Department of Civil Engineering, BUET. These two project areas protected by geojute have performed surprisingly satisfactorily. It seems that apart from exerting the administrative decisions and generating mass awareness, technical solutions comprised of geojute and vegetations should be implemented simultaneously.

RECENT THREATS AND LANDSLIDE EVENTS

Landslide has become very common in the hilly areas of southeastern Bangladesh, especially in Chittagong, Bandarban, Rangamati, Khagrachhari and Cox's Bazar. Illegal hill-cutting due to rampant building has left some 70,000 (IRIN, 2008) people at risk of landslides in 18 sub-districts of the hill districts, as well as the city of Chittagong, warned specialists. Every year especially in the rainy season landslides take place in both natural and man-induced slopes. Considerable number of buildings, roads and other infrastructures are damaged and valuable lives are lost in these incidents. The major roads connecting hilly areas with the rest of the country are affected by landslides almost every year isolating the towns and contiguous areas. Many buildings and infrastructures especially those located on steep high slopes usually fail due to landslides. The loss of lives and properties due to Landslide events in Chittagong is very significant. In June 2007, a landslide at Mati Jharna colony of Lalkhan Bazar, right in the heart of Chittagong, killed 128 people when a hill collapsed on to an adjacent slum. More than 300 people have been killed in landslides in Chittagong in recent years (IRIN, 2008). Now time has come to find out the cause of such landslide events in Chittagong City and surrounding areas and to take necessary preventions to avoid repeated casualties. The chronology of the landslide occurrences in the Chittagong, cited from Banglapedia 0365, and some other sources, are listed below:

Chronology of major landslides (Source: Banglapedia 0057) :

1968 At Kaptai-Chandraghona road where the protective vegetation is removed, the soil gets exposed to the monsoon rains and eroded rapidly. This resulted in landslides, and the loose soil washed down the slopes and carried by rivers into the kaptai lake. As a result, the reservoir silted up and the authorities confirmed that in its 30 years existence it had lost about 25% of its volume due to siltation.

1970 Similar event along Ghagra-Rangamati road.

1990 Occurred on May 30, 1990. Affected the link road embankment at Jhagar beel area of Rangamati district.

1997 A major landslide occurred in July 1997 at Charaipada of Bandarban. The total area affected by it was about 90,000-sq m. If such a landslide occurred in Bandarban Town and any other urban or semi-urban centre, the devastation would be tremendous.

1999 Two big landslides one in Bandarban and the other one in Chittagong occurred on 11 and 13 August 1999 respectively claiming the life of 17 people. Out of 17 fatalities, 10 were in Chittagong and the rest in Bandarban district. Heavy and incessant rainfall at that time was one of the causes of sliding. This landslide affected Lama thana and the Aziz Nagar union of Bandarban district. Aziz Nagar is almost an inaccessible rugged hilly terrain. Landslide badly affected the villages of Chittaputti, Monargiri, Meounda, Muslimpara, Sonaisari, Bazapara, Kalargiri, Maishkata, Aungratali, Chionipara, Kariungpara. The 11 August landslide was followed again on 15 August at Chittaputti area. At least 50 houses were completely vanished under the solid earth and 300 houses were partly damaged. About 283.50 ha of cultivated land, 810 ha of household garden, and 50 km unmetalled road were crushed. Road communication between Bandarban headquarters and remote thanas became snapped. Especially, Aziznagar-Bazalia road had been closed for traffic due to falling of huge mass of earth over the road at 25 places.

Chittagong landslide location was at Gopaipur under Chittagong Kotwali Thana. The slides crushed two thatched houses at the foot of the hill claimed the lives of the inmates of the houses who were asleep.

2000 At least 13 people were killed and 20 injured in landslide incidents on the Chittagong University campus and other parts of Chittagong City on Saturday, the 24 June 2000. The incident was caused due to the deluge of mud and water that swamped various part of the port city amid torrential rain.

Major landslide events from miscellaneous sources:

2003 In 15th June of 2003 (International Landslide Centre) total 6 casualties were reported at Cox's Bazar due to Landslides caused by heavy rain. The earthquake of July 30, 2003(The New Nation, 2007) with a magnitude of 5.9 hit the Chittagong area causing casualties of six persons in Cox's Bazar by landslide.

2006 In September 2006 A landslide triggered by days of heavy rain killed two children and injured six in village Rajarkol. Villagers said a big chunk of soil buried the thatched home while they were asleep, instantly killing the children. (International Herald Tribune, 2006)

2007 In June 2007, a landslide at Mati Jharna colony of Lalkhan Bazar, right in the heart of Chittagong, killed 128 people when a hill collapsed on to an adjacent slum. More than 300 people have been killed in landslides in Chittagong in recent years (IRIN, 2008). Nineteen people, 12 of them children, died in landslides in Cox's Bazar district in the first half of July 2007 alone.

2008 Nineteen people died in landslides in Cox's Bazar district in the first half of July 2008 alone. The incident occurred at Teknaf in Cox's Bazar district, 450 kilometres from the capital Dhaka. On 14 July two people died under a mudslide at Himchhari. The two were buried alive when a large chunk of earth fell on the thatched house of at the foot of a hill at about 10:00am. (Source: The Daily Star, 15 July 2008, UNB, Cox's Bazar). On August 11, 2008 three members of a family were buried alive as their mud-hut collapsed in Cox's Bazar. On August 18, at least 14 people were killed, a dozen injured and 10 others feared trapped under the rubble of collapsed houses in a landslide in Bangladesh's Chittagong port city and Cox's Bazar. The landslide, triggered by heavy rain, occurred at the city's Motijahrna hillside slum area.

PRESENTATIONS ON RAINCUT EROSION CONTROL IN CHITTAGONG HILLY AREAS

Bangladesh Network Office for Urban Safety (BNUS) organized a lecture on Raincut Erosion Control in Chittagong Hilly Areas on August 28, 2008, at ITN Conference Room of the Civil Engineering Building (3rd Floor), Bangladesh University of Engineering and Technology (BUET), Dhaka. The program was chaired by the honorable Vice Chancellor of BUET, Prof Dr. M. M. Shafiullah and moderated by Prof. Dr. Mehedi Ahmed Ansary, Dept. of Civil Engineering. Prof. Abdul Jabbar Khan from the Dept. of Civil Engineering, BUET, delivered a lecture on the application of Geojute – a special type of woven type open mesh jute geotextiles, for protection against raincut erosion of hilly areas. After the presentation a roundtable meeting was held where twenty six responsible personnel from Education Engineering Department (EED), Geological Survey of Bangladesh (GSB), Fire Service and Civil Defense, IWM, CEGIS, PWD, RAJUK, SPARRSO, ECB and

Professors from BUET participated the meeting. They appreciated the efforts and initiatives taken for examining the applicability of geojute and suggested that apart from exerting the administrative decisions and generating mass awareness, technical solutions comprised of geojute and vegetations should be implemented simultaneously.

The team of experts from BNUS, formed by Dr. Abdul Jabbar Khan, Professor and Dr. Raquib Ahsan, Associate Professor from the Department of Civil engineering, BUET, visited some landslide prone hills of Chittagong from September 10 to 11, 2008. Later, Professor Dr. Khan delivered a lecture on the same issue combined with his filed experience from Chittagong, arranged on November 15, 2008, jointly organized by Bangladesh Network Office for Urban Safety (BNUS) and Bangladesh Earthquake Society (BES), chaired by Prof. Dr. Jamilur Reza Chowdhury, President, BES. There Prof. Khan presented his experience of visiting the landslide prone hilly areas of Chittagong and addressed that application of Geojute could be a probable option to prevent rain induced erosions in those areas also. The rest of the segments of the report summarize the findings of Dr. Khan.

MAJOR CATEGORIES OF RAINCUT EROSION

Rainfall is one of the most significant triggering factors for landslide occurrence. When the ground is not protected by vegetation, raindrops can loosen particles of soil and scatter them in all directions. Heavy rainfall may remove a layer of topsoil and send them rushing away in a swiftly moving current. In general, the effect of rainfall infiltration on slope could result in changing soil suction and positive pore pressure, or main water table, as well as raising soil unit weight, reducing anti-shear strength of rock and soil. The pore pressure response processes exhibit some general characteristics. The largest and most rapid pore pressure (positive and negative) response takes place at shallow depths in slopes. Deeper slopes have slow pore pressure changes in response to rainfall process. With the rising of rainfall intensity, the pore pressure at different depths of slope increases gradually to similar magnitude, and finally to peak value. During the finishing period of rainfall, pore pressure declines and soil suctions develop to some extent relying on the slopes permeability. In the slope with low permeability, the pore pressure declines slowly and even keeps on a high value at the end of rainfall process. In the slopes with high permeability, pore pressure declines rapidly synchronized with rainfall process. At the end period of rainfall, the soil suction recovers to some extent.

Raincut or rain induced erosion can occur due to top soil erosion, block slide and/or manmade unstable slopes (Figure 1).

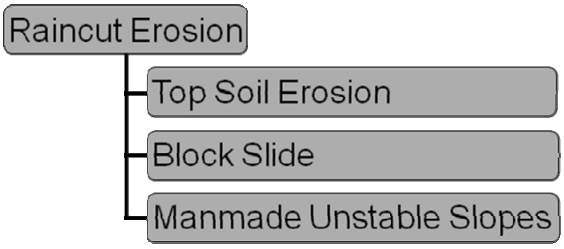


Figure 1: Causes of raincut erosion

A. Top Soil Erosion

Mechanism: Rain is undoubtedly the largest cause of erosion. During heavy rainfall, soils become waterlogged and lose their strength. On steep hills they have the potential to slip and slump into the valleys below. Water is about 800 times heavier than air, half to one third the weight of rock and about equal in weight to loose topsoil. When it flows, it can move loose substances with ease. Rain's most damaging moment is when a water drop hits the ground. Figure 2 shows the effect of raindrop impact.

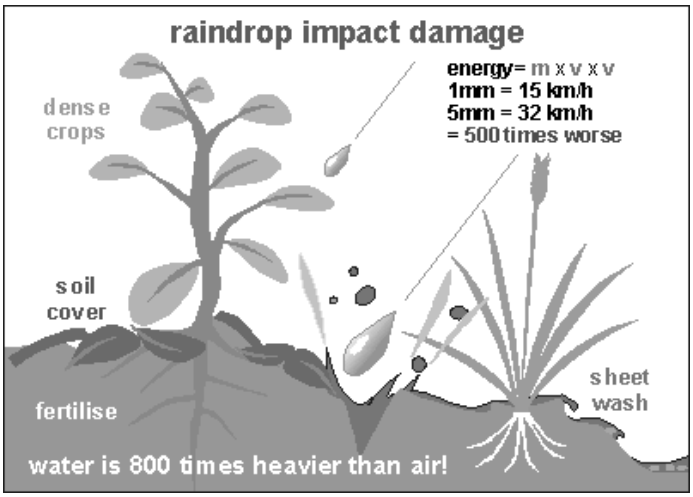


Figure 2: Impact of raindrop

As rain drops hit the soil, they loosen its structure (Figure 3-a), freeing up fine clay particles, which do not settle down easily, and which are transported down-hill (Figure 3-b). Previously it was thought that sheetwash, the flow of water over the soil, was the most destructive. The kinetic energy of a moving object is equal to half its mass multiplied by its speed squared: e=mv2/2. As water droplets grow in size, both their speed and mass increase. The mass of a 5 mm raindrop is 5x5x5=125 times that of a 1 mm drop and its 'terminal' speed doubles, resulting in a destructive energy 500 times larger. Thus the destructive power of rain increases dramatically as the rainstorm produces larger drops, which is relatively rare. But when it occurs, its effect is profoundly destructive. In the past ten years, starting around 1987, rains have become heavier everywhere in the world, and with it, erosion from raindrop impact (seafriends).

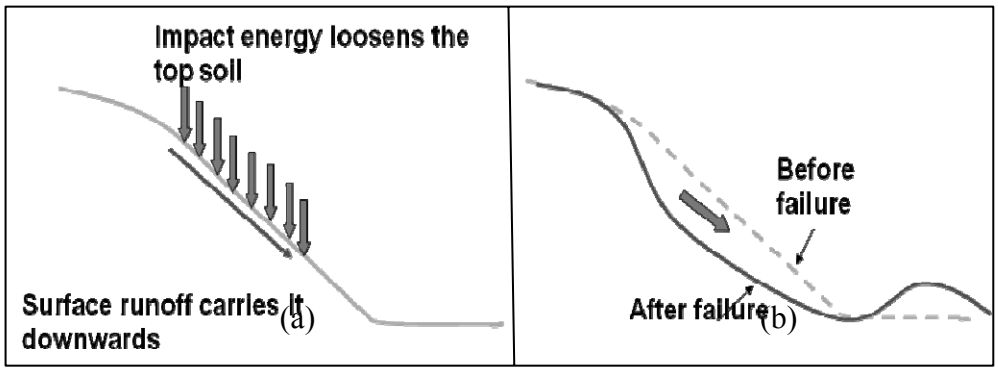


Figure 3: Top soil erosion due to impact energy caused by rain drops

Top Soil Erosion Due to Raincut at Rangamati: The following figures (Figure 4) show some hills at Rangamati, Chittagong, where rain induced tops soil erosion has been caused. It is notable that all these slopes are either uncovered or denuded.

(a) Rubber Bagan

(b) Dangerous Curve 1

(c) Kalabagan

(d) Dangerous Curve 2

Figure 4: Top soil erosion due to raincut at Rangamati

B. Rain Induced Block Slide/ Landslide

Mechanism: In the majority of cases the main trigger of landslides is heavy or prolonged rainfall. Generally this takes the form of either an exceptional short lived event, such as the passage of a tropical cyclone or even the rainfall associated with a particularly intense thunderstorm or of a long duration rainfall event with lower intensity. In the former case it is usually necessary to have very high rainfall intensities, whereas in the latter the intensity of rainfall may be only moderate - it is the duration and existing pore water pressure conditions that are important. Principally rainfall triggers so many landslides because the rainfall drives an increase in pore water pressures within the soil. Many soils, especially clays, are hard when dry but transform into soft muds when a small amount of moisture is added. The addition of water reduces the shear strength of the soil and can result in landsliding. Also, water pressure within the porosity of a soil has the effect of "inflating" the pore spaces and reducing the frictional forces between soil particles. This loss of friction can result in a rapid landslide. Figure 5 illustrates the movement of a large chunk of land that is starting to slide. Here the gravity is pulling it downward at a pretty fast speed. The movement of the block is parallel to the plains of weakness.

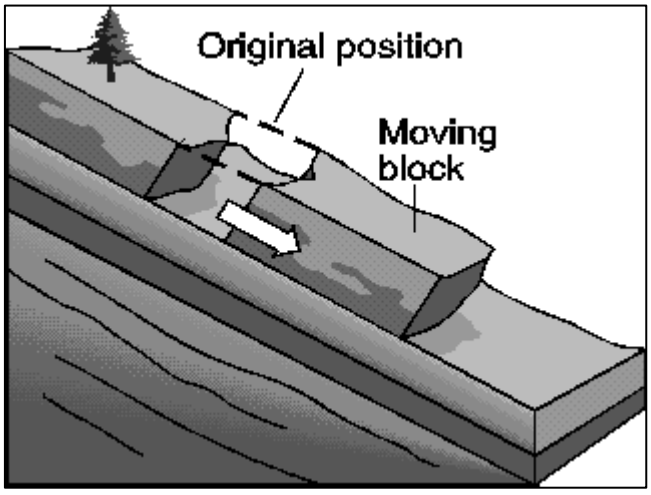


Figure 5: Movement of a block while sliding (seafriends.nz)

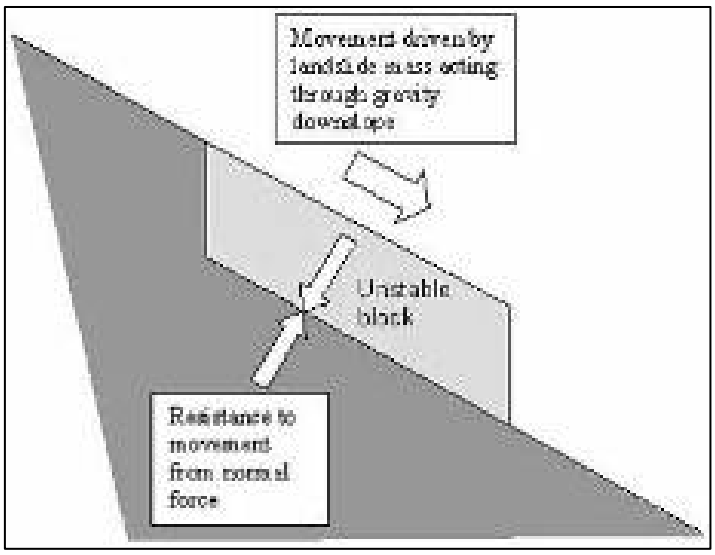


Figure 6: Forces acting on an unstable block on a slope (Wikipedia)

The Figure 6 and 7 illustrate the forces acting on an unstable block on a slope. The diagrams illustrate the resistance to, causes of, and movement in a slope system consisting of an unstable block. Movement is driven by shear stress, which is generated by the mass of the block acting under gravity down the slope. Resistance to movement is the result of the normal load.

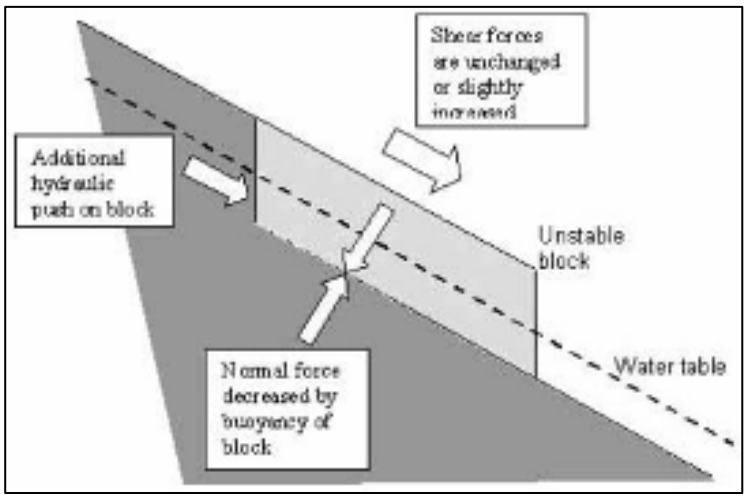


Figure 7: Forces acting on an unstable block when the slope is filled with water (Wikipedia)

When the slope fills with water (Figure 7), the fluid pressure provides the block with buoyancy, reducing the resistance to movement. In addition, in some cases fluid pressures can act down the slope as a result of groundwater flow to provide a hydraulic push to the landslide that further decreases the stability.

Rain Induced Block Slide at Chittagong: The case described at Figure 7 was observed at hills in Chittagong University (Figure 8). Figure 9 shows a close observation to the soil structure of the hills. It is noticeable here that the clay or shale layers are overlain by thick sand layers which are easily susceptible to impact loading caused by rainfall. The probable plane of failure developed in these layers is shown in Figure 10.

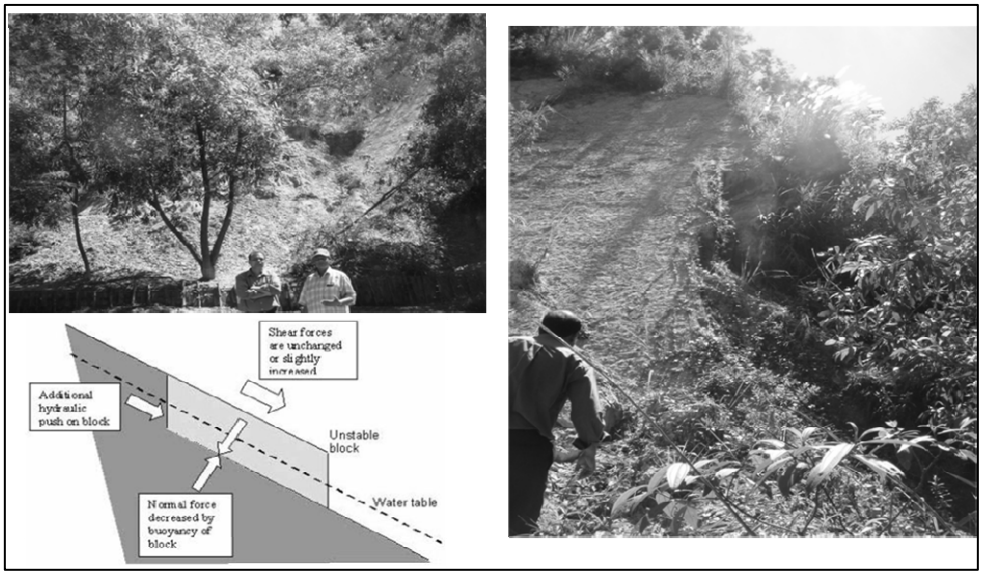


Figure 8: Block slide at a hill of Chittagong University

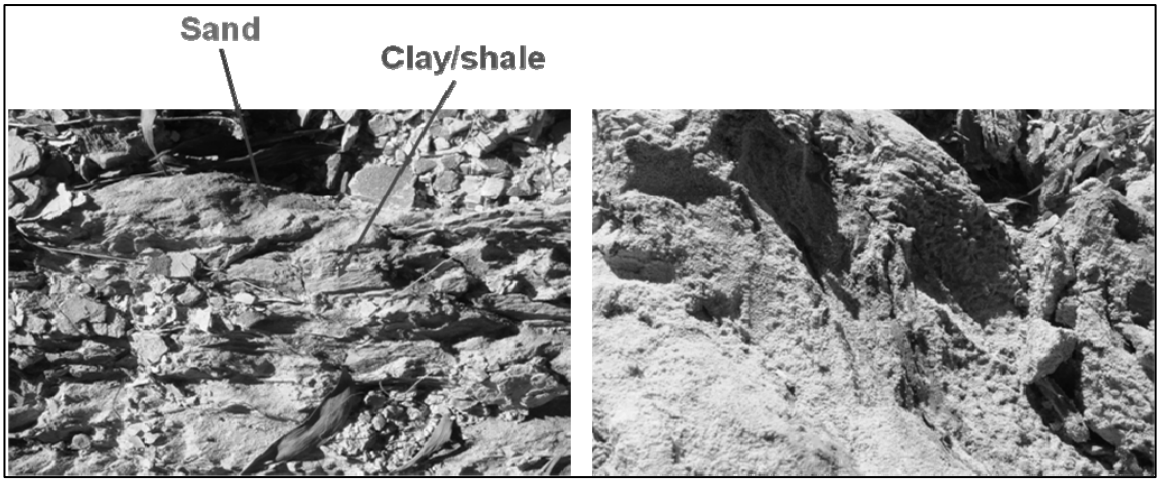


Figure 9: Soil structure of the hill at Chittagong University

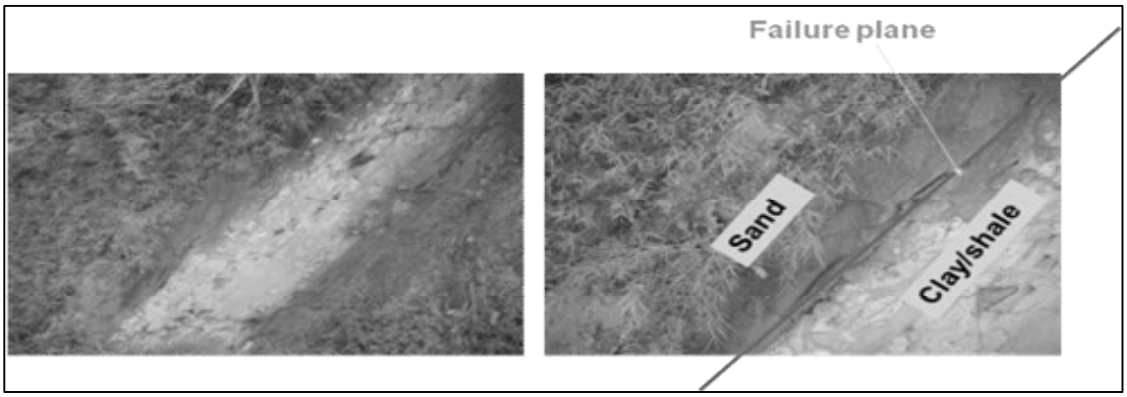


Figure 10: Plane of failure for the hill at Chittagong University

C. Rain Induced Failure of Manmade Unstable Slopes

Mechanism: Other than the natural causes different man-made activities or processes can cause the slope of a hill to be unstable. The activities may include the followings:

(a) Excavation of the slope or its toe
(b) Loading of the slope or its crest
(c) Drawdown (of reservoirs)
(d) Irrigation
(e) Defective maintenance of drainage systems
(f) Water leakage from services (water supplies, sewers, stormwater drains)
(g) Vegetation removal (deforestation)
(h) Mining and quarrying (open pits or underground galleries)
(i) Creation of dumps of very loose waste
(j) Artificial vibration (including traffic, pile driving, heavy machinery)

Excavation or erosion at the base of a slope (or on a slope) can cause an unstable situation. The removed material is supposed to frequently support the soil directly upslope from the disturbed area. This loss of support can immediately or eventually result in landsliding.

The angle of repose is the maximum angle that a material can be stacked and remain stable. If soil is piled at an angle that exceeds the angle of repose, landsliding can result.

FAILURE OF MANMADE UNSTABLE SLOPES IN CHITTAGONG

The landslide event of Motijharna has been considered as an example caused by man-made unstable slopes and investigated to explore the reasons behind. From the Figure 11, it can easily be seen that the natural slopes have been cut to almost vertical (90°) and sometimes to even more than 90° with the horizontal. The formation of soil structure (Figure 12) of this hill consists of alternate layers of sand and very thin film of cementing clay/ shale. Rainwater seeps through the layers and over the ages reduce the bond between the sand and clay/ shale which loosen and get separated as soon as the rain drops strike. In fact no slope of a natural deposit, unless it is made of hard rock, can remain stable at 90° angle. So it can be inferred that the reasons for landslide/slope failure at Motijhorna are definitely manmade. By visiting another hill at Motijhorna (Figure 13 and 14), once again very steep manmade slope has been observed which no wonder imposes risk of landslide or slope failure for the place. Surprisingly, all the urban utility services such as electricity, water supply have been found in the slums beneath these hills (Figure 15). The question is whether these houses have holding numbers.

Figure 11: Slopes at Motijhorna Hill-1

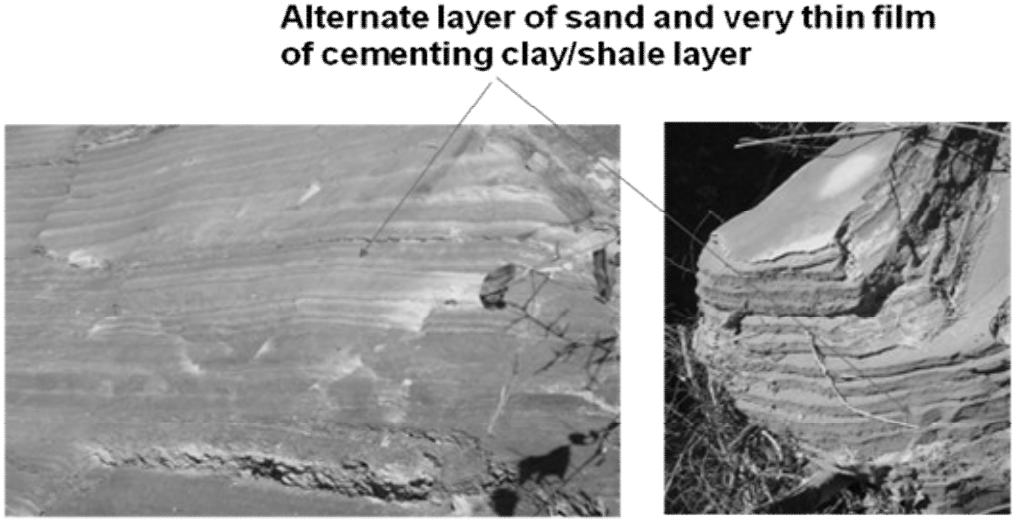


Figure 12: Formation of Soil at Motijhorna Hill-1

Figure 13: Motijhorna Hill-2

Figure 14: Slope at Motijhorna Hill-2

Figure 15: Utility Services at the Slums beneath Motijhorna-2

Another place called Tankir Pahar (Figure 16) was visited by the team. The hill is named after the large water reservoir built on the top. Natural drains (Figure 17) are created on the slope surface although there exists some sort of vegetation.

Figure 16: Hill of Tankir Pahar at Chittagong

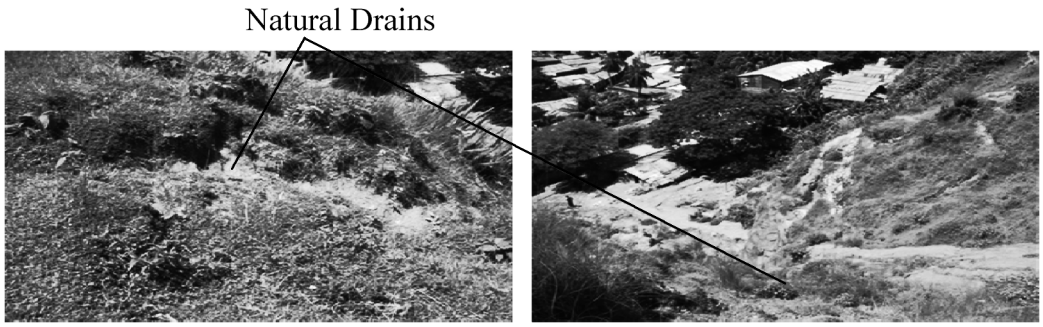


Figure 17: Natural drains developed at Tankir Pahar

Ponding (Figure 18) has been observed on the leveled top surface of the hills which is a dangerous source of landslide. Moreover, cases of sliding soil lumps have also been found on the slip of the hill (Figure 19). Here the formation of soil is also a matter of concern since it contains thick strata of sand followed by a thin seam of clay/shale.

Figure 18: Ponding at Tankir Pahar

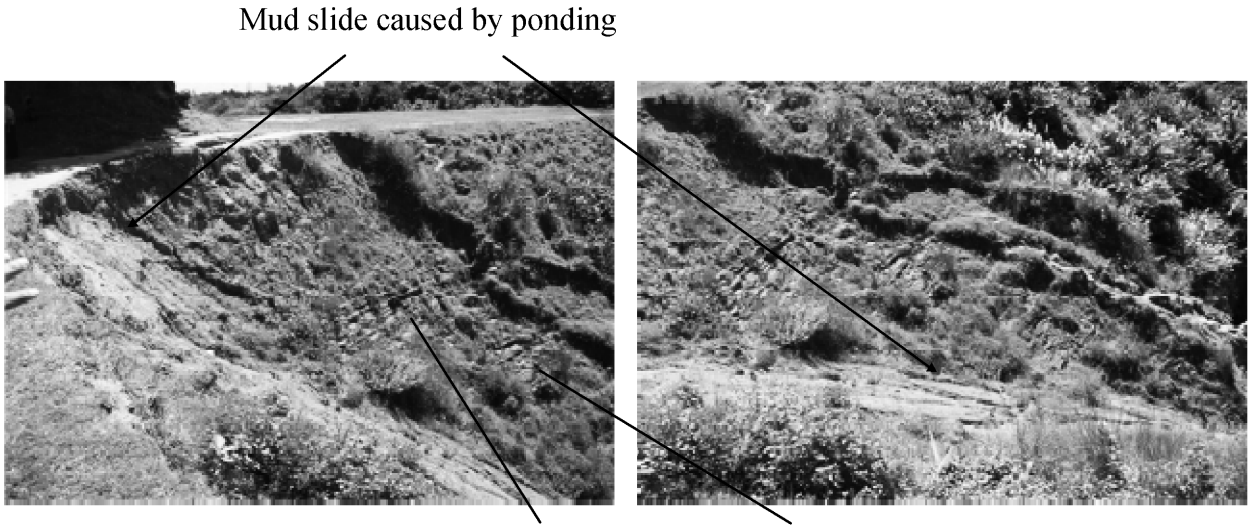


Figure 19: Sliding of soil lumps slopes of at Tankir Pahar

Similar man made slope destabilization has been found while visiting Batali hill (Figure 20) also. The hill has been excavated near the toe and the slope has become even more than 90° posing great danger of severe landslides, obviously nature reacts when it is disturbed.

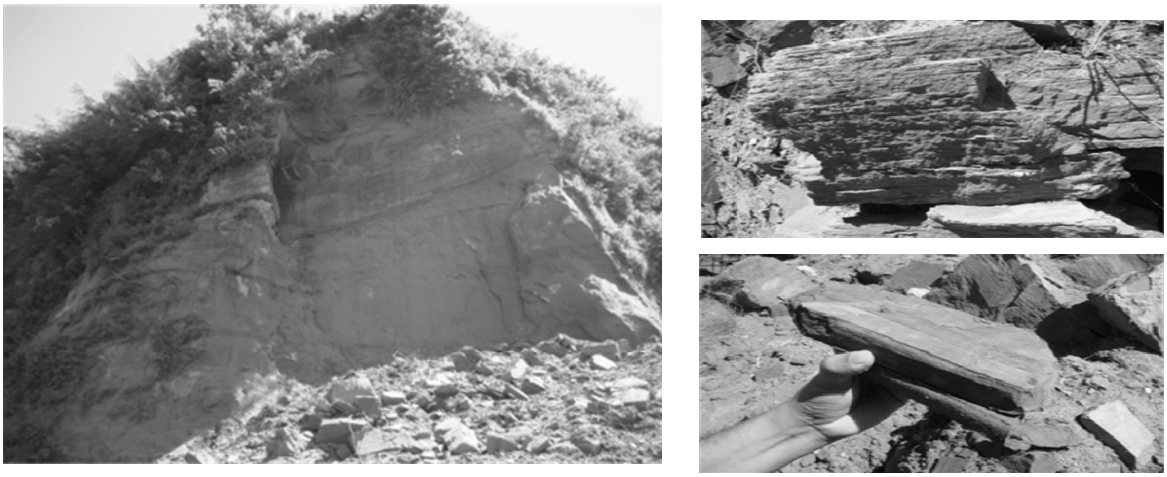


Figure 20: Slope and soil formation of Batali Hill

Although while visiting the hills of Tiger Pass (Figure 21), the surfaces were found to be covered with plenty of vegetations, but the important fact is that whether these vegetations are of right types and capable of reducing raincut erosions or landslide. Natural drains (Figure 22) have been observed whose formation might pose threat, but still the slopes are expected to be more stable as long as they are covered.

Figure 21: Vegetation at hills of Tiger Pass

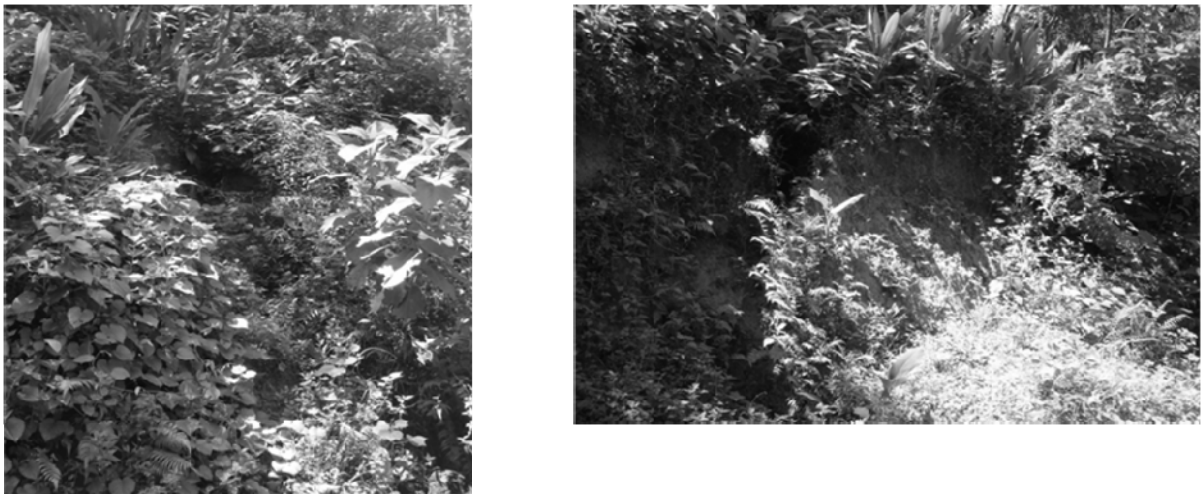


Figure 22: Natural drains at Tiger Pass Hills

The man made activities are increasing rapidly in the slopes of Tiger Pass (Figure 23), even sometimes in the name of religion, the slopes are being excavated and houses are being built at proximity.

Figure 23: Manmade activities continued at Tiger Pass

VEGETATION AS THE SOLUTION TO LANDSLIDE PROBLEMS

Tree-cover largely increases the stability of the underlying ground by increasing root strength, intercepting direct effect of precipitation and reducing pore water pressure by evapotranspiration. Vegetation provides a cover and cushions the impact of rain, the root systems work as apparent cohesion. Vegetation also adds weight to the slope. Therefore, bio-engineering methods including that of large scale afforestation and protection of existing vegetation cover needs to be adopted in the landslide-prone areas. The selection of suitable plant species should be such that can with stand the existing hydrological conditions of the terrain. Deep-rooted vegetations are effective in holding the soil tightly. Some quickly grown grasses like Vitiver (Figure 24) whose root system goes up to 14 ft deep in six to eight months of time can be grown more on these slopes to prevent raincut erosions.

Figure 24: Vitiver grasses

BIO-ENGINEERING SOLUTION TO RAIN INDUCED LANDSLIDE AIDED BY GEOJUTE

A permanent and self-propagating vegetal cover is found to be an ideal solution to the problems regarding erosion along degraded hill slopes. Use of natural and locally available materials such as geojute (Figure 25 and 26) can be considered as a recent technique in stabilisation of soil along the hill slopes. Jute is a natural and biodegradable fibres that can aid in vegetative turfing in the form of netting along the slopes. These nettings serve as a physical barrier between the soil particles and

rainwater and protect the seeds and the soil until the sites are permanently stabilised with vegetal cover. The jute nettings spread over seeded slopes shield the soil and seeds from the impact of rain drops, minimise runoff and slow down its velocity, maintain the capacity of soil to absorb water, hold the soil particles and seeds in place and retain soil moisture. When seeds germinate, they grow through the gaps in the fabric and achieve a cover all over as the biodegradable geojute netting begins to degrade. This technology is appropriately applicable to highly erodable slopes where mechanical methods prove unsuitable. This technology is also cheaper (Figure 27) compared to the other available methods.

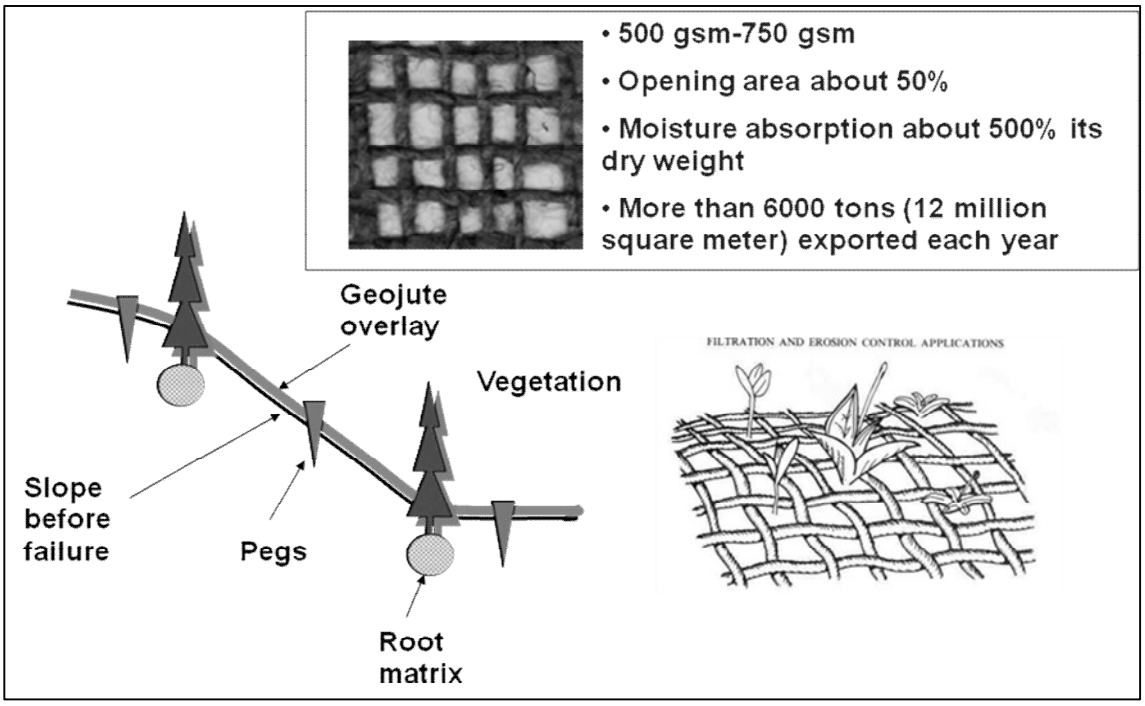


Figure 25: Application of Geojute on degraded slope

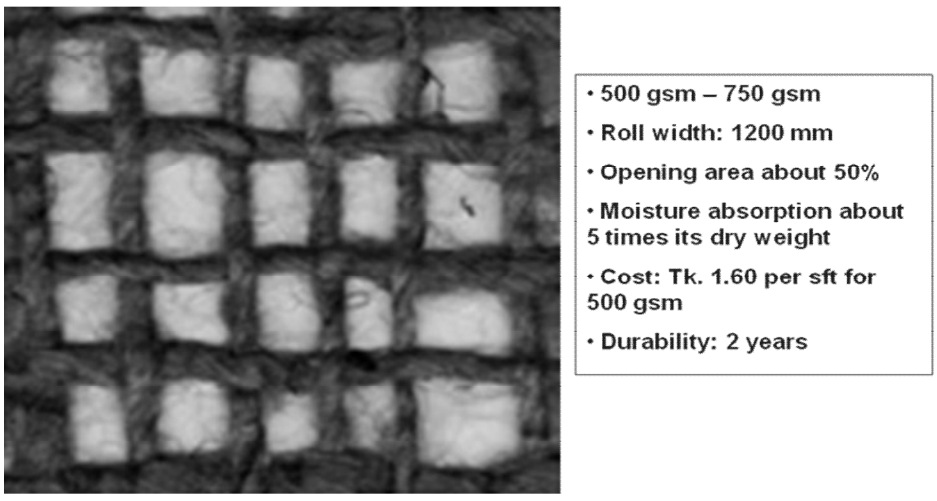
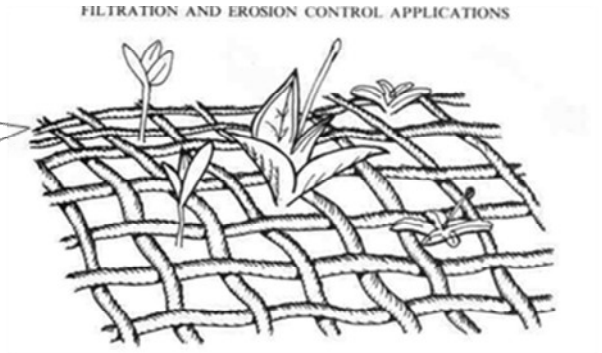


Figure 26: Geojute- woven type (open mash) sample produced by BJMC and private jute mills in Bangladesh



For a height of 30.0m, 1V:2H slope consumption will be 5 ton/100m.

(1 Ton = 2000 m2)

Cost of the system: 3.50 Tk/sft – 4.00 Tk/sft

Figure 27: Requirement and cost of geojute application

Geojute absorbs water required for vegetation growth and acts as much on its biodegradation. This helps growth of vegetation in almost half the time required for same amount of growth without Geojute. As the Geojute degrades with time, grasses and trees grow up and take over the job of Geojute.

CASE STUDIES OF SOLUTION TO RAIN INDUCED TOP SOIL EROSION

This segment of the report deal with the case study based on the practical application of Geojute in Bangladesh, guided by Dr. Khan. Here it has been assessed whether the problems of recent landslides in Chittagong can be treated with Geojute aided bio-engineering solution.

Case Study: A successful integrated bioengineering approach for landslide protection and mitigation was carried for Raincut Erosion Control of a Hill at Dangerous Curve-2, Rangamati (Figure 28). The work was patronised by 16 Engineering Construction Battalion (ECB) of Bangladesh Armed Forces Division and supervised by Dr. Khan. The slope of the hill was quite steep and becomes very risky in rainy season. Thus slope stabilisation for such steep hills require special attention. Grass seeds were spread on the affected area and later it was covered up with Geojute Textile. The Geojute Textile was then reinforced by pegging bamboo posts. The flow of water from the hilltop was diverted away from the affected area by digging up natural drainage facility at the landslide susceptible hilltop. The growth of the vegetation as well as the effectiveness of Geojute cover was then monitored. The following photographs are self explanatory in describing the progress of the work and the condition of the stabilized slope after completion.

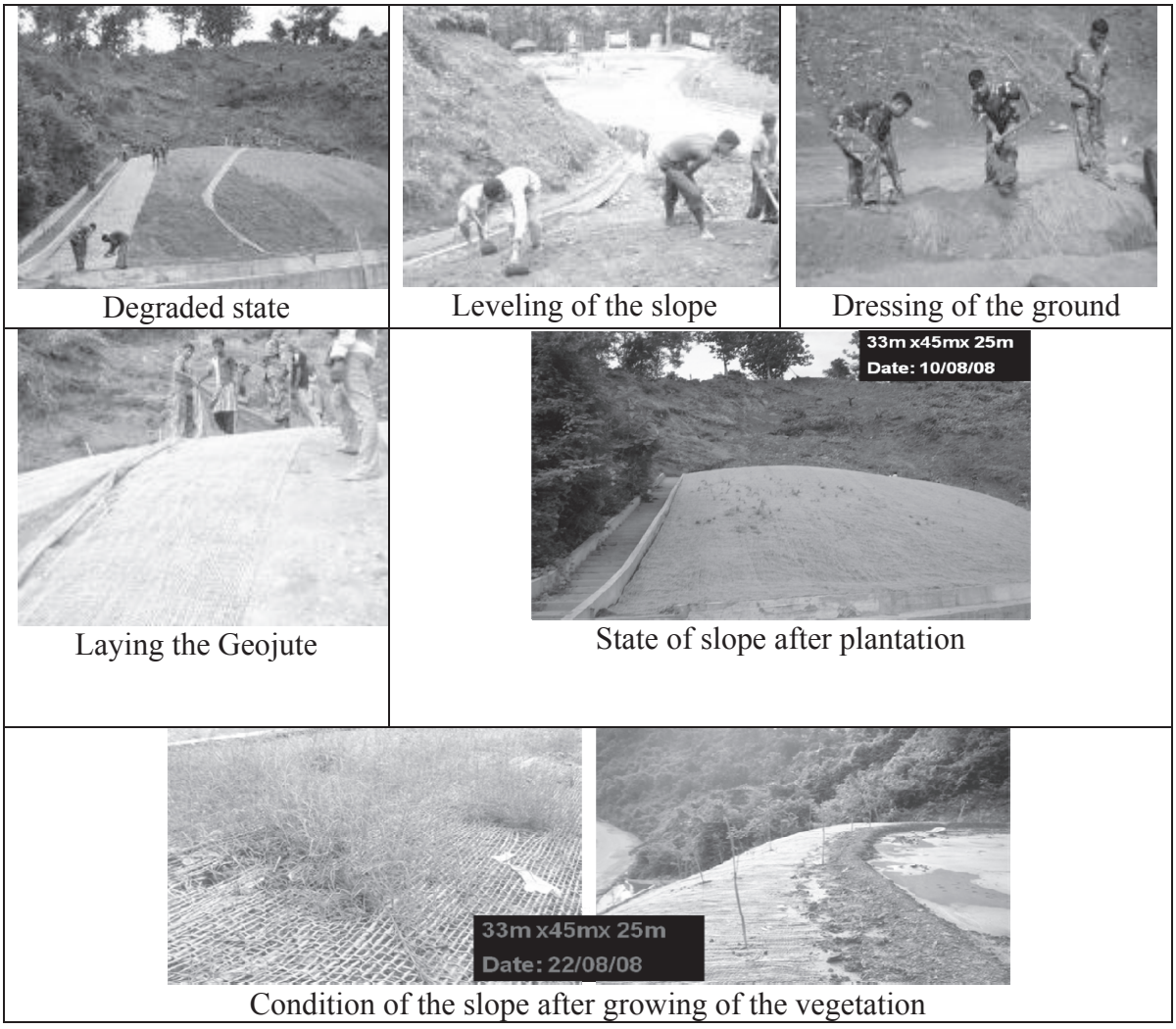


Figure 28: Application of Geojute for Dangerous Curve-2 at Rangamati

According to the study of Dr. Khan, it has been found that laid over denuded surface, Geojute takes away about 40% of the raindrop impact energy. Geojute reduces surface runoff to about 35% by absorbing 4 to 5 times water of its dry weight. The reduced runoff flows gently (spillway effect) (Figure 29) over the Geojute covered surface due to miniature dam effect.

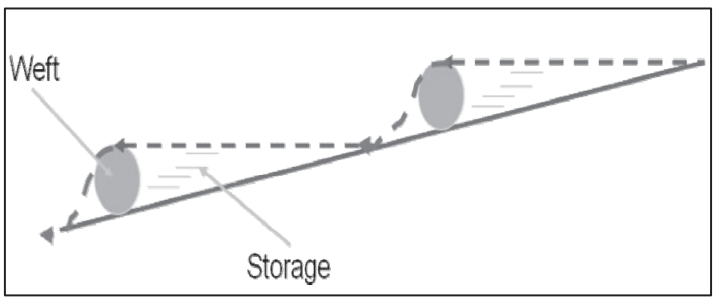


Figure 29: Spillway effect

RECOMMENDATIONS

From the study it was recommended that -

1. For road side slopes, Geojute aided bioengineering solution may be an alternative to providing expensive clay cladding and hard concrete covers.
2. For hills where slopes are not unstable due to cutting but vulnerable to top soil erosion due to denudation may be secured by Geojute aided bioengineering solution.
3. For hills within Chittagong city area:
    - No further cutting of the hills should be allowed.
    - The hills may be cut, if extremely required, maintaining their stability.
    - It would not be practical to suggest rehabilitation of the large population of the localities.
    - A vulnerability risk assessment mapping of the hills must be done immediately.
    - No top surface of the hills should be allowed to be leveled.
    - No residential facilities should be allowed on the already leveled tops.
    - The top of the leveled hills may be immediately covered with clay membrane/impermeable membrane with grading maintained away from the slopes.
    - All the hills which are not currently showing any sign of distress, should be covered with proper vegetations of deeper root systems.

DISCUSSION AND CONCLUSION

Landslide has become very frequent event in the hilly areas in Bangladesh, especially in the rainy season. The loss of lives left behind by this man- made disaster needs utmost concern of the general people, government agencies as well as the scientists, engineers and non-government workers in this field. To avoid repeated casualties in Chittagong by landslide precautionary measures have become very essential. Hill cutting should be totally stopped and developing or levelling of undulated land should have proper peripheral land slope or retaining wall. Creation of slum area on hills and hill sides should be stopped. Proper plantation and vegetation should be created on hill slopes to reduce the landslide. Special legislation is required to protect the hills by providing well-defined rules and conditions that need to be fulfilled during construction. Buildings constructed on hills should have proper, drainage and sewerage system without disturbing natural slope of the hills and rule should be framed to construct houses maintaining a safe distance from hill. Overall, a vigorous campaign on safe living is needed. Those who live in areas vulnerable to landslides need to be relocated properly. Moreover, whenever heavy rains strike, the authorities should dispatch teams of public announcers to high-risk areas convince residents to leave their homes temporarily.

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8. The New Nation, 2007. htttp://www.bcas.net/Env.Features/NaturalHazards/2007/June2007/16%20to%2031.htm (accessed on February 07, 2009)

APPENDIX

Photographs of the Workshop held on August 28, 2008

Prof. Abdul Jabbar Khan presenting his lecture

Prof. M. A. Ansary, Director BNUS, inaugurating the workshop

A portion of the participants of the roundtable meeting chaired by VC, BUET

A portion of the participants of the roundtable meeting chaired by VC, BUET

Photographs of the Workshop held on November 15, 2008

LANDSLIDE THREATS AND DESTRUCTIONS IN CHITTAGONG

Living on dangerous slope
(Photo from Getty Images by AFP/Getty Images

Big shots levelled vast terrain of Ctg hills (www.sos-arsenic.net/english/ homegarden/gani.html)

Bangladeshi rescue workers recover the body of a child after the landslide in Chittagong, 11 June 2007 (Photo from Getty Images by AFP/Getty Images)

Photo: AP
Several rescuers dig for victims in Chittagong, Bangladesh, after mudslides (www.msnbc.msn.com/id /19168088/)

Bangladeshi rescue workers (AFP photo)
www.tribuneindia.com/2007/20070612 /world.htm

Bangladeshi rescue workers recover bodies after a landslide in Chittagong, 12 June 2007.
www.daylife.com/photo/0gDvdODcZg5QF

STEPS OF GEO-JUTE APPLICATION
Case Study of Road Side Slope Protection at Ranirhat Bridge Approach, Rangamati
Patronised by 16 Engineering Construction Battalion (ECB)


Dressing & Levelling of Ground


Spreading Of Fertilizer


Making Holes For Plantation


Laying And Fixing Geojute


Inserting U-Hook


Fixing Of Geojute Completed


Plantation


Plantation


Support For Plants


Spreading Grass Seeds


Seeds Germinated


Plants Growing Up

BANGLADESH NETWORK
OFFICE FOR URBAN SAFETY

PART-III

MACROSEISMIC SURVEY OF TWO RECENT EARTHQUAKES (RAJSHAHI & MYMENSINGH)

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared by: Afifa Imtiaz
Mehedi Ahmed Ansary

ABSTRACT

The seismic intensity is a very important information base for seismologists and engineers for research purposes and different types of seismological reconnaissance investigations. Estimation of strong motion parameters such as intensity is significant to evaluate attenuation characteristics and vulnerability relations of structures. Moreover, seismic intensity scale is widely used along with instrumental or recorded intensity for assessing the extents of probable damage distribution and needs for emergency response as well as for macro and micro zoning. The study of the "felt effects" of an earthquake through collecting and evaluating non-instrumental data on earthquakes such as observable effects on objects, people, buildings, and nature is termed as Macroseismology [3]. This is in distinction to Microseismology, which is the study of the instrumental recordings of earthquakes, i.e. seismograms. The methods for collecting and evaluating the macroseismic data often involves procedures based on long (trial-and-error) experience. After an earthquake is felt in some region, the data are usually collected by means of questionnaires. Field survey is an obligatory tool that complements the questionnaires in the case of a damaging earthquake. The present study deals with the collected information from questionnaire survey to estimate intensity of two recent earthquakes occurred on 5th and 27th July 2008 in Rajshahi and Mymensingh districts of Bangladesh.

INTRODUCTION

Recently Bangladesh has faced few consecutive earthquakes. Among them two earthquakes were felt considerably around the epicentral regions as well as in the capital Dhaka along with few occurrences of damages and panic among people. These earthquakes named as Rajshahi and Mymensingh, have become the focus of interests for the researchers of this field in the country. Since Bangladesh is still not well-equipped with the earthquake recording or measurement instruments, Earthquake Intensity scale, which do not require any instrumental procedure, can be a very effective tool to express the severity of an earthquake occurred. To enhance the earthquake research, and conduct seismic intensity surveys Bangladesh Network Office for Urban Safety (BNUS) formed a team with its working researchers under the guidance of the Director of BNUS, Prof. Dr. Mehedi ahmed Ansary. The main purpose of this research was to estimate the intensity of the two earthquakes as accurately as possible and try to extract some information in the absence of a strong motion seismograph record. A questionnaire was developed for the survey. Immediately after the occurrences of the earthquakes, the survey team visited the selected areas surrounding the origin and the persons live in and around the localities were interviewed door to door according to the questionnaire. Overall, the Field Survey received over 320 responses, where participants were mainly the local people. During the intensity survey, few damages at several locations were also observed. Figure 1 shows few recent earthquakes of Bangladesh along with the occurrences discussed in this study.

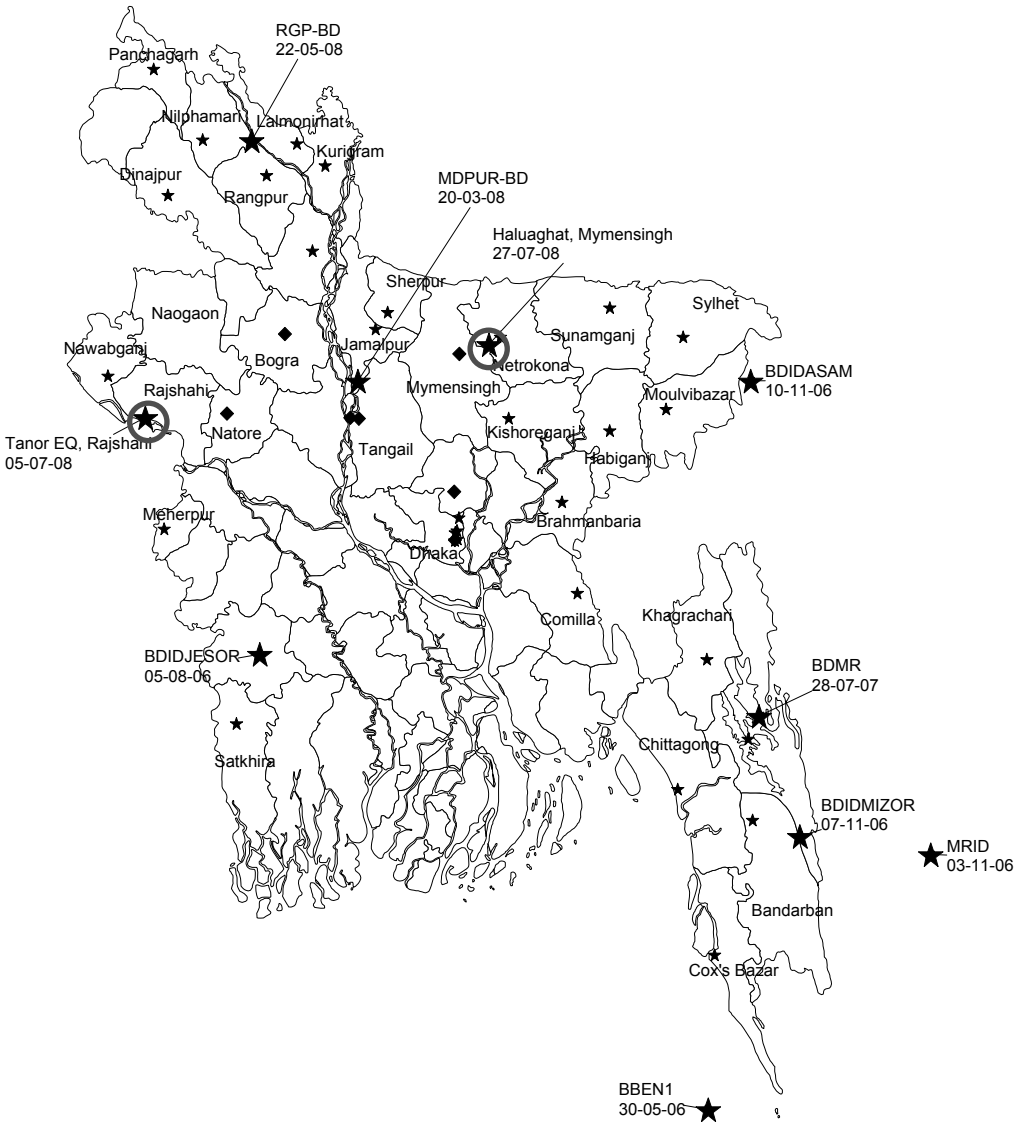


Figure 1: Few recent earthquakes of Bangladesh

THE SCALES OF EARTHQUAKE MEASUREMENT

Earthquakes are recorded with a seismometer. The severity or size of an earthquake is expressed in terms intensity and magnitude. These two terms are quite different. Seismologists use a Magnitude scale to express the seismic energy released by each earthquake. Magnitude is related to the amount of seismic energy released at the hypocenter of the earthquake. It is based on the amplitude of the earthquake waves recorded on instruments which have a common calibration. The magnitude of an earthquake is thus represented by a single, instrumentally determined value. Because magnitude does not describe the extent of the damage, its usefulness is limited to an approximation of whether the earthquake is large, small, or medium-sized. The destructiveness of an earthquake is a complex matter, related to the geology, population density, and cultural features of a specific area at a specific distance from the epicenter.

The effect of an earthquake on the Earth's surface is called the intensity. In seismology a scale of seismic intensity is a way of measuring or rating the effects of an earthquake at different sites. Intensity is based on the observed effects of ground shaking on people, buildings, and natural features. It varies from place to place within the disturbed region depending on the location of the observer with respect to the earthquake epicenter.

The Intensity Scale differs from the Richter Magnitude Scale in that the effects of any one earthquake vary greatly from place to place, so there may be many Intensity values (e.g.: IV, VII) measured from one earthquake. Each earthquake, on the other hand, should have just one Magnitude, although the several methods of estimating it will yield slightly different values (e.g.: 6.1, 6.3).

The European Macroseismic Scale, chosen as the basis of the current study, is commonly used in European countries by seismologists seeking information on the severity of earthquake effects. Intensity ratings are expressed as Roman numerals between I at the low end and XII at the high end.

THE EUROPEAN MACROSEISMIC SCALE

The European Macroseismic Scale (EMS) is the basis for evaluation of seismic intensity in European countries and moreover in use on most other continents. Issued in 1998 as update of the test version from 1992, the scale is referred to as EMS-98.
The history of the EMS began in 1988 when the European Seismological Commission (ESC) decided to review and update the Medvedev-Sponheuer-Karnik scale (MSK-64), which was used in its basic form in Europe for almost a quarter of a century. After more than five years of intensive research and development and a four-year testing period, the new scale was born. In 1996 the XXV General Assembly of the ESC in Reykjavik passed a resolution recommending the adoption of the new scale by the member countries of the European Seismological Commission.

The European Macroseismic Scale EMS-98 is the first intensity scale designed to encourage co-operation between engineers and seismologists, rather than being for use by seismologists alone. It comes with a detailed manual, which includes guidelines, illustrations, and application examples.

Unlike the earthquake magnitude scales, which express the seismic energy released by an earthquake, EMS-98 intensity denotes how strongly an earthquake affects a specific place. The European Macroseismic Scale has 12 divisions.

Table 1: Degrees and definitions of European macroseismic scale [6]

Short Form

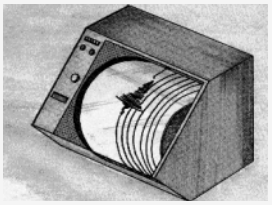
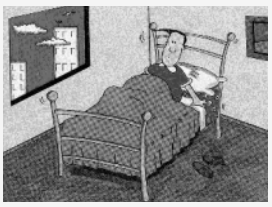
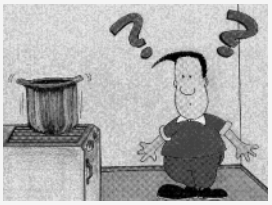
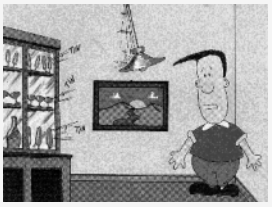
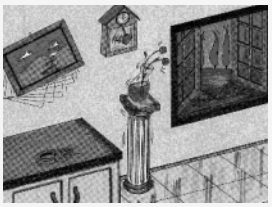
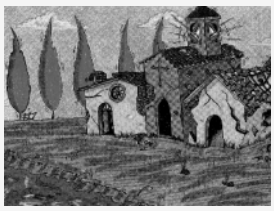
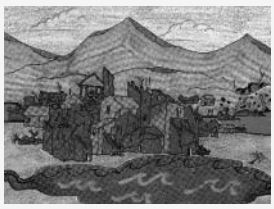
I. Not felt		Not felt, even under the most favorable circumstances.
II. Scarcely felt		Vibration is felt only by individual people at rest in houses, especially on upper floors of buildings.
III. Weak		The vibration is weak and is felt indoors by a few people. People at rest feel a swaying or light trembling.
IV. Largely observed		The earthquake is felt indoors by many people, outdoors by very few. A few people are awakened. The level of vibration is not frightening. Windows, doors and dishes rattle. Hanging objects swing.
V. Strong		The earthquake is felt indoors by most, outdoors by few. Many sleeping people awake. A few run outdoors. Buildings tremble throughout. Hanging objects swing considerably. China and glasses clatter together. The vibration is strong. Topheavy objects topple over. Doors and windows swing open or shut.
VI. Slightly damaging		Felt by most indoors and by many outdoors. Many people in buildings are frightened and run outdoors. Small objects fall. Slight damage to many ordinary buildings; for example, fine cracks in plaster and small pieces of plaster fall.

Table 1(contd.): Degrees and definitions of European macroseismic scale [6]

VII. Damaging		Most people are frightened and run outdoors. Furniture is shifted and objects fall from shelves in large numbers. Many ordinary buildings suffer moderate damage: small cracks in walls; partial collapse of chimneys.
VIII. Heavily damaging		Furniture may be overturned. Many ordinary buildings suffer damage: chimneys fall; large cracks appear in walls and a few buildings may partially collapse.
IX. Destructive		Monuments and columns fall or are twisted. Many ordinary buildings partially collapse and a few collapse completely.
X. Very destructive		Many ordinary buildings collapse.
XI. Devastating		Most ordinary buildings collapse.
XII. Completely devastating		Practically all structures above and below ground are heavily damaged or destroyed.

THE M4.1 RAJSHAHI EARTHQUAKE, 2008

A light earthquake occurred on the Bangladesh-India border, on 5 July 2008 at 22:55 PM local time in Bangladesh. According to ASC-India website, it had a magnitude of M=4.1(IMD) and was felt in parts Rajshahi in Bangladesh as well as in parts of West Bengal in India. The earthquake was centred 6.4 kms WNW of Rajshahi, Bangladesh.

In Rajshahi division it was strongly felt at Tanore, Bagha, Charghat, Puthia, Godagari, Chapainawabganj, Naogaon, Baghmara, Natore, Pabna and Rajshahi sending many people rushing outdoors. At least five buildings were partially damaged when a mild earthquake was felt in Rajshahi and its adjacent areas on Saturday night. The earthquake lasted for few seconds and the people of these areas getting panicked came out of their houses and stayed outside for some times to avoid any possible disaster. The Met Office in Rajshahi could not give any information about the earthquake as it has no Richter scale. News agency bdnews24.com adds: Mainul Islam, a meteorologist of the Met Office in Dhaka, said the quake was recorded at 10:55pm Saturday with its epicentre located 290 kilometres north-northwest of Dhaka. The UNB said: Around 300 university and college students left the private hostel Sunday morning as the six-storey building tilted during Saturday night's earthquake. Haji Hostel, housing 300 students of Rajshahi University, Rajshahi College and other educational institutions, tilted on the night but no one was reported injured. Around 20-30 old buildings in the north-western city also developed cracks, but there were no reports of anyone hurt [4]. Figure 2 shows the location and other information of the earthquake as published in ASC-India.

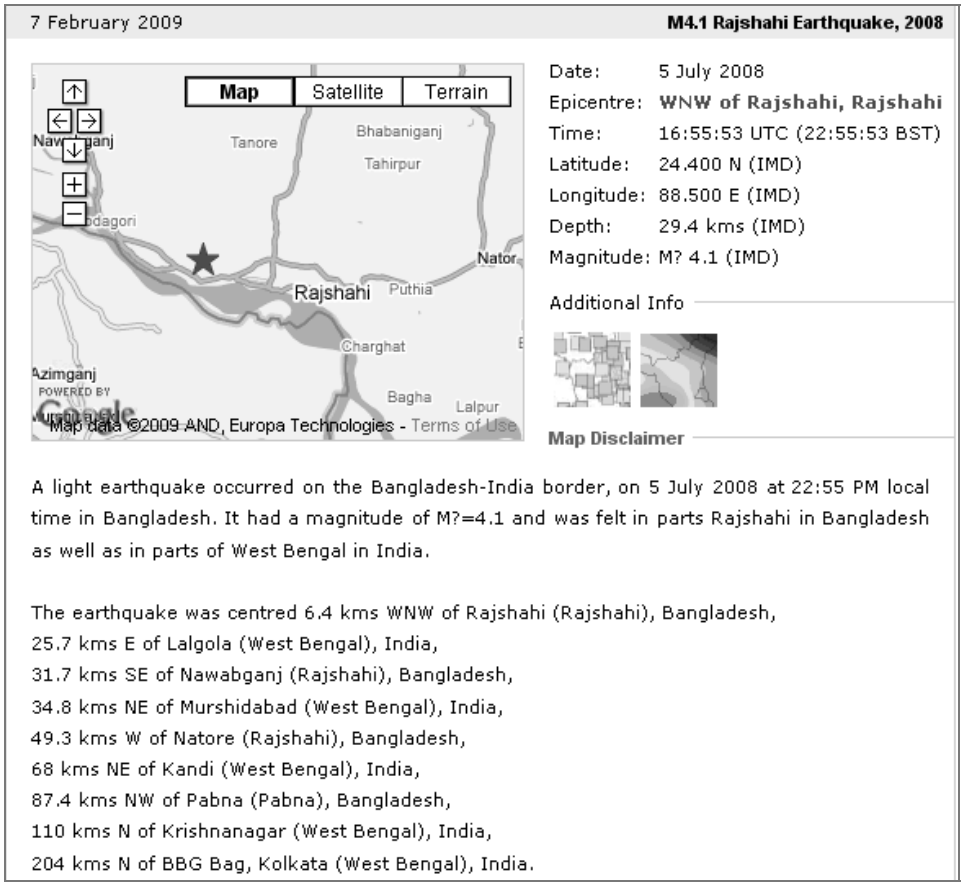


Figure 2: Location and description of Rajshahi Earthquake [1]

THE M4.9 MYMANSINGH-GAURIPUR EARTHQUAKE, 2008

A light earthquake occurred in northern Bangladesh, on 27 July 2008 at 00:51 AM local time (+6 GMT) in Bangladesh. It had its epicenter at ENE of Mymensingh and magnitude of Mb=4.9 (according to ASC-India website and U.S. Geological Survey, Mb=4.9: GS-NEIC, 5.1: GSR, 5.6 Reported by Bangladesh Weather Monitoring

Station). The tremor lasted for approximate 8 seconds and was felt in many parts of Bangladesh causing several injuries and considerable panic including the capital Dhaka. People panicked as the tremor shook twice at 00:51am when most people were asleep (saarc-sdmc). Many city-dwellers woke up and screamed in panic as buildings and cots jolted for a while. A meteorologist of the Metrology Department, cited at The New Nation, said that the earthquake originated from the bordering area of Sylhet and its magnitude was the highest in the year so far. It was reported that being panicked by the earthquake, a sexagenarian man died of heart attack at Talam Nadipara village in Tarash Upazila in Sirajganj district. Meanwhile, over 50 students of Dhaka University were injured as they jumped out from their dormitory windows to save their lives. Of the 50 injured students, the conditions of 10 were reported to be serious. They needed to be admitted to different hospitals including the Dhaka Medial College Hospital. The tremor also shook the buildings and business establishments in the Rajshahi city panicking the local people. Local people got scared as a few days back a moderate earthquake struck the northwestern part of the city at night. In the Barguna district, some 247 km south of the capital, people also felt the earthquake. The ceilings of two buildings of fourth-class employees of Dhaka Medical College Hospital (DMCH) at Elephant Road collapsed and walls developed cracks at many residential halls of Dhaka University after being jolted by the moderate earthquake. Around three to four thousand people of the staff quarters came hurriedly out of their residences under the open sky. Figure 3 shows the location and other information of the earthquake as published in ASC-India.

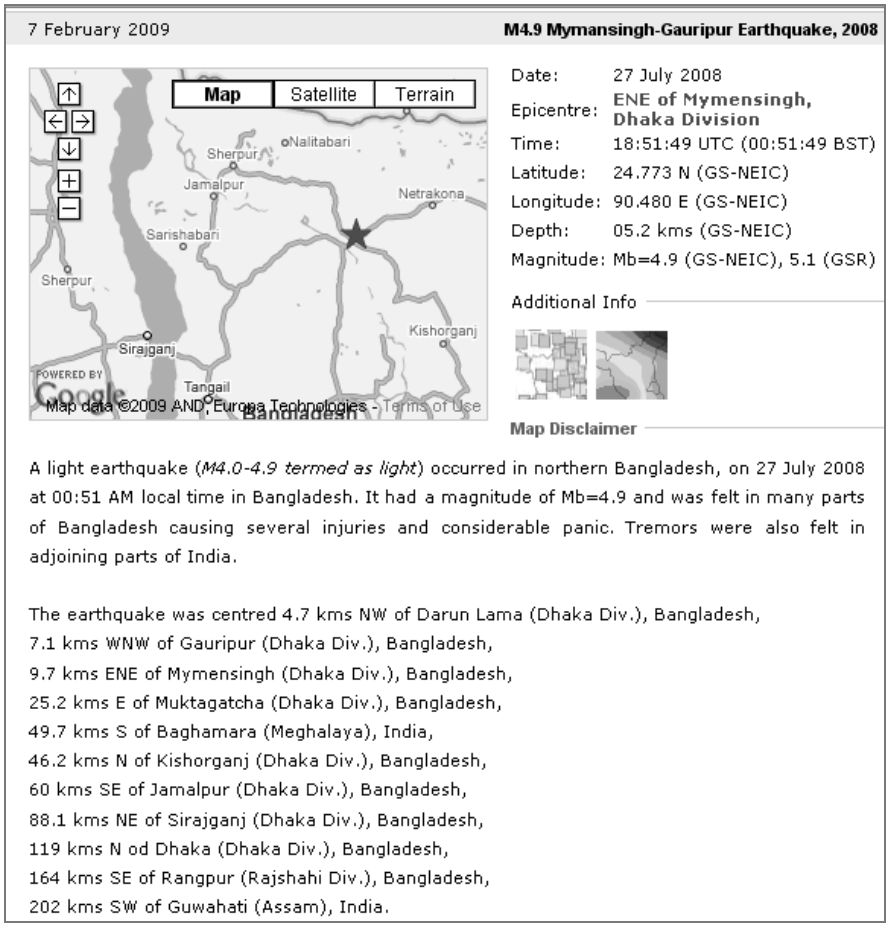


Figure 3: Location and description of Mymensingh earthquake [2]

THE QUESTIONNAIRE

A questionnaire consisting of 26 questions was developed for the survey. It was translated in Bengali for the convenience of communicating with local people. Questions were related to the person's location at the moment quake occurred and sensation of quaking, that is, personal experience, observed effects on the surroundings, condition of furniture inside house etc. The questions and answers were developed based on the definition of European Macroseismic Scale of 12 levels. For each item category, corresponding seismic intensity was given. Among the 26 survey questions, there were 16 items directly related to the intensity estimation. The questionnaire has been attached herewith as Appendix-A.

ESTIMATION OF THE INTENSITY

The Representative Seismic Intensity Method was used for estimating the intensity of a particular area. The method involves finding the maximum number of the distribution using the total number of participants' response. From one participant's response an estimate of the intensity was obtained. Then the group intensity formula (Eq 1) was used with the participant's intensity response.

$$\text{Representative Seismic Intensity} = \sum I_i / N \qquad (1)$$

I_i = Intensity from Each Survey Answer
N = Number of Participants

By this method the group intensity for a selected location is estimated. Then the average intensity of each area is obtained. A map of the seismic intensity distribution then is to be completed showing intensities of the selected areas around the source location of earthquake occurrence.

SURVEY DESCRIPTION

M4.1 Rajshahi Earthquake

The locations selected to perform the survey around the earthquake source, were Rajshahi City, Chapainawabganj, Godagari, Charghat and Saroda, Baghmara and Keshore, Natore and Tanore. The survey was conducted in all the areas except Tanore, from July 16th to 19th of 2008. Tanore was surveyed on July 27th, 2008. The survey was carried out through the pre-formatted questionnaire. A total of 200 inhabitants from the selected areas were considered for the questionnaire survey. From the collected data Intensity of different locations was assumed. The intensity of the quake assumed from the survey was V at Rajshahi, Chapainawabgonj, Baghmara, Keshore and Tanore, IV at Godagari, Saroda and III at Natore. Table 2 shows the summary of survey and estimated intensities.

Rajshahi City: The survey results indicate that the people living in Rajshahi and adjacent areas could feel the shaking which according to them, lasted for 5/6 seconds. Some people woke up from sleep and shaking of light furniture, doors and windows, gentle oscillation of hanging objects were also noticed in some cases. According to majority of the people the shaking was horrifying to them. The houses and shops of the city are mostly single or two storied brick-built and some are concrete structures with more than two stories. People living in tin-shed houses could notice a strange sound also. The surveyed students of Rajshahi University reported that almost all the students could feel the shaking and few became panicked. A hostel (six storied),

housing 300 students of Rajshahi University, Rajshahi College and other educational institutions, tilted on the night but no one was reported injured (Photo in Appendix). The building tilted on the nearby seven storied building and the residents of that building reported that they got frightened. Few hairline cracks on plasters were observed on the wall of the slanted building. Few other incidences of falling plasters and small cracks were found while surveuing.

Chapainawabganj: Most of the people in this town could feel the earthquake shaking. The houses and shops in the area are mostly brick built, some are of tin shed and some buildings were found to be of reinforced concrete frame. The people sleeping were awakened by the vibration. Someone noticed vibration on the pond water. The hanging objects and things on shelves swung and moved. The people living in tin-shed houses reported that they heard a strange noise on the tin. The furniture was also shaken a bit. But nobody reported about banging of doors and windows. Most of the people told that it was easy to stand while a few opined negatively. The people living near to railway station could not notice the vibration as they are quite used to that.

Godagari: Most of the buildings in the area are mostly brick built and some are of tin shed. The surveyed people were found to be indoors during the earthquake and some woke up from sleep due to vibration. Few people could notice swing in hanging objects or shaking of furniture. The people living in tin-shed houses could hear some strange noise. Nobody reported about banging of doors and windows. A housewife from the Agriculture Office Quarter reported that few utensils fell down from show case. One shop keeper claimed that he noticed long cracks on his shop's walls in the next morning (Photo in Appendix)

Tanore: Some people said there was a sound. Also doors and windows were vibrating. Hanging light bulbs were swinging like a pendulum. Surveys were carried down at market places, a group of people. After making conversations, it is skeptic that they got frightened. The area was beside Padma river. Maximum houses are built of clay soil. Some cracks occurred in some clay built houses. According to the seismic map of Bangladesh, this area falls under moderate seismic zone.

Baghmara and Keshor: The houses and shops in these two places were found to be mostly earthen, tin-shed and some with brick walls. The people could feel the shaking here clearly. The vibration was felt in houses. The small shops (surrounded by tin and having tin-shed) vibrated severely and things fallen from the shelves. Rattling sound was also noticed in doors and windows. A man claimed that one of the walls of his earthen house fallen due to the earthquake (Photo in Appendix).

Charghat (Sarada): The surveyed people at Charghat could feel the shake but few people noticed any objects moving or swinging. Few woke up from sleep. The persons from Police Academy reported that they could feel the vibration for 5/6 seconds, movement was felt easy, fans and light furniture moved a little but there was no vibration observed in doors and windows.

Natore: The people in this town were mostly in sleep during the earthquake. Many of them could not notice any earthquake. The persons who felt the shaking woke up from sleep, but reported that the vibration was very light and sudden. Few people could notice movement or swinging of objects or doors and windows.

M4.9 Mymansingh-Gauripur Earthquake

BNUS team surveyed towns and villages around the earthquake source through the same pre-formatted questionnaire. The survey was held from July 29th to August 4th of 2008 and a total of 120 inhabitants of the nearby areas were considered for the questionnaire survey. The team visited Mymensingh town and Agricultural University Premises, Haluaghat, Jaymangal, Nalitabari, Nakla, Dhobaura, Sherpur, Durgapur and Netrakona. From the collected data Intensity of different locations was assumed. The survey results indicate that the tremor lasting between 5-10 seconds was felt by many people indoors. It was strong enough to awaken the most of the sleeping people, shake light furniture, gently oscillate hanging objects and make showpiece fall from shelves. This earthquake was severely felt at Bangladesh Agriculture University, Mymensingh. Cracks due to this earthquake were observed in almost students' hall in this university. Some students were injured due to the panic from earthquake. The intensity of the quake assumed from the survey was VI at Mymensingh, Nalitabari and Nakla, VI+ at Haluaghat and Dhobora, V at Sherpur and Durgapur and IV at Netrakona. Table 3 shows the summary of survey and estimated intensities.

Haluaghat: The survey was started from Haluaghat village. All the people of the locality could feel the vibration of earth surface and they think that the vibration was not light rather stronger. Sixty percent of the surveyed people agreed that they could feel after shock and the rest were not agreed with this. No such visible damage occurred. But people felt the shaking very much. Someone dropped from beds when sleeping. Household materials dropped from shelves. Somebody said there was roaring sound during the earthquake. At one primary school plastering from the window wall spilled out. Crack also occurred in one clay-built house. Jaymangal, a small village near Haluaghat, faced earthquake severely. The main reason might be that most of the houses in this area were made by mud. Some small inhabitants of the villages Chatugaon, Ronokutura etc. on the way of Jaymangal also felt the vibration strongly. But no damage or crack occurred.

Mymensingh City: Most of the people were at sleep during the earthquake. Almost 85% people woke up due to the vibration. All the people who were not at sleeping condition felt the vibration. Public Works Department (PWD) and Local Government Engineering Department (LGED) were not reported about any damage due to this earthquake. People said about the swinging of hanging objects and shaking of the things kept on shelves. Few people noticed that birds showed anomaly behavior. This earthquake was severely felt at Bangladesh Agriculture University, Mymensingh. Cracks developed due to this earthquake were observed in students' halls in this university. Bangabandhu and Shahid Nazmul Ahsan Halls were affected. The team got the information that some students were injured due to the panic from earthquake.

Dhobaura: All the surveyed people of this area could feel the shaking and they think that the vibration was stronger. They were frightened due to sudden shock. Hanging elements such as fan, photo frame etc. was shaken. Glass, plate, bottle etc. were fallen from shelves. Chair, table, bed etc. were displaced in some house. They did not feel any aftershock. One man demanded that a mud wall of his house was fallen due to earthquake.

Sherpur: The surveyed people felt earthquake shaking. They think the strength of vibration was medium. The local shacks and stalls vibrated strongly. Biscuit packet, empty bottle were reported to be fallen from shelves of the shops. A man told that he was fallen from his bed. In Jalalpur, crack was found in a one storied house. Another person demanded that one part of his house collapsed due to earthquake. Door, windows were also swinging during earthquake.

Durgapur: Eighty percent people of this zone could feel the vibration of earth surface and they think that the vibration was medium or stronger. The people were frightened due to sudden shock. All small shabby shop vibrated strongly. Biscuit packet, empty bottle were fallen from shelf of these shop. At the center of Durgapur, the shop and houses found to be better built. No things from shelf were fallen and no damage occurred. But hanging things such as calendar, wall clock were vibrated. A fisher man told that he saw that frogs and fishes in the waterbody were jumping. In some houses chair, table etc. got displaced due to earthquake.

Netrakona: It is a densely populated town. The effect of earthquake was felt lightly here. Sixty people felt the vibration here. No damage was occurred due to earthquake. No object was fallen from shelf.

Nakla: Nakla is a small village. Maximum houses were Tin-shade. At some grocery shops some grocers said various items got displaced from shelves. One Rice mill owner showed his house, claiming that crack has occurred.

Nalitabari: In Nalitabari, almost all the surveyed people felt the vibration. But no one reported about any materials fallen from shelf. The people felt that the earthquake was more than medium. Some people faced trouble while walking. Someone heard strange sound during earthquake. Iron-gate of a house was making sound due to vibration. Plaster spilled out form a wall in UNO office and a mosque.

RESULTS AND DISCUSSION

From the results of the survey intensity isoseismals (Figure 4 and 5) have been drawn for both of the earthquake. The final intensity for Rajshahi earthquake was estimated to be IV+ and for Mymensingh earthquake VI-.

Table 2: Summary of survey for Rajshahi Earthquake

Locations	**Number of Surveys**	**Group Intensity**	
Rajshahi	40	V	5
Chapainawabgonj	40	V	5
Godagari	30	V	5
Baghmara & Keshore	25	V	5
Charghat & Saroda	15	IV	4
Natore	15	III	3
Tanore	35	V	5
Total	**200**	**Avg.**	**4.4**

Table 3: Summary of survey for Mymensingh Earthquake

Locations	Number of Surveys	Group Intensity	
Haluaghat	15	VI+	6.5
Jaymangal (Haluaghat)	10	VI+	6.5
Nalitabari	10	VI	6
Nakla	10	VI	6
Dhobaura	10	VI+	6.5
Mymensingh	25	VI	6.5
Sherpur	10	V	5
Durgapur	15	V	5
Netrakona	15	IV	4
Total	**120**	**Avg.**	**5.8**

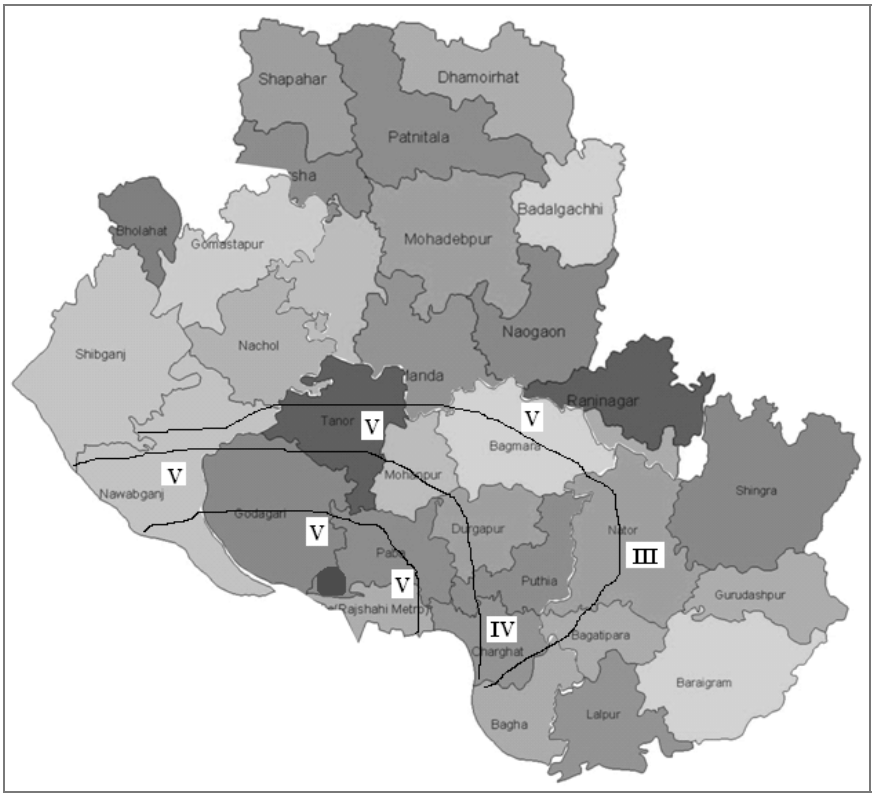


Figure 4: MM intensity isoseismals for Rajshahi Earthquake

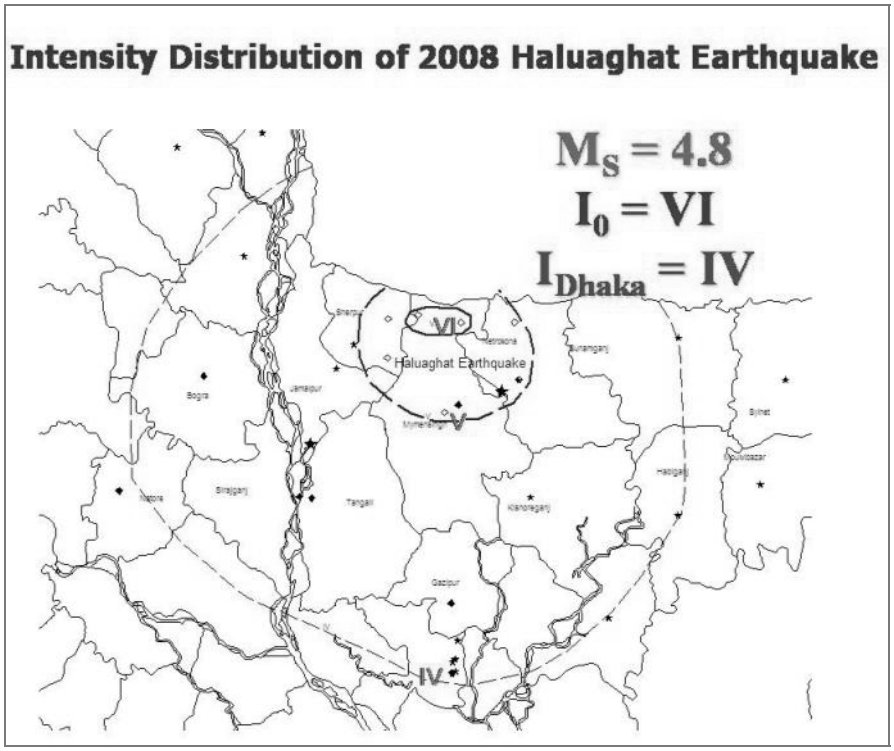


Figure 5: MM intensity isoseismals for Mymensingh Earthquake

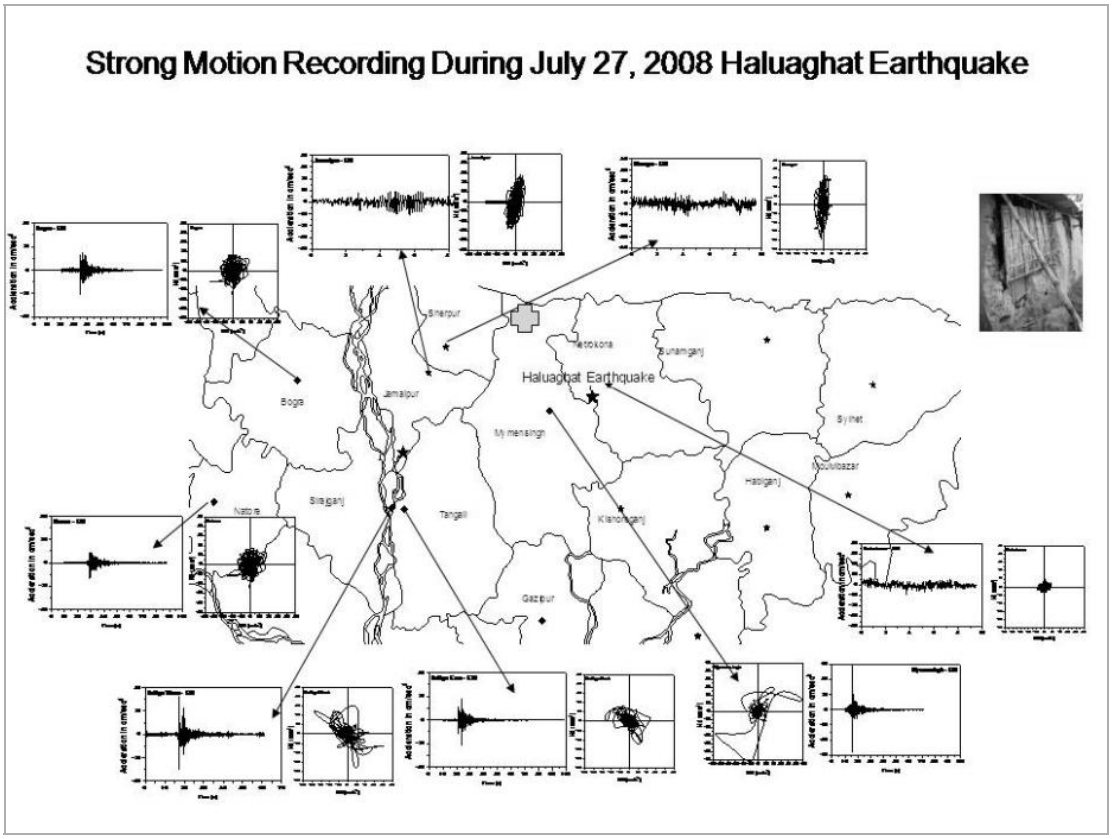


Figure 6: Strong motion record for Mymensingh Earthquake

The intensities from the survey can be more accurately defined if Fuzzy theory could be applied. More locations and people around the earthquake source could be surveyed also for better interpretation. Nevertheless there is scope of more research

and analysis from the surveyed data. The accuracy of the intensity distribution maps produced might be in question since they have been drawn roughly. Despite these difficulties, it is possible to make estimates because the number of participants is good enough, the surveys have been conducted immediately after the occurrences and the responses of the participants are concentrated in the selected places that are very close to the earthquake origin.

CONCLUSION

The estimated results obtained from the study seem to be quite comparable to the instrumentally measured earthquake magnitude. Since this type of seismic intensity survey is not performed very often in case of any earthquake occurrence in Bangladesh, the study lays a representation that this type of survey could be very useful for the researchers working in this field. It is possible to analyze the information more and find out some better interpretations and understandings from this study regarding the earthquakes which might be very helpful in effective macro as well as micro zoning and planning for the areas of concern.

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APPENDIX A
QUETIONNAIRE

Questionnaire for Earthquake Intensity Survey
Bangladesh University of Engineering and technology, Dhaka, Bangladesh

Name:
Age:
Education:
Gender:

1. Did you feel the earthquake? a) Yes b) No
   If the answer is Yes, then the other questions are asked.
2. Where were you when the earthquake occurred?
   Union/Village:
   Upazila, District:
3. The Place where you were during earthquake is a-

a) Plane Land b) On a hill c) Slope d) Valley e) Other……

4. Were you indoors or outdoors when the earthquake occurred?

a) Indoors b) Outdoors c) On the car

5. If you were inside the house, then which was that?

a) Home b) Office c) Shop d) Other……

6. What was the main material of the building?

a) Brick-built b) Earthen c) Wooden d) Bamboo-made e) Concrete d) Other……

7. The number of stories of the house: _____
8. Which floor were you staying on: _____
9. According to you how was the tremor?

a) Slight and hardly felt [-2] b) Slight (a light truck passing by) [3]
c) Considerable (a heavily loaded truck passing by) [4]
d) Strong (a heavy object falling inside the building) [5]
e) Very Strong and destructive [6-]

10. How long was the tremor?

a) Sudden (5-6 secs) b) Short (10-15 secs) c) Long (20-30 secs) d) Very Strong (≥30secs)

11. Did you awake due to the earthquake?

a) Was not sleeping b) No [-4] c) Yes, but did not realize why awoke [5]
d) Yes, and realized that it was an earthquake [6-]

12. Were you frightened during the tremor?

a) Not at all [-4] b) A little bit [5] c) Quite [6] d) Scared [7-]

13. What did you do during the shaking?

a) Stayed still on the place b) Trying to save myself or something valuable
c) Went to other room d) Went out of the house e) Other…….

14. How difficult was movement during shaking---

a) Easy [-5] b) Difficult but movement possible [6] c) Difficult to stand and move [7]
d) Faltered during movement [8-] e) Did not want to move

15. How the animals behaved

a) There was no animal to observe b) Behaved abnormally [-4]
c) Ran outdoor [-6] d) Was running here and there and screaming [7-]

16. Were the hanging objects such as photo-frames or light swinging?

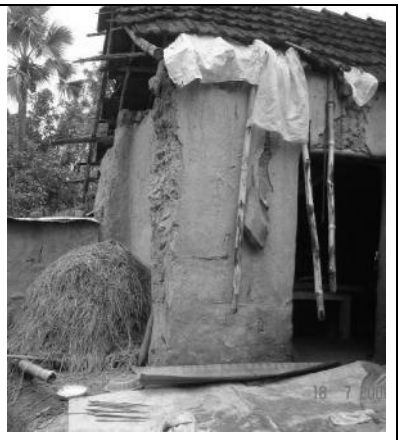
a) No [-3] b) Slight swinging [4] c) Significant Swinging with banging noises [5]
d) Severe Shaking or fallen [6] e) Few fallen & damaged [7]
17. What happened to the windows, doors or utensils?
a) Nothing [-3] b) Rattling of windows and dishes [4]
c) Banging of Doors and Windows [5] d) Some Utensils broken [6]
e) Few windows broken [7]
18. Did the objects kept at shelves shake?
a) No [-3] b) Few displaced [4] c) Few overturned [5]
c) Few fallen [6] d) All fallen [7-]
19. What happened to the furniture?
a) Nothing [-4] b) Slight Shaking [5] c) Considerable Shaking [6]
c) Partly moved [7] d) Moved and overturned [8] e) Furniture Damaged [9]
20. What happened to the plaster?
a) Nothing [0] b) Fine cracks on plaster [-5] c) Plaster removed from here & there [6]
d) Plaster fallen in considerable amount [7] e) Whole faces of plaster fallen [8-]
21. What happened to the outer walls?
a) Nothing [-6] b) Small cracks [7] c) Large and deep cracks [8]
e) Gaps or One or more walls collapsed [9-]
22. What was the damage to the building?
a) Nothing. [-7] b) Damage in the outer walls and roofs [8]
c) Collapse in the outer walls [8-]
23. Was there any damage to the boundary wall or sculpture nearby?
a) No [-5] b) Narrow crack [6] c) Deep crack [7] d) Toppled down [8-]
24. Was there any crack on the earth or landslide nearby?
a) No [-5] b) Narrow cracks [6-7] c) Many instances and wide cracks [8]

d) Innumerable instances [9]
25. Was anyone injured from you or your family?
a) No b) Yes, slightly c) Treatment needed d) Needed to be hospitalized
26. Did you feel any shaking afterwards?
a) Yes b) No

APPENDIX B
Photographs of Damages Observed

Tilting of 6-story building in Rajshahi, due to Rajshahi Earthquake

Crack in a shop at Godagari, due to Rajshahi Earthquake



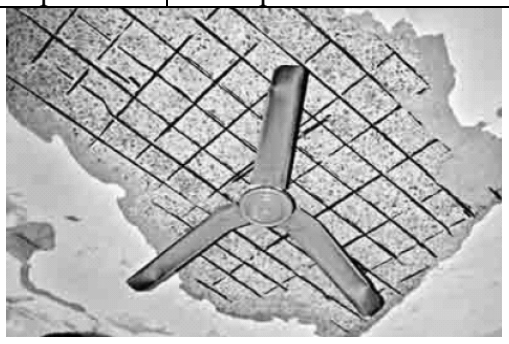
Collapse of an earthen wall at Baghmara, due to Rajshahi Earthquake

Crack in clay built house at village Haluaghat due to Mymensingh Earthquake

Crack in a residential hall at Mymensingh Agricultural University due to Mymensingh Earthquake

Hairline Crack occurred at a rice mill owner's house, Nakla due to Mymensingh Earthquake

Cracks on wall of Muhsin Hall Dhaka University and injured students, due to Mymensingh Earthquake [5]

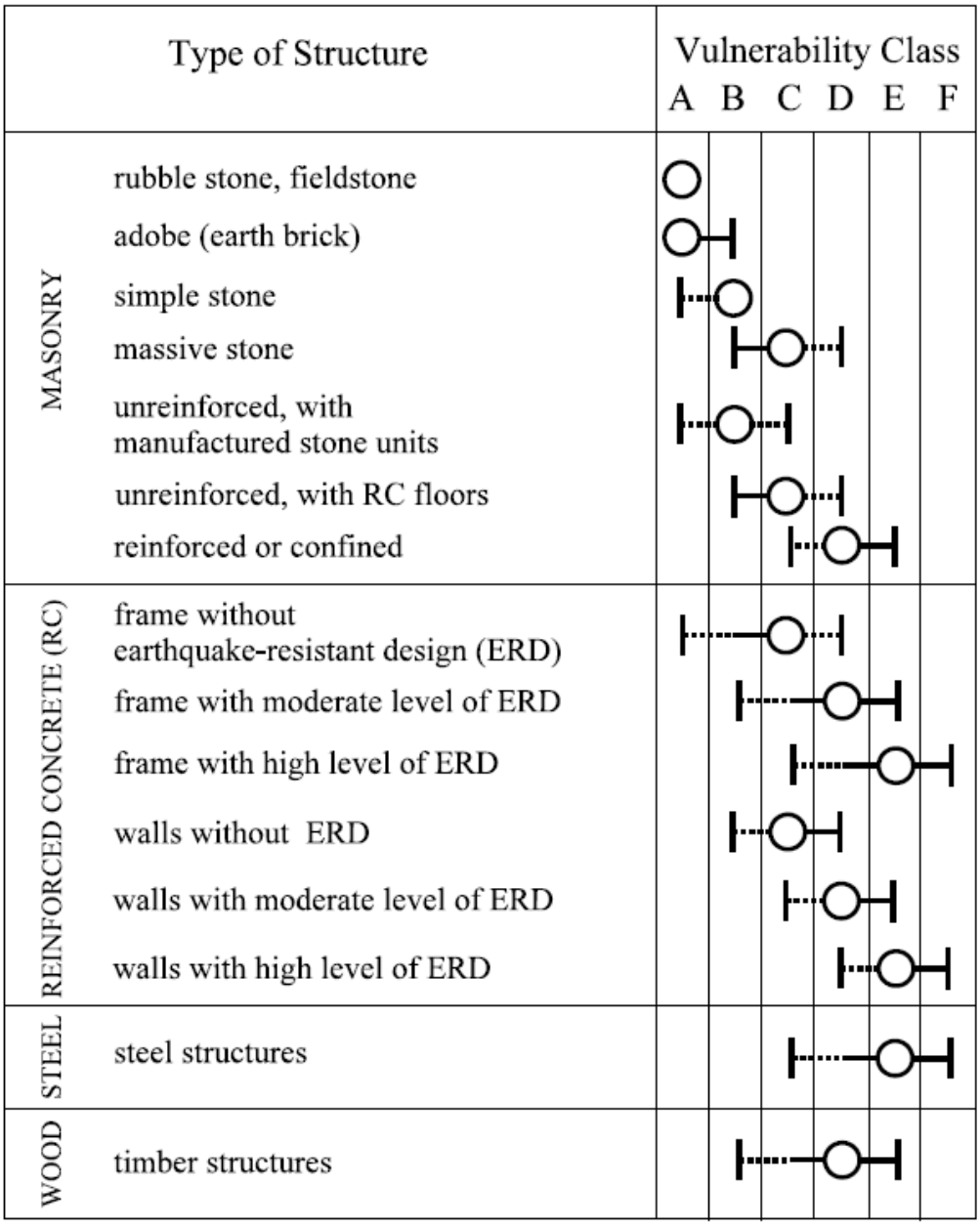


Roof of a residential quarter of Dhaka Medical College Employee, due to Mymensingh Earthquake [5]

APPENDIX C

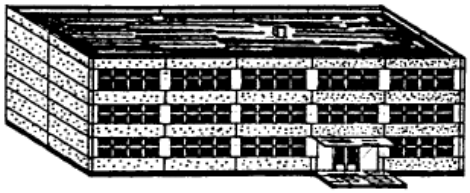
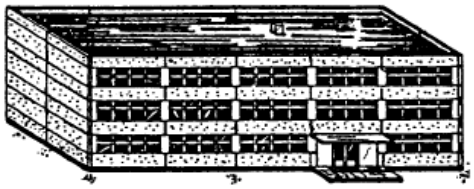
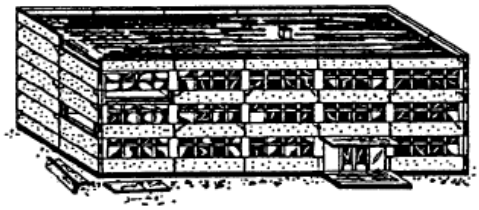
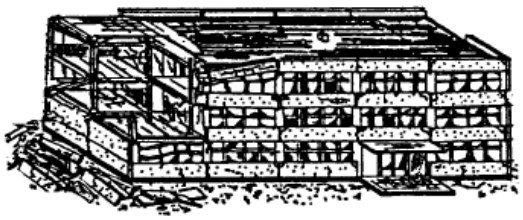
MACROSEISMIC INTENSITY SCALE [7]
Classifications used in the European Macroseismic Scale (EMS)

Differentiation of structures (buildings) into vulnerability classes (Vulnerability Table)

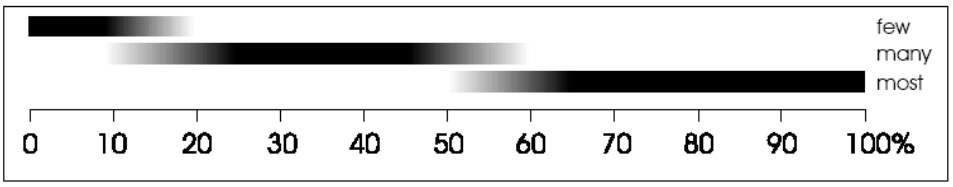


Classification of damage

Classification of damage to masonry buildings	
	**Grade 1: Negligible to slight damage** **(no structural damage, slight non-structural damage)** Hair-line cracks in very few walls. Fall of small pieces of plaster only. Fall of loose stones from upper parts of buildings in very few cases.
	**Grade 2: Moderate damage** **(slight structural damage, moderate non-structural damage)** Cracks in many walls. Fall of fairly large pieces of plaster. Partial collapse of chimneys.
	**Grade 3: Substantial to heavy damage** **(moderate structural damage, heavy non-structural damage)** Large and extensive cracks in most walls. Roof tiles detach. Chimneys fracture at the roof line; failure of individual non-structural elements (partitions, gable walls).
	**Grade 4: Very heavy damage** **(heavy structural damage, very heavy non-structural damage)** Serious failure of walls; partial structural failure of roofs and floors.
	**Grade 5: Destruction** **(very heavy structural damage)** Total or near total collapse.

Classification of damage to buildings of reinforced concrete	
	**Grade 1: Negligible to slight damage** **(no structural damage,** **slight non-structural damage)** Fine cracks in plaster over frame members or in walls at the base. Fine cracks in partitions and infills.
	**Grade 2: Moderate damage** **(slight structural damage,** **moderate non-structural damage)** Cracks in columns and beams of frames and in structural walls. Cracks in partition and infill walls; fall of brittle cladding and plaster. Falling mortar from the joints of wall panels.
	**Grade 3: Substantial to heavy damage** **(moderate structural damage,** **heavy non-structural damage)** Cracks in columns and beam column joints of frames at the base and at joints of coupled walls. Spalling of conrete cover, buckling of reinforced rods. Large cracks in partition and infill walls, failure of individual infill panels.
	**Grade 4: Very heavy damage** **(heavy structural damage,** **very heavy non-structural damage)** Large cracks in structural elements with compression failure of concrete and fracture of rebars; bond failure of beam reinforced bars; tilting of columns. Collapse of a few columns or of a single upper floor.
	**Grade 5: Destruction** **(very heavy structural damage)** Collapse of ground floor or parts (e. g. wings) of buildings.

Definitions of quantity



Definitions of intensity degrees

Arrangement of the scale:
a) Effects on humans
b) Effects on objects and on nature
c) Damage to buildings

I. Not felt
a) Not felt, even under the most favourable circumstances.
b) No effect.
c) No damage.

II. Scarcely felt
a) The tremor is felt only at isolated instances (<1%) of individuals at rest and in a specially receptive position indoors.
b) No effect.
c) No damage.

III. Weak
a) The earthquake is felt indoors by a few. People at rest feel a swaying or light trembling.
b) Hanging objects swing slightly.
c) No damage.

IV. Largely observed
a) The earthquake is felt indoors by many and felt outdoors only by very few. A few people are awakened. The level of vibration is not frightening. The vibration is moderate. Observers feel a slight trembling or swaying of the building, room or bed, chair etc.
b) China, glasses, windows and doors rattle. Hanging objects swing. Light furniture shakes visibly in a few cases. Woodwork creaks in a few cases.
c) No damage.

V. Strong
a) The earthquake is felt indoors by most, outdoors by few. A few people are frightened and run outdoors. Many sleeping people awake. Observers feel a strong shaking or rocking of the whole building, room or furniture.
b) Hanging objects swing considerably. China and glasses clatter together. Small, top-heavy and/or precariously supported objects may be shifted or fall down. Doors and windows swing open or shut. In a few cases, window panes break. Liquids oscillate and may spill from well-filled containers. Animals indoors may become uneasy.
c) Damage of grade 1 to a few buildings of vulnerability class A and B.

VI. Slightly damaging
a) Felt by most indoors and by many outdoors. A few persons lose their balance. Many people are frightened and run outdoors.

b) Small objects of ordinary stability may fall and furniture may be shifted. In few instances dishes and glassware may break. Farm animals (even outdoors) may be frightened.
c) Damage of grade 1 is sustained by many buildings of vulnerability class A and B; a few of class A and B suffer damage of grade 2; a few of class C suffer damage of grade 1.

VII. Damaging

a) Most people are frightened and try to run outdoors. Many find it difficult to stand, especially on upper floors.
b) Furniture is shifted and top-heavy furniture may be overturned. Objects fall from shelves in large numbers. Water splashes from containers, tanks and pools.
c) Many buildings of vulnerability class A suffer damage of grade 3; a few of grade 4.
Many buildings of vulnerability class B suffer damage of grade 2; a few of grade 3.
A few buildings of vulnerability class C sustain damage of grade 2.
A few buildings of vulnerability class D sustain damage of grade 1.

VIII. Heavily damaging

a) Many people find it difficult to stand, even outdoors.
b) Furniture may be overturned. Objects like TV sets, typewriters etc. fall to the ground. Tombstones may occasionally be displaced, twisted or overturned. Waves may be seen on very soft ground.
c) Many buildings of vulnerability class A suffer damage of grade 4; a few of grade 5.
Many buildings of vulnerability class B suffer damage of grade 3; a few of grade 4.
Many buildings of vulnerability class C suffer damage of grade 2; a few of grade 3.
A few buildings of vulnerability class D sustain damage of grade 2.

IX. Destructive

a) General panic. People may be forcibly thrown to the ground.
b) Many monuments and columns fall or are twisted. Waves are seen on soft ground.
c) Many buildings of vulnerability class A sustain damage of grade 5.
Many buildings of vulnerability class B suffer damage of grade 4; a few of grade 5.
Many buildings of vulnerability class C suffer damage of grade 3; a few of grade 4.
Many buildings of vulnerability class D suffer damage of grade 2; a few of grade 3.
A few buildings of vulnerability class E sustain damage of grade 2.

X. Very destructive

c) Most buildings of vulnerability class A sustain damage of grade 5.
Many buildings of vulnerability class B sustain damage of grade 5.
Many buildings of vulnerability class C suffer damage of grade 4; a few of grade 5.
Many buildings of vulnerability class D suffer damage of grade 3; a few of grade 4.
Many buildings of vulnerability class E suffer damage of grade 2; a few of grade 3.
A few buildings of vulnerability class F sustain damage of grade 2.

XI. Devastating

c) Most buildings of vulnerability class B sustain damage of grade 5.
Most buildings of vulnerability class C suffer damage of grade 4; many of grade 5.
Many buildings of vulnerability class D suffer damage of grade 4; a few of grade 5.
Many buildings of vulnerability class E suffer damage of grade 3; a few of grade 4.
Many buildings of vulnerability class F suffer damage of grade 2; a few of grade 3.

XII. Completely devastating

c) All buildings of vulnerability class A, B and practically all of vulnerability class C are destroyed. Most buildings of vulnerability class D, E and F are destroyed. The earthquake effects have reached the maximum conceivable effects.

BANGLADESH NETWORK
OFFICE FOR URBAN SAFETY

PART-IV

TRAINING PROGRAM FOR MASONS: HOW TO BUILD EARTHQUAKE RESISTANT BUILDINGS

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared by: Rajon Saha
Mehedi Ahmed Ansary

INTRODUCTION

On the 16th October 2008, BNUS organized a three day training program particularly for the masons. They were given theoretical knowledge about earthquake definition, how it occurs, and earthquake history of Bangladesh, how to arrange and form special reinforcement in beams and columns and slabs. Also knowledge on how to form hooks in stirrups, ties and bar splicing, earthquake resistant wall footings, single footings, combined footings etc. were given. At the end of the training they appeared for written exams. After the theoretical training they had also built a small structure consisting of 10' x 10' small room providing earthquake resistant reinforcement with base footing. Generally in Bangladesh masons do not have any idea about building earthquake resistant buildings. They do not reinforce the partition walls and also how to integrate it with the beam column. They were given knowledge about forming collar in partition walls to give it stiffness and integrate it with the beam column to resist lateral force during earthquake. They were also given knowledge about placing vertical rods in the partition walls. The knowledge of masons are very poor if we compare it with earthquake resistant reinforcement specially in bending hooks in stirrups and ties of beam and column. Also they were informed about quality control and maintenance. At the end of the theoretical training they were given ideas about how to retrofit previously built buildings such as the method of bolting, jacketing, beam column casing, split and bandage.

DETAIL INVESTIGATION

Masons are given idea about following ten chapters of the manual.

1. Earthquake and its cause
2. Site selection
3. Preparation of foundation
4. Building foundation of concrete buildings
5. Beam and column
6. Walls
7. Slab
8. Quality control and evaluation of work
9. Repair and maintenance
10. Retrofitting

Figure 1: Masons conducting theoretical training

Figure 2: At the end of theoretical training

At the end of theoretical training masons appeared for written exams and their performance was good.

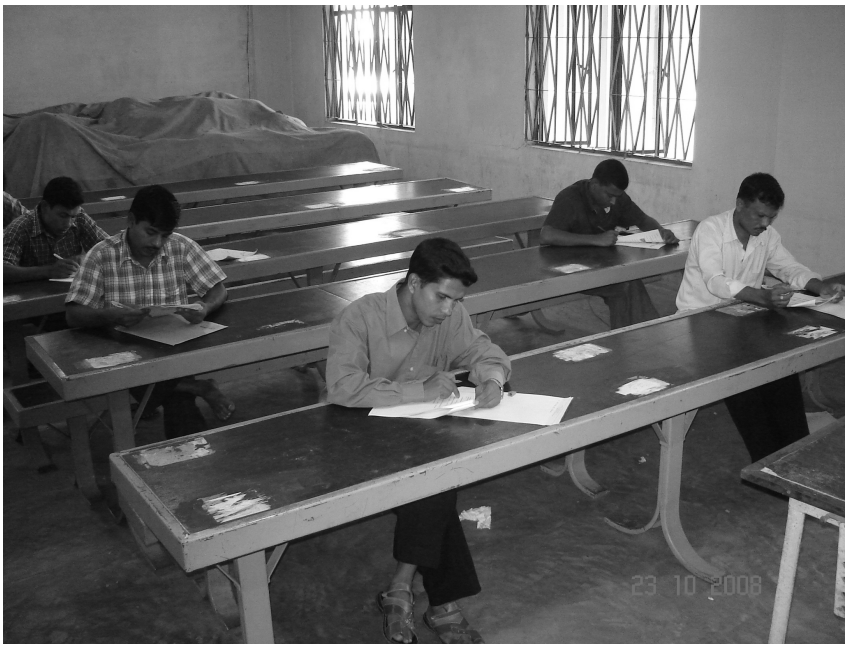


Figure 3(a): Written exam is ongoing

Figure 3(b): At the end of written exam.

After the three day continuous training program written exam was taken. All the questions were multiple choice question type. Their performance was very good. After the three days long theoretical training masons started their practical training.

The objective of the practical training is to build a 10'x10' small room with beams, columns and footings on ground. 10 mm, 12 mm and 16 mm rods are purchased for the purpose. For stirrups and ties mainly 10 mm rods are used. For beam and column 12mm and 16mm rods are used. The whole structure was on the ground. At first, stirrup and tie rods were bent. For bending of stirrups and ties, masons bent the rods at 135 degree angle. Actually they do the traditional bending of 90 degree which is not acceptable. G.I. wires were used for attaching the rods with one another. Then footing rods are prepared. Column rods are bent accordingly for joining them with the footing. Masons attached column rods strongly with the footing rods. Tie spacing from the column base is 100 mm c/c up to the grade beam and column joint. Stronger beam column joint are generally expected for proper earthquake resistant reinforcement.

Figure 4: Bending of stirrups and tie rods.

Figure 5: Beam and column preparation.

Figure 6: Beam and column fixing.

Figure 7: Preparation of the structure.

100 mm stirrup and tie spacing is strongly maintained at all beam and column joints.

(a)

(b)

Figure 8: Final preparation.

At other places except the joints stirrup and tie spacing was 150 mm. Masons used ladder for fixing the top beam. Same as the grade beam stirrup spacing is maintained at top beam.

Figure 9: Completed structure

Figure 10: Structure was painted for easy understanding of critical zones

BANGLADESH NETWORK
OFFICE FOR URBAN SAFETY

PART-V

STRONG MOTION MONITORING SYSTEM IN BANGLADESH (MAR 2008 - FEB 2009)

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared by: Md. Samsur Rahman
Mehedi Ahmed Ansary

INTRODUCTION

An earthquake is a sudden and violent motion of the earth usually caused by volcanic eruption, plate tectonics, or man-made explosions which lasts for a short time, and within a very limited region. Most earthquakes last for less than a minute. The larger earthquakes are followed by a series of after-shocks which also may be dangerous. Volcanic eruption or plate tectonics is responsible for causing earthquakes. Also small earthquakes can be caused by blasting, quarrying and mining. Man made earthquakes are like underground nuclear explosions. But plate tectonics cause large number of big earthquakes. Recently on August 22, 2008 an earthquake was recorded by the free-field stations Rangamati, Bandarban and Chittagong (Agrabad) at 07:42:55 hrs BST (13:42:55 hrs GMT,August 22, 2008). Magnitude of this earthquake was 4.9 and depth 25 Km. Maximum acceleration of this earthquake in Chittagonj (Rahmatganj) was 58.5964 cm/sec^2 and it was in North-South directions. On another earthquake July 27,2008 Mymensingh (Haluaghat) was recorded by the free-field stations at Netrokona, Kishoreganj, Sherpur, Jamalpur, Hobiganj, Moulovibazar, Rangpur and Nilphamari in the time of 12:52:58 hrs BST (18:52:58 hrs GMT, July 27, 2008). Magnitude of this earthquake was 4.8 and depth was 44 Km. Maximum acceleration of this earthquake in Jamalpur was 54.3198 cm/sec^2 and it was in North-South direction. Last on January 06, 2009 an Earthquake (Tangail-Local Earthquake) was recorded by the free-field stations Jamuna-bridge east site, west site, Bogra and Natore at 22:03:32 hrs BST (16:03:32 hrs GMT, January 06, 2009). The 1897 Great Indian earthquake with a magnitude of 8.7 is one of the strongest earthquakes in the world, had its epicenter only 230 km from Dhaka. While the earthquake affected almost whole of Bangladesh, damages were very severe particularly in Sylhet, Rangpur, Dhaka and Mymensingh. In the city of Dhaka most of the brick masonry buildings either collapsed or were severely damaged. The relationship between magnitude, epicentral distance and peak ground acceleration of those earthquakes constitute the basic parameter needed for assessing seismic hazard at a given site. The purpose of this study is to present a predicting model for acceleration-attenuation for earthquakes in Bangladesh and its neighboring region. For this purpose, 34 analog SMAs were recently deployed all over in Bangladesh. The Operating and Monitoring Phase of the project has started on April 01, 2005.This accelerometer gives data in North-South, East-West and Up-Down direction. Then Fourier spectrum ratio (Horizontal to Vertical) for various free field stations are studied and compared. The worldwide tendency of the people to concentrate more in urban areas increases the seismic risk, especially in the developing countries. This paper explains the main steps of the process to estimate the distributions of the ground shaking intensity and of the corresponding damage to structures. After collecting of earthquake data, it is necessary to process this data by SCANVIEW PLUS software. Origin can be used to read from ASCII file input and to obtain corrected acceleration time history and Fast Fourier Transform of data from various stations. The Strong Motion Accelerograph must be situated in the ground surface, soil condition to be hard or sandy soil. In case study there are two SMA-Instrument setup at the top slab in a 6th storied building and another of the 11th storied building and that we are shown in difference between them.

OBJECTIVES

During the last two centuries, Bangladesh and its neighbouring region have experienced several large earthquakes. The peak ground acceleration of these earthquakes has been estimated using different existing attenuation law. But for

earthquake hazard analysis, unified acceleration attenuation relationship for Bangladesh is required.

The major objectives of the study are as follows:

(a) To develop an acceleration based attenuation relationship for Bangladesh and it's surrounding region**.**
(b) To identify the factor involved in soil displacement for Ground Motion.

EARTHQUAKE AWARNESS

Community Awareness Programs through meetings, seminars, workshops, posters have been carried forward among community leaders and community people, local NGOs, school teachers etc. to raise awareness and develop interest regarding Earthquake Hazards. School and community based training programs and mock exercises have also been conducted to make people prepared and ensure their participation at disaster period activities as well as post disaster actions.

EARTHQUAKE RECORDS

Recorded earthquakes with different accelerometer are listed bellow

- May 30, 2006 : Bay of Bengal Earthquake
- August 05, 2006 : Jessore Earthquake
- November 03, 2006 : Myanmar-India Earthquake
- November 10, 2006 : Bangladesh-India (Assam) Earthquake
- July 28, 2007: India-Myanmar Earthquake
- November 07, 2007: Bangladesh-Myanmar Earthquake (1)
- March 20, 2008: Modhupur Earthquake
- July 05, 2008: West-Bengal (Rajshahi) Earthquake
- July 27, 2008: Haluahhat (Mymensingh) Earthquake
- August 23, 2008: Bangladesh-Myanmar Earthquake (2)
- January 06, 2009: Tangail (Local) Earthquake

As a result of continuous monitoring in the four year of the monitoring phase, ten earthquake has been detected at the SMA site. At first on May 30, 2006, a small earthquake was recorded at 19:43:51 hrs BST, (13:43:51 hrs GMT, May 30, 2006) at the Chittagong site and Name of Earthquake Bay of Bengal earthquake. Its Magnitude was 4.7 and depth was 29Km. This is the first earthquake recorded by the stations since their installation. Epicentre of this earthquake lies close to the SMA site. Last on January 06, 2009 an Earthquake (Tangail-Local Earthquake) was recorded by the free-field stations Jamuna-bridge east site, west site, Bogra and Natore at 22:03:32 hrs BST (16:03:32 hrs GMT, January 06, 2009). The recorded SMA sites Chittagong (Rahmatganj), Bandarban and Rangamati. Its Magnitute was 4.9 and depth was 25 Km. Maximum acceleration of this earthquake in Chittagong (Rahmatganj) was 58.5964 cm/sec.^{2} and it was in North-South direction.

4.1 May 30, 2006: Bay of Bengal earthquake: On May 30, 2006 an earthquake was recorded by the free-field stations Cox's bazar at 19:43:51 hrs BST (13:43:51 hrs GMT, May 30, 2006). Its latitude was 22.60ºN and longitude was 91.94ºE This earthquake occurred in the Bay of Bengal. Agrabad and Rahamatganj free-field stations also recorded this event. Magnitude of this earthquake was 4.7 and depth was 29 Km. Maximum acceleration of this earthquake at Cox's bazar was 16.5989 cm/sec.^{2} and it was in North-South direction.

4.2 August 05, 2006: Jessore earthquake: On August 05, 2006 an earthquake was recorded by the free-field stations Meherpur at 14:42:51 hrs BST (08:42:51 hrs GMT, August 05, 2006). This earthquake occurred in the Jessore. Its latitude was 23.10ºN and Longitude was 89.20ºE Sathkhira free-field stations also recorded this event. Its Magnitude 4.0 and depth was 15 Km. Maximum acceleration of this earthquake in Meherpur was 24.3526 cm/sec.^{2} and it was in North-South direction.

4.3 November 03, 2006: Myanmar-India earthquake: On November 03, 2006 an earthquake was recorded by the free-field stations Cox's bazar, Chittagong (Rahmatganj), Bandarban, Rangamati and Khagrachari at 18:45:58 hrs BST (12:45:58 hrs GMT, November 03, 2006). Its latitude was 22ºN and longitude was 93.30ºE This earthquake occurred in the Myanmar-India. Magnitude of this earthquake was 5.2 and depth was 33 Km. Maximum acceleration of this earthquake in Chittagong (Rahmatganj) was 34.565 cm/sec.^{2} and it was in East-West direction.

4.4 November 10, 2006: Bangladesh-India (Assam) earthquake: On November, 2006 an earthquake was recorded by the free-field stations Sylhet at 07:32:45 hrs BST (13:32:45 hrs GMT, November 10, 2006). This earthquake occurred in Bangladesh-India (Assam). Sunamganj, Moulovibazar and Hobiganj free-field stations had also recorded this event. Magnitude of this earthquake was 5.0 and depth was 33 Km. Maximum acceleration of this earthquake in Cox's bazar was 34.5989 cm/sec.^{2} and it was in North-South direction.

4.5 July 28, 2007: India-Mynmar earthquake: On July 28, 2007 an earthquake was recorded by the free-field stations Rangamati at 08:25:50 hrs BST (14:25:50 hrs GMT, July 28, 2007). This earthquake occurred in the Rangamati, Bandarban, Khagrachari and Chittagong (Rahmatganj) this event. Magnitude of this earthquake was 4.8 and depth was 32 Km. Maximum acceleration of this earthquake in Rangamati was 30.1254cm/sec.^{2} and it was in East-West direction.

4.6 November 07, 2007: Bangladesh-Mynmar earthquake (1): On November 07, 2007 an earthquake was recorded by the free-field stations Bandarban at 12:42:58 hrs BST (06:42:58hrs GMT, November 07, 2007). This earthquake occurred in the Rangamati, Bandarban, Khagrachari, Coxsbazar and Chittagong (Rahmatganj) this event. Magnitude of this earthquake was 5.3 and depth was 25 Km. Maximum acceleration of this earthquake in Bandarban was -95.8806cm/sec.^{2} and it was in North-South direction.

4.7 March 20, 2008: Modhupur earthquake: On March 20, 2008 an earthquake was recorded by the free-field stations Airport Hazicamp and jamalpur at 07:30:50 hrs BST (13:30:50 hrs GMT, March 20, 2008). Magnitude of this earthquake was 4.2 and depth was 25 Km. Maximum acceleration of this earthquake in Jamalpur was 32.2265cm/sec.^{2} and it was in North-South direction.

4.8 July 05, 2008: West-Bengal (Rajshahi) earthquake: On July 05, 2008 an earthquake was recorded by the free-field stations Chapai-Nawabganj at 10:55:58 hrs BST (16:55:58 hrs GMT, July 05, 2008). Magnitude of this earthquake was 4.1 and depth was 29 Km. Maximum acceleration of this earthquake in Chapai-Nawabganj was -42.9893 cm/sec.^{2} and it was in East-West direction.

4.9 July 27, 2008: Haluaghat earthquake: On July 27, 2008 an earthquake was recorded by the free-field stations Netrokona, Kishoreganj, sherpur, jamalpur, Hobiganj, Rangpur and Nilphamari at 12:55:58 hrs BST (18:52:58 hrs GMT, July 27, 2008). Magnitude of this earthquake was 4.8 and depth was 44 Km. Maximum acceleration of this earthquake in Jamalpur was 54.3198 cm/sec.^{2} and it was in North-South direction.

4.10 August 23, 2008: Bangladesh-Myanmar Earthquake (2): On August 23, 2008 an earthquake was recorded by the free-field stations Rangamati, Bandarban and Chittagong (Agrabad) at 07:42:55 hrs BST (13:42:55 hrs GMT, August 23, 2008). Magnitude of this earthquake was 4.9 and depth was 25 Km. Maximum acceleration of this earthquake in Chittagonj (Rahmatganj) was 58.5964 cm/sec.^{2} and it was in North-South direction.

4.11 January 06, 2009: Tangail (Local) Earthquake: On January 06, 2009 an earthquake was recorded by the free-field stations Jamuna Bridge East site, West site, Bogra and Natore at 22:03:32 hrs BST (16:03:32 hrs GMT, August 23, 2008). Magnitude of this earthquake was 4.0 and depth was 10 Km. Maximum acceleration of this earthquake in Jamuna bridge east site was 19.72705 cm/sec.^{2} and it was in East-West direction. Time history of ground motion are shown in Appendix-A and last SMAs monitoring schedule are shown in Appendix-B.

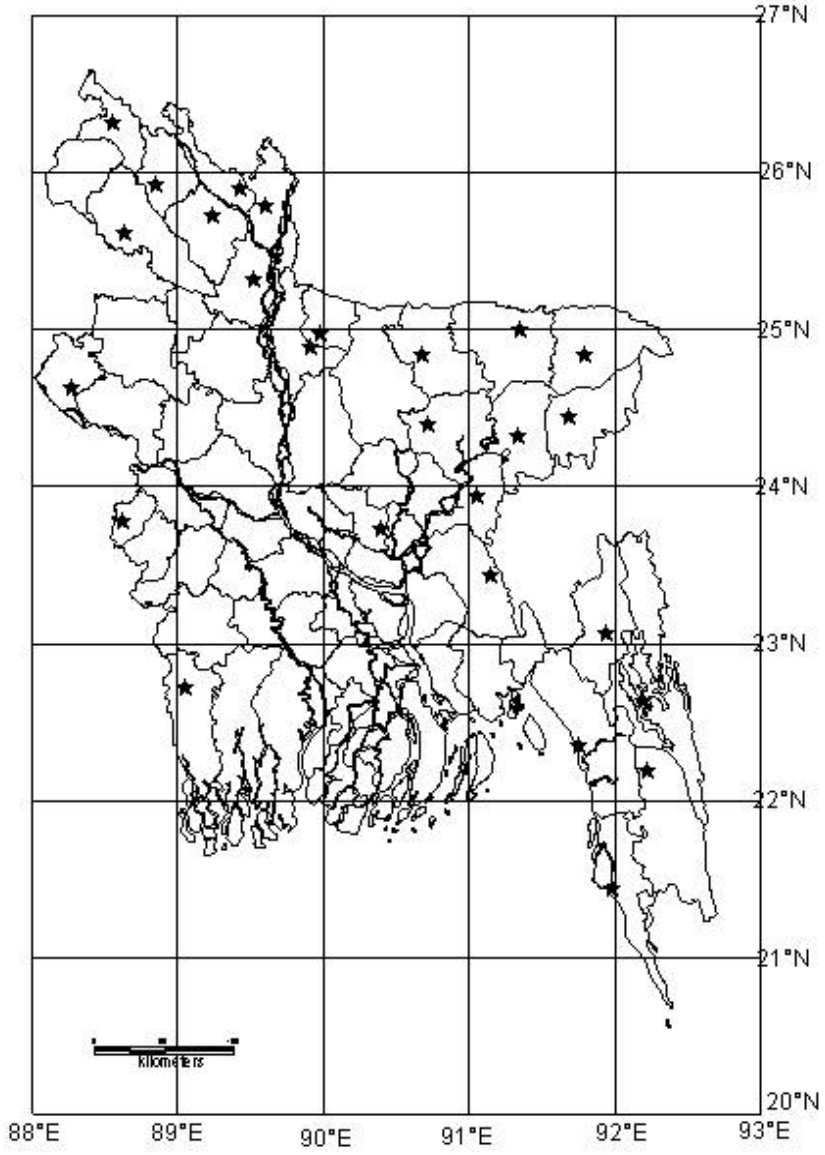


Figure1: SMAs-Location map of the study

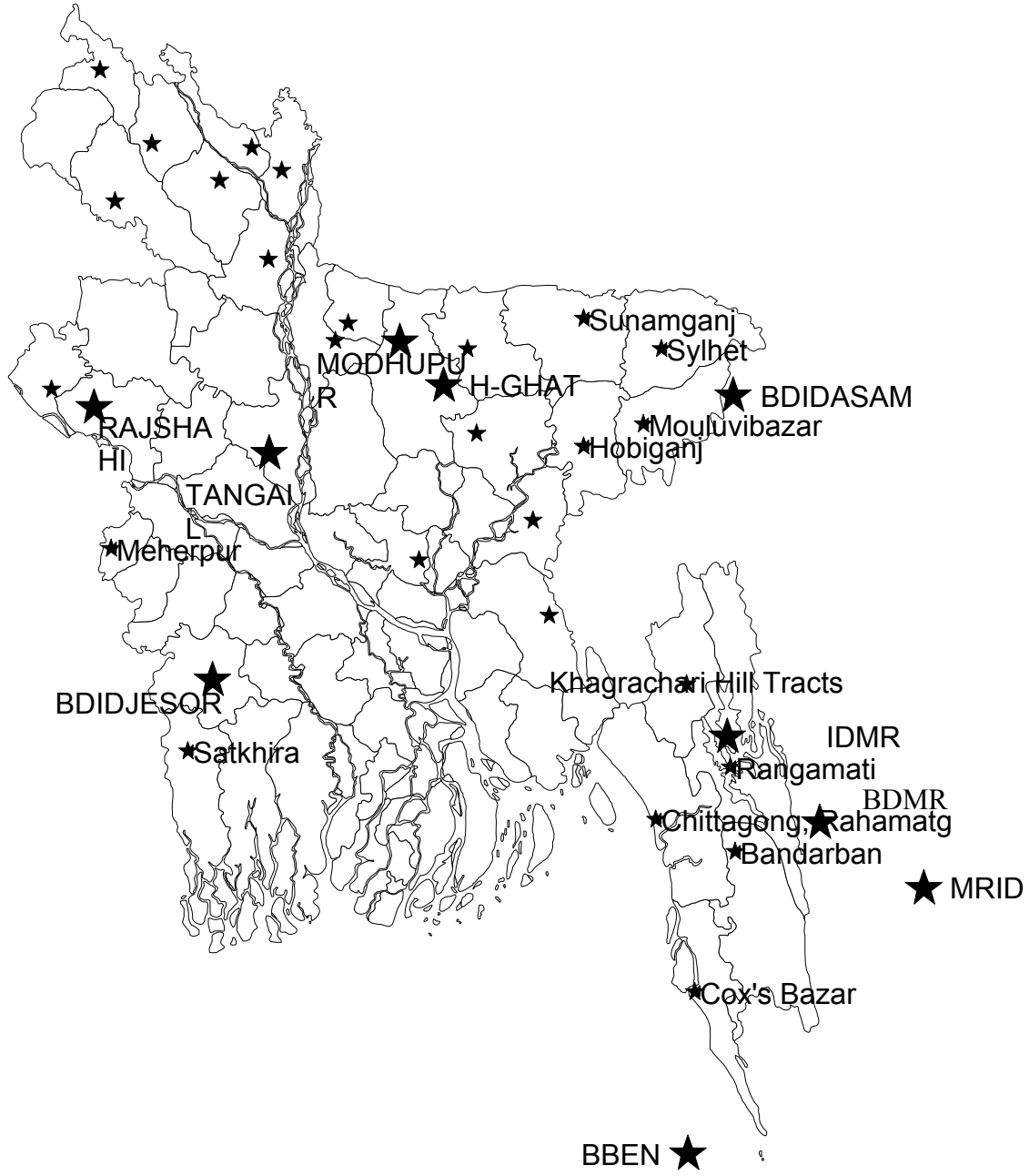


Figure 2: Name of earthquake and Location of SMAs was recorded at free-field station

Table 1: Summary of recorded earthquake events with different accelerometer are shows in below

Name of the earthquake	Occurrence date	Latitude (deg.)	Longitude (deg.)	Magnitude	Depth (km)	Maximum recorded acceleration (cm/sec^2)	Recorded site
Bay of Bengal	30.05.2006	20.60ºN	91.94ºE	4.7	29	16.0	Agrabad, Rahamatganj and Coxbazar
Jessore	05.08.2006	23.10ºN	89.20ºE	4.0	15	24.0	Meherpur and Sathkhira
Mynmar-India	03.11.2006	22ºN	93.30ºE	5.2	33	34.0	Rahamatganj, Coxbazar, Bandanbhan, Khagrachari and Rangamati
Bangladesh-India (Assam)	10.11.2006	24.60ºN	92.20ºE	5.0	33	34.0	Sylhet, Sunamganj, Moulovibazar and Hobiganj
India-Mynmar	28.07.2007	22.80ºN	92.60ºE	4.8	15	32.0	Rahamatganj, Bandarbhan, Khagrachari and Rangamati
Name of the earthquake	**Occurrence date**	**Latitude (deg.)**	**Longitude (deg.)**	**Magnitude**	**Depth (km)**	**Maximum recorded acceleration (cm/sec^2)**	**Recorded site**
Modhupur	20.03.2008	23.60ºN	91.20ºE	4.2	25	32.0	Airport Hazicamp ,jamalpur and Serajganj Jamuna Bridge east end and west end.
Bangladesh-	07.11.2007	22.80ºN	92.60ºE	5.3	15	96.0	Rahamatganj, Bandarbhan, Khagrachari,Cox'sbazar

Myanmar (1)							and Rangamati
West-Bengal (Rajshahi)	05.07.2008	24.4ºN	88.5ºE	4.1	29	42.9893	Chapai-nawabganj
Haluaghat (Mymensingh)	27.07.2008	23.60ºN	91.20ºE	4.8	44	54.3198	Sherpur, Jamalpur, Netrokona, Kishoreganj, Hobiganj, Rangpur and Nilphamari
Bangladesh-Myanmar (2)	22.08.2008	22.80ºN	92.60ºE	4.9	25	58.5964	Rangamati, Bandarban and Chittagong(Rahmatganj)
Tangail (Local)	06.01.2009	24.39ºN	89.75ºE	4.0	10	19.72705	Jamuna-bridge East site, West site, Bogra and Natore

Table 2: Summary of ground motion in free field stations due to Bay of Bengal Earthquake on May 30, 2006

Station ID#	**Channel**	**Date**	**Time (GMT)**	**Latitude & Longitude**	**Derived Max. Peak Ground Acceleration** (cm/sec^2)
Cox's-bazar	EW	30.05.2006	13:43:51	20.60ºN 91.94ºE	4.9
	UD	30.05.2006	13:43:51		13.5
	NS	30.05.2006	13:43:51		14.5
Chittagong Rahmatganj	EW	30.05.2006	13:43:51	22.36ºN 91.754ºE	8.8
	UD	30.05.2006	13:43:51		23.5
	NS	30.05.2006	13:43:51		14.8
Chittagong Agrabad	EW	30.05.2006	13:43:51	22.36ºN 91.754ºE	7.2
	UD	30.05.2006	13:43:51		11.3
	NS	30.05.2006	13:43:51		8.0

Note. EW represents East-West direction,
UD represents Vertical direction
NS represents North-South direction

Table 3: Summary of ground motion in free field stations due to Mynmar-India Earthquake on July 28, 2007

Station ID#	**Channel**	**Date**	**Time (GMT)**	**Latitude & Longitude**	**Derived Max. Peak Ground Acceleration** (cm/sec^2)
Chittagonj Rahmatganj	EW	28.07.2007	14:25:50	22.36ºN 91.754ºE	30.1234
	UD				7.4503
	NS				-24.037
Khagrachari	EW	28.07.2007	14:25:50	23.073ºN 91.932ºE	22.631
	UD				-13.4388
	NS				17.4021
Rangamati	EW	28.07.2007	14:25:50	22.636ºN 92.184ºE	30.1251
	UD				-9.3788
	NS				26.5455
Bandarban	EW	28.07.2007	14:25:50	22.19ºN 92.211ºE	-27.7955
	UD				27.9241
	NS				27.8693

Note. EW represents East-West direction
UD represents Vertical direction
NS represents North-South direction

Table 4 Summary of ground motion in free field stations due to India-Myanmar Earthquake on November 07, 2007

Station ID#	**Channel**	**Date**	**Time (GMT)**	**Latitude & Longitude**	**Derived Max. Peak Ground Acceleration** (cm/sec^2)
Chittagonj Rahmatganj	EW	07.11.2007	07:42:58	22.36ºN 91.754ºE	70.8127
	UD				-54.2329
	NS				61.098
Bandarban	EW	07.11.2007	07:42:58	22.19ºN 92.211ºE	93.8406
	UD				-79.0933
	NS				-95.8806

Note. EW represents East-West direction
UD represents Vertical direction
NS represents North-South direction

Table 5: Summary of ground motion in free field stations due to Modhupur Earthquake on March 20, 2008

Station ID#	Channel	Date	Time (GMT)	Latitude & Longitude	Derived Max. Peak Ground Acceleration (cm/sec^2)
Airport Hazicamp	EW	20.03.2008	07:30:50	24.36ºN 90.754ºE	14.077
	UD				-9.7784
	NS				-23.3316
Jamalpur	EW	20.03.2008	07:30:50	23.19ºN 89.94ºE	-16.2078
	UD				-27.450
	NS				-32.2265
Serajganj Jamuna Bridge East-End site	EW	20.03.2008	07:30:50	24.56ºN 92.32ºE	-14.05202
	UD				-5.68216
	NS				-8.18763
Serajganj Jamuna Bridge West-End site	EW	20.03.2008	07:30:50	24.56ºN 92.32ºE	-16.29742
	UD				4.63804
	NS				-14.74256

Note. EW represents East-West direction
UD represents Vertical direction
NS represents North-South direction

Table 6: Summary of ground motion in free field stations due to (Haluaghat) - Mymensingh Earthquake on July 27, 2008

Station ID#	**Channel**	**Date**	**Time (GMT)**	**Latitude & Longitude**	**Derived Max. Peak Ground Acceleration** (cm/sec^2)
Sherpur	EW	27.07.2008	18:52:58	23.25ºN 89.64ºE	-10.9215
	UD				6.4647
	NS				-38.4383
Jamalpur	EW	27.07.2008	18:52:58	23.19ºN 89.94ºE	-32.4108
	UD				-6.3360
	NS				29.1048
Netrokona	EW	27.07.2008	18:52:58	23.15ºN 8924ºE	-10.2193
	UD				22.8482
	NS				9.7069
Kishoreganj	EW	27.07.2008	18:52:58	23.01ºN 89.14ºE	-9.1392
	UD				9.053
	NS				-18.0918

Note. EW represents East-West direction
UD represents Vertical direction
NS represents North-South direction

Table 7: Summary of ground motion in free field stations due to Rajshahi (Local) Earthquake July 05, 2008

Station ID#	Channel	Date	Time (GMT)	Latitude & Longitude	Derived Max. Peak Ground Acceleration (cm/sec^2)
Chapai-Nawabganj	EW	05.07.2008	16:55:58	24.4ºN 88.5ºE	-42.9893
	UD				22.7635
	NS				24.1283
Hobiganj	EW	27.07.2008	18:52:58	23.19ºN 89.94ºE	15.3964
	UD				5.1350
	NS				11.3501
Rangpur	EW	27.07.2008	18:52:58	24.56ºN 92.32ºE	-30.9155
	UD				-10.3673
	NS				-35.8158
Nilphamari	EW	27.07.2008	18:52:58	24.56ºN 92.32ºE	-20.3333
	UD				-6.2455
	NS				-24.3198

Note. EW represents East-West direction
UD represents Vertical direction
NS represents North-South direction

Table 8: Summary of ground motion in free field stations due to Bangladesh-Myanmar Earthquake-2 on August 23, 2008

Station ID#	**Channel**	**Date**	**Time (GMT)**	**Latitude & Longitude**	**Derived Max. Peak Ground Acceleration** (cm/sec^2)
Rangamati	EW	23.08.2008	13:42:55	24.36ºN 90.754ºE	18.6082
	UD				6.4106
	NS				-50.075
Bandarban	EW	23.08.2008	13:42:55	23.19ºN 89.94ºE	-13.0285
	UD				-6.1549
	NS				45.4263
Chittagong (Rahmatganj)	EW	23.08.2008	13:42:55	24.56ºN 92.32ºE	20.8493
	UD				-6.5376
	NS				58.5964

Note. EW represents East-West direction
UD represents Vertical direction
NS represents North-South direction

Table 9: Summary of ground motion in free field stations due to Tangail (Local) Earthquake on January 06, 2009

Station ID#	Channel	Date	Time (GMT)	Latitude & Longitude	Derived Max. Peak Ground Acceleration (cm/sec^2)
Jamuna-bridge East-site	EW	06.01.2009	22:03:32	24.39ºN 89.80ºE	17.4063
	UD				-9.7964
	NS				-16.1617
Jamuna-bridge West-site	EW	06.01.2009	22:03:32	24.39ºN 89.75ºE	-18.3281
	UD				-6.3768
	NS				-19.7205
Bogra	EW	06.01.2009	22:03:32	23.96ºN 89.02ºE	-3.03319
	UD				-202147
	NS				2.9243
Natore	EW	06.01.2009	22:03:32	23.7ºN 89.52ºE	2.4357
	UD				1.6186
	NS				1.4875

Note. EW represents East-West direction
UD represents Vertical direction
NS represents North-South direction

The summary of recorded earthquake events and the description of those earthquakes are shown in Table 2, 3, 4, 5, 6, 7, 8, 9 and Table10. Earthquake time period (duration) of different location of instrumentation.

Table 10: Earthquake time period (duration) of different location of instrumentation

Station ID#	**Latitude & Longitude**	**Time period (sec.)**
Bay of Bengal Earthquake	20.60ºN 91.94ºE	22
Jessore Earthquake	23.10ºN 89.20ºE	18
Myanmar-India Earthquake	22ºN 93.30ºE	17
Bangladesh-India (Assam) Earthquake	24.60ºN 92.20ºE	16
India-Myanmar Earthquake	22.80ºN 92.60ºE	25
Bangladesh-Myanmar Earthquake (1)	22.80ºN 92.60ºE	21
Modhupur Earthquake	24.36ºN 90.754ºE	20
West-Bengal (Rajshahi)	24.4ºN 88.5ºE	18
Mymensingh (Haluaghat)	24.16ºN 90.65ºE	15
Bangladesh-Myanmar Earthquake (2)	22.80ºN 92.60ºE	17
Serajganj (Local) Earthquake	24.39ºN 89.75ºE	16

CONCLUSION

The first earthquake recorded by SMAs was the Bay of Bengal Earthquake (1) on May 30, 2006. Recently on August 22, 2008 an earthquake was recorded by the free-field stations Rangamati, Bandarban and Chittagong (Rahmatganj)) at 07:42:55 hrs BST (13:42:55 hrs GMT, August 22, 2008) with the name of Bangladesh-Myanmar Earthquake. On January 06, 2009 another Earthquake (Tangail-Local Earthquake) was recorded by the free-field stations Jamuna-bridge east site, west site, Bogra and Natore at 22:03:32 hrs BST (16:03:32 hrs GMT, January 06, 2009). By recording this earthquake events, the installation of the earthquake monitoring system for Bangladesh entered in to an interesting stage. The earthquake, which was a minor one, is estimated to be located close to the SMA site. This paper presents analysis results of that particular earthquake data recorded by three free-field stations namely, Chittagong (Rahmatganj), Rangamati and Bandarban. After installation of the system so far ten earthquakes were recorded. It is hoped that the system will yield valuable data to the local researchers to have better ideas on the performance of the SMA sites as well as seismic activities of the whole region. For the next few years compilation of such earthquake data is needed to develop the attenuation law for Bangladesh. This attenuation law will help us to develop the seismic zonation map for Bangladesh.

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APPENDIX-A

Time history of ground motion at free field stations in the last five earthquakes between MAR 2008 and FEB 2009

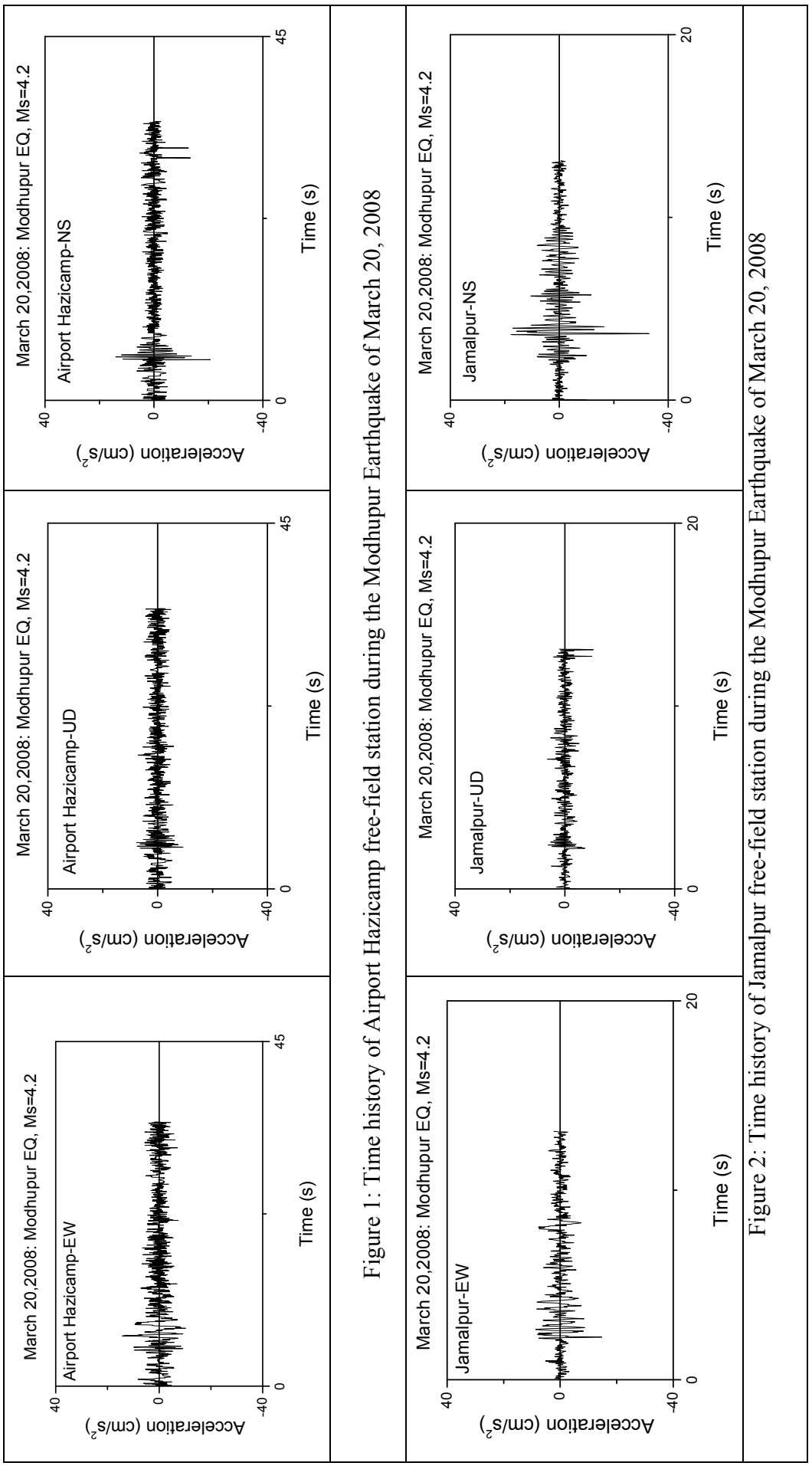
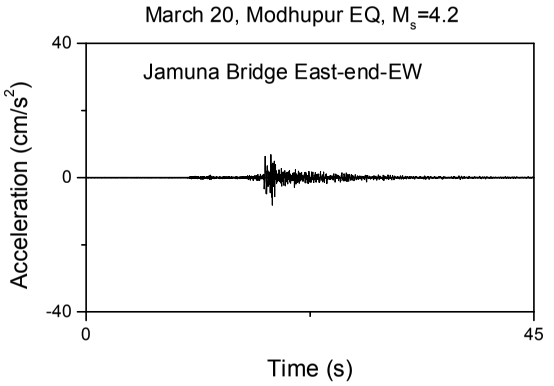
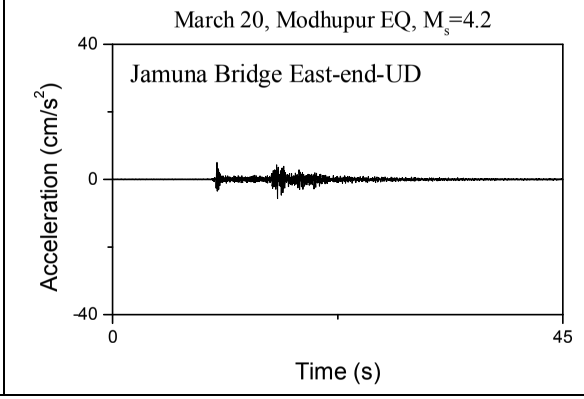


Figure 1: Time history of Airport Hazicamp free-field station during the Modhupur Earthquake of March 20, 2008

Figure 2: Time history of Jamalpur free-field station during the Modhupur Earthquake of March 20, 2008





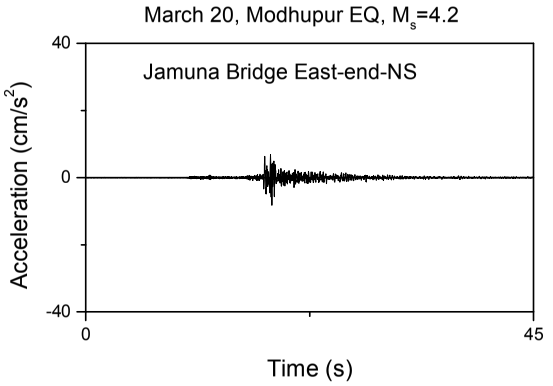
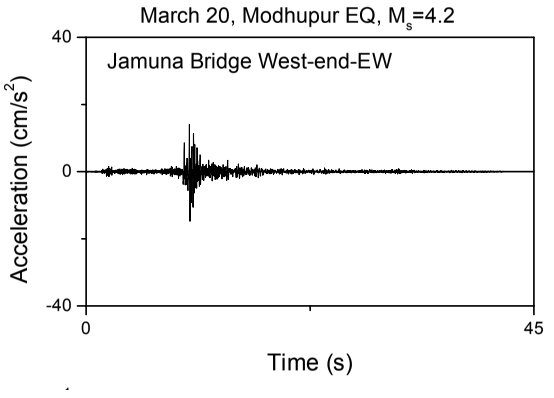
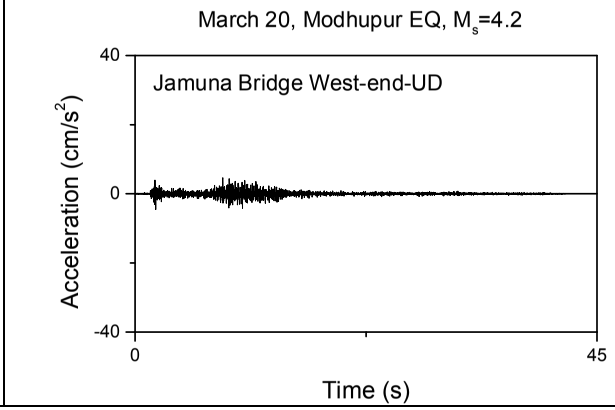


Figure 3: Time history of Jamuna Bridge east-end free-field station during the Modhupur Earthquake of March 20, 2008





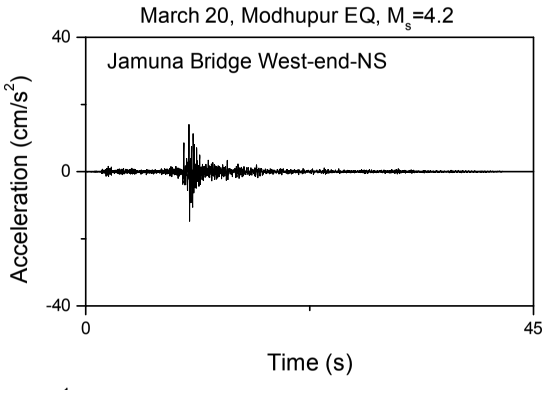
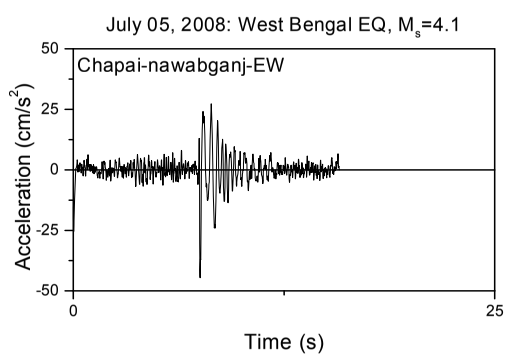
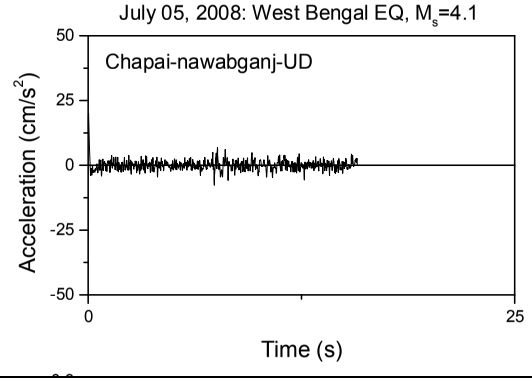


Figure 4: Time history of Jamuna Bridge west-end free-field station during the Modhupur Earthquake of March 20, 2008





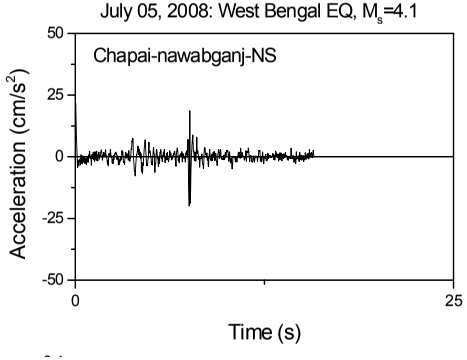
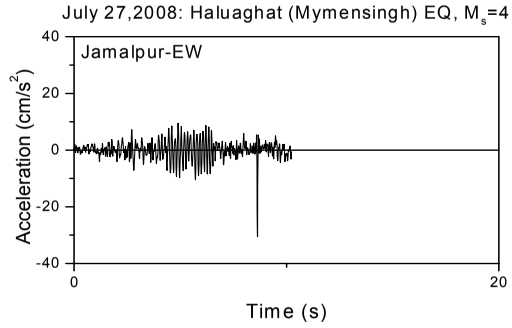
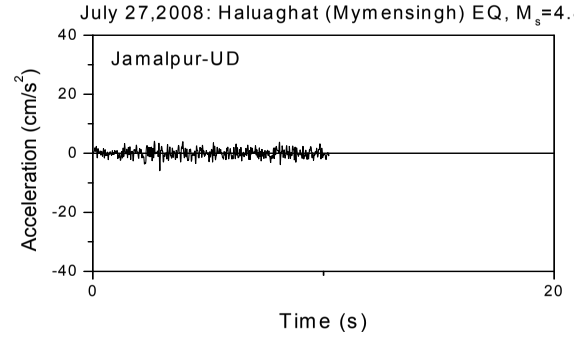


Figure 5: Time history of Chapai-Nawabganj free-field station during the West-Bengal (Rajshahi) Earthquake of July 05, 2008





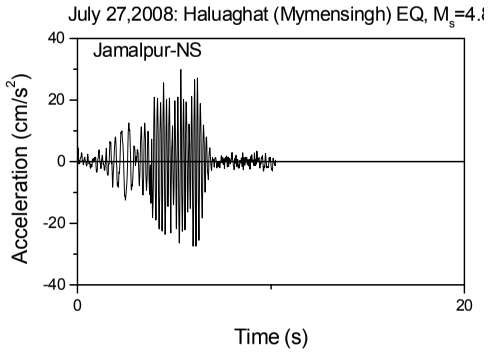
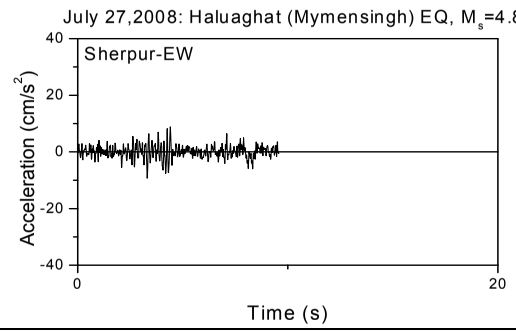
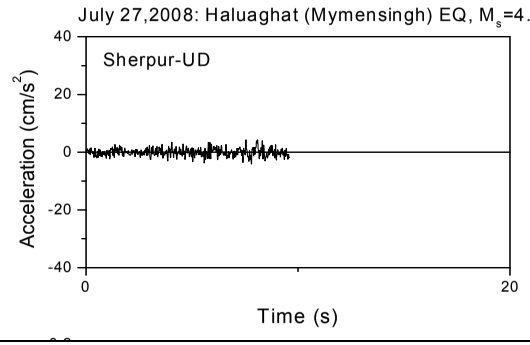


Figure 6: Time history of Jamalpur free-field station during the Haluaghat (Mymensingh) Earthquake of July 27, 2008





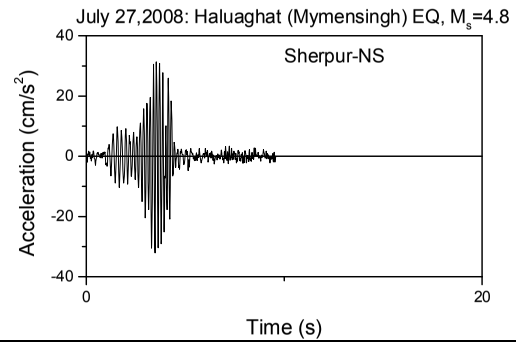
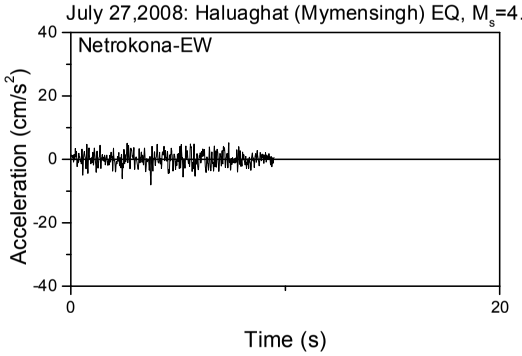
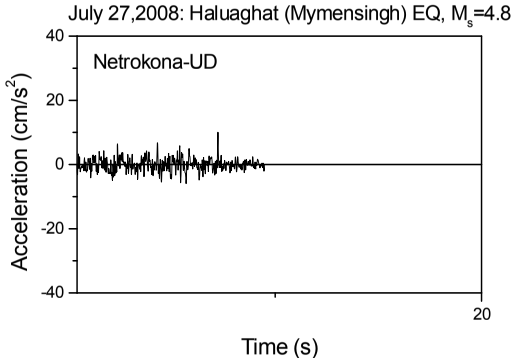


Figure 7: Time history of Sherpur free-field station during the Haluaghat (Mymensingh) Earthquake on July 27, 2008





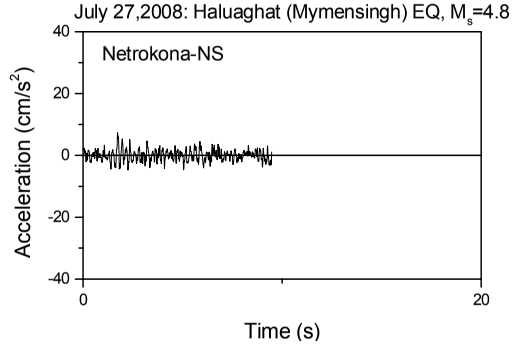


Figure 8: Time history of Netrokona free-field station during the Haluaghat (Mymensingh) Earthquake on July 27, 2008

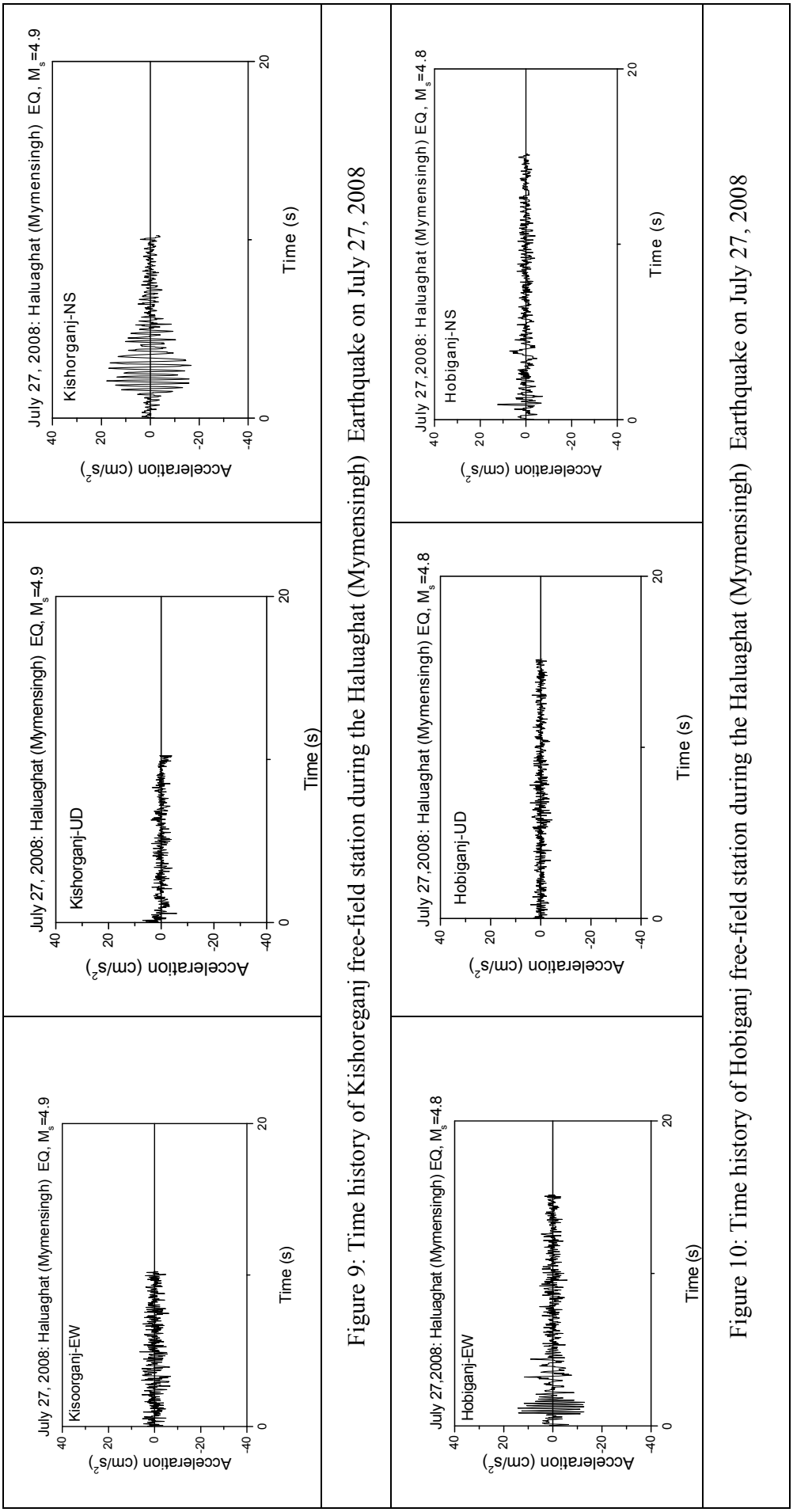
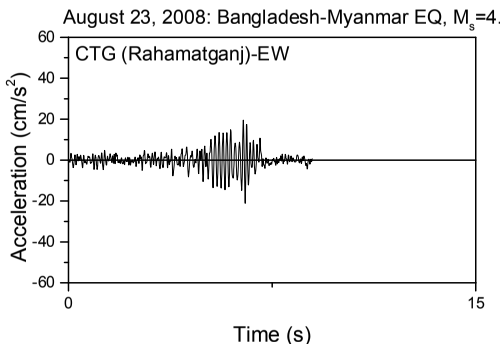
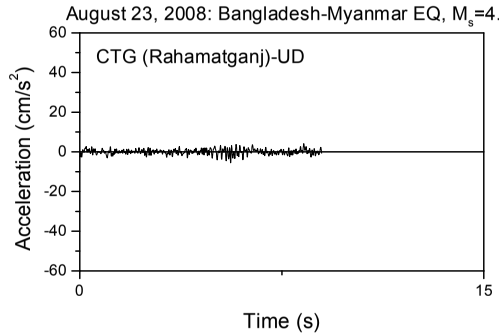


Figure 9: Time history of Kishoreganj free-field station during the Haluaghat (Mymensingh) Earthquake on July 27, 2008

Figure 10: Time history of Hobiganj free-field station during the Haluaghat (Mymensingh) Earthquake on July 27, 2008





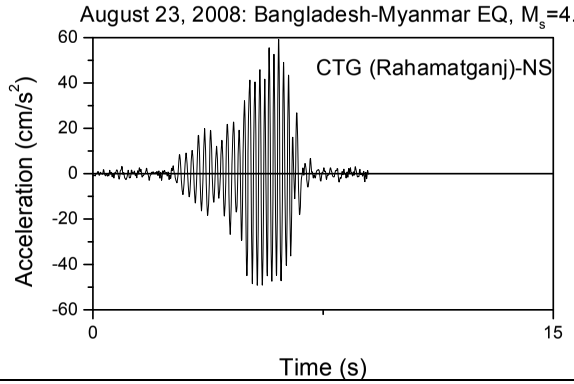
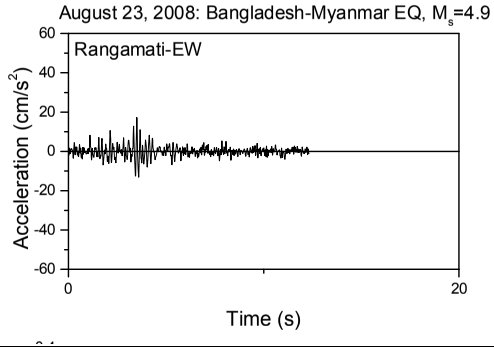
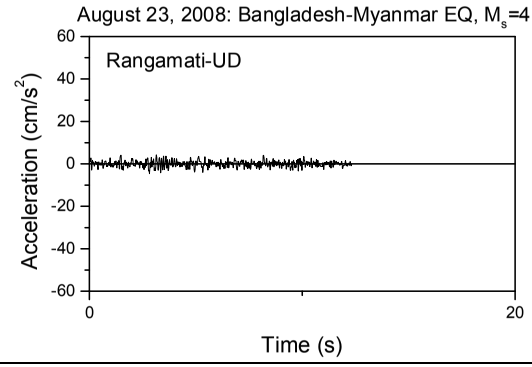


Figure 11: Time history of Chittagong (Rahmatganj) free-field station during the Bangladesh-Myanmar Earthquake (2) on August 23, 2008





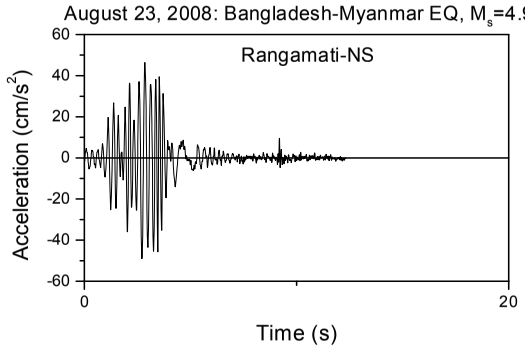
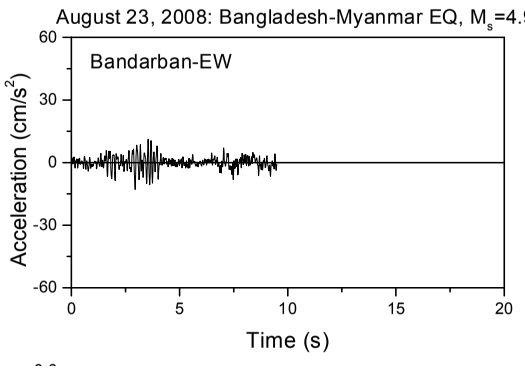
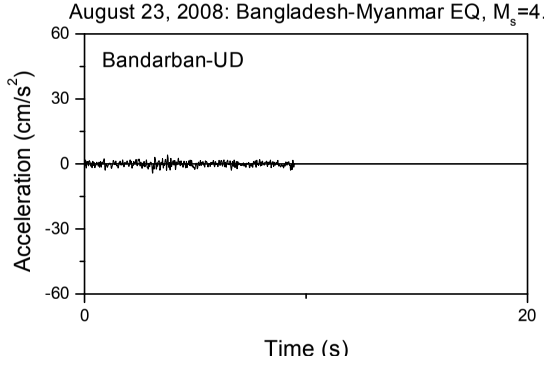


Figure 12: Time history of Rangamati free-field station during the Bangladesh-Myanmar Earthquake (2) on August 23, 2008





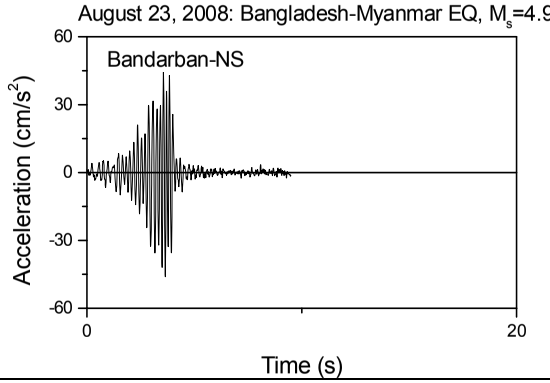
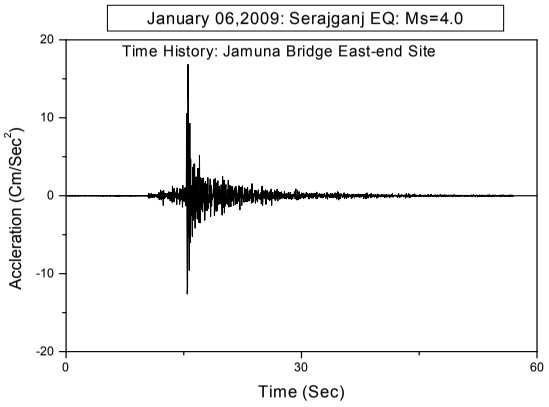
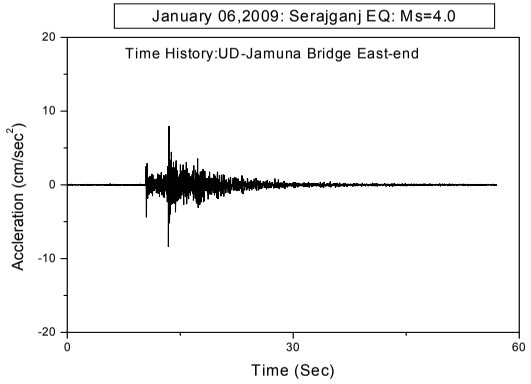


Figure 13: Time history of Rangamati free-field station during the Bangladesh-Myanmar Earthquake (2) on August 23, 2008





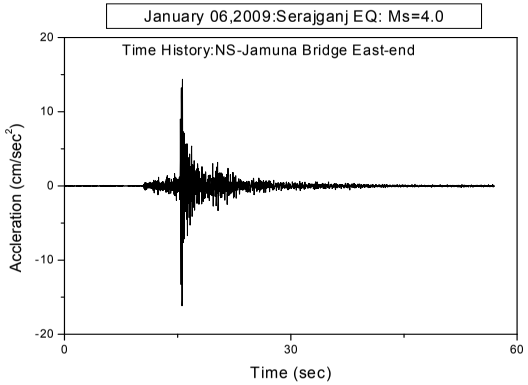
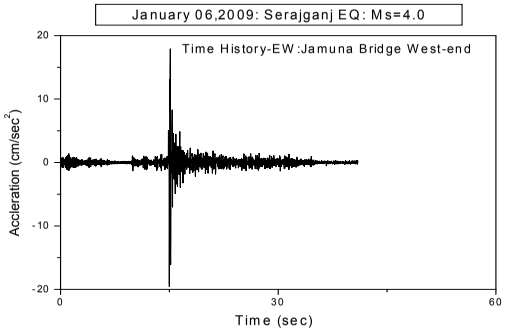
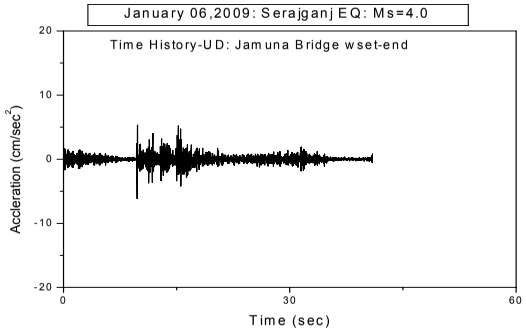


Figure14: Time history of Jamuna Bridge Eest-end free-field station during the Tangail Earthquake on January 06, 2009





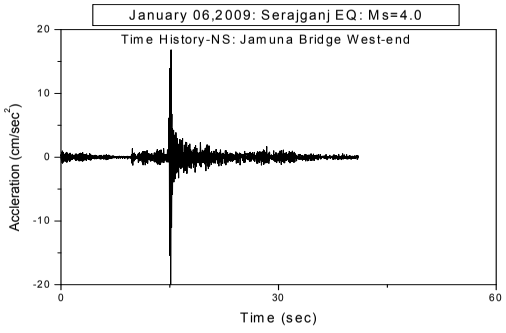
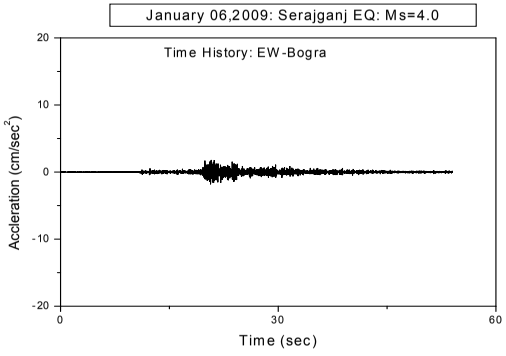
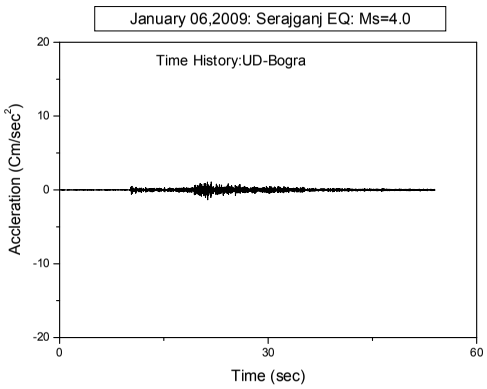


Figure 15: Time history of Jamuna Bridge West-end free-field station during the Tangail Earthquake on January 06, 2009





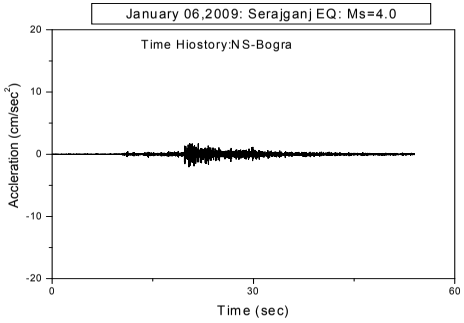


Figure 16: Time history of Bogra free-field station during the Tangail Earthquake on January 06, 2009

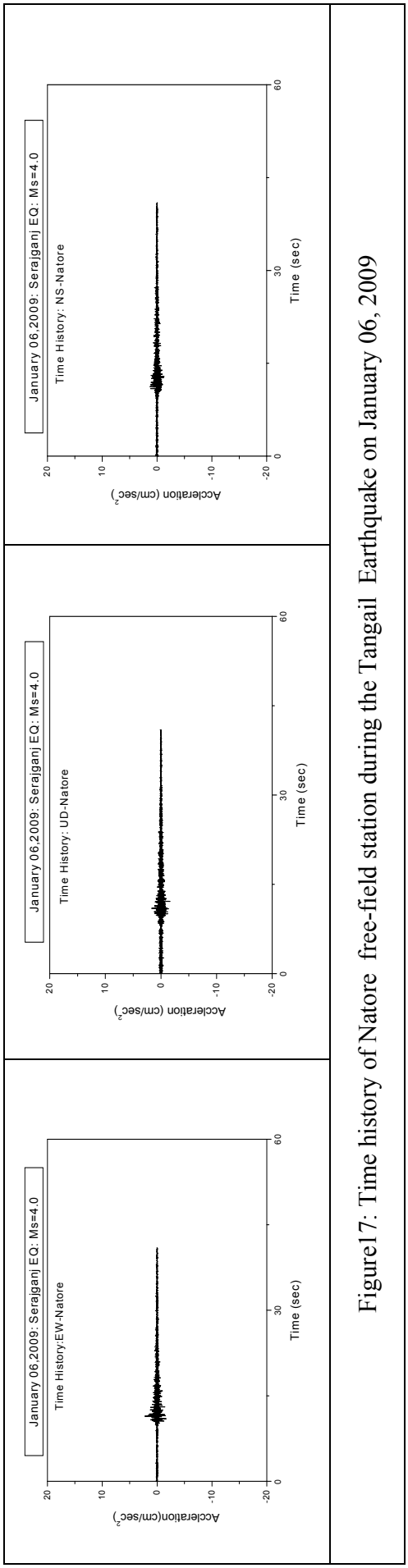


Figure17: Time history of Natore free-field station during the Tangail Earthquake on January 06, 2009

BANGLADESH NETWORK
OFFICE FOR URBAN SAFETY

ICUS
INSTITUTE OF INDUSTRIAL SCIENCE THE UNIVERSITY OF TOKYO

PART-VI

RETHINKING THE PUBLIC BUILDING AS POST DISASTER SHELTER: IN THE CONTEXT OF OLD DHAKA

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared by: Md. Yousuf Reza
Israt Jahan
Mehedi Ahmed Ansary

ABSTRACT

Earthquake risk is prominent in a disaster prone country like Bangladesh. A strong earthquake will affect major urban centers like Dhaka. Damage and destructions will be massive in proportion & will create disastrous consequences for the entire country. It is therefore essential to be prepared for possible earthquake threats and to take appropriate measures to minimize possible losses and damages. This would help to develop rational mitigation measures for minimizing the adverse impacts of earthquakes. To reduce earthquake vulnerability in urban areas as well as to save human lives, property etc. We need to set up earthquake preparedness plan or strategies for earthquake protection. Highly dense urban areas like old Dhaka are experiencing physical vulnerability like existence of vulnerable built environment, narrow street pattern, poor infrastructures etc. Thus several hundred peoples are living a insecure life. A proper guideline is needed to reduce the destructions. On this regard to post disaster situation shelters & other facilities are needed. For these purpose public buildings at neighborhood level like schools, religious buildings, community centers, hospitals etc. can serve the dual purpose and these places could be used as post disaster shelters. This paper aims to analyze the existing condition & location of these public buildings in old Dhaka according to earthquake vulnerability and various measures that can be taken to use these buildings as workable post disaster shelters and how we can improve both quality and quantity of open spaces regarding street pattern, communication & necessities. So to make better dual use of these public buildings we need to either retrofit them or demolish them by redesigning.

INTRODUCTION

Old Dhaka with several hundred years urban settlements have thousands of people. They are living a precarious life at awfully dilapidated buildings in congested manner. Over the period of time old Dhaka is becoming denser. Lack of open spaces & narrow road width became the main reason for many natural disasters like earthquakes. Poor infrastructures & vulnerable buildings caused most serious threat of collapse at old Dhaka. So disasters like earthquake will cause a severe damage to this area because at post disaster situation people will be either inside the rubbles of tumbled building or will not be able to reach any post disaster shelters. As this total area is devoid of proper open spaces and public buildings are at very poor condition so people of this area have no proper option for post disaster shelters. An organized policy will make a proper dual use for these public buildings & thus these buildings will serve proper during post disaster situation.

EARTHQUAKE RISK & LOSS REDUCTION ACTIVITIES DURING DIFFERENT PHASES OF THE DISASTER CYCLE

Mitigation:

- Encouragement of the private sector, communities and individuals to consider the hazard vulnerability implications of their own actions and decisions, both directly for themselves and society.
- Encouragement of the insurance industry to offer reduced catastrophic insurance premiums to domestic property and commercial policy holders who have implemented sufficient structural mitigation measures.

Preparedness:

- Sustained investment in scientific monitoring and dissemination activities, including the provision of public information in an easily understood and usable form. This may require international, regional and national funding, human resources and political commitment to co-operate.
- Strengthening of government, NGO and community disaster-preparedness capacity to facilitate rapid and effective emergency response, including training of personnel and stockpiling of supplies.
- Institutional preparedness, ensuring that adequate disaster preparedness and response plans are in place, clearly outlining the roles and functions not only of government but also of civil society and private -sector organizations.
- Fully operational and effective early warning and evacuation systems, including the equipment and training of local volunteers.
- Construction and maintenance of evacuation shelters.

Detailed focus on urban design to reduce risk at post disaster situation:

- It is commonsense that land areas over active faults in urban areas be acknowledged by providing open park-like spaces.
- Open spaces provide for refuge and temporary storage of post-earthquake building debris.
- Wide streets provide greater assurance of maintaining traffic flows and quick response and rehabilitation following damage to city blocks.
- Landscape architectural elements can also enhance public safety.
- Acknowledged by building back from site boundaries and creating vertical separation gaps between buildings to avoid hammering.
- Public facilitated buildings should be built different as if this buildings use as a disaster shelter.

Hazard risk needs to be integrated into the development process. This requires a holistic Approach. There is a need to incorporate hazard risk concerns into appraisal and assessment of individual development projects. These concerns must also be integrated into sectoral and national policies and strategies (e.g., poverty reduction, environmental management), thus seeking to promote structural reforms that would enhance resilience. Progress in this requires strong institutional support and the involvement and commitment of governments, aid agencies and civil society. It also requires political commitment, both at national and local levels, to address long-term hazard risks, over-riding the temptation for governments to pursue populist policies for short-term gains rather than sustainable development.

STUDY AREA

Ward no. 68 of Old Dhaka is selected as the study area due to its earthquake vulnerability. The site is characterized by a high density of population living in a very compact land area with close proximity of buildings along a very narrow local street. In most cases it is difficult to differentiate the buildings from each other. The prevailing circumstance gives a view of buildings may collapse without any disaster like earthquake. The condition is unthinkable and unimaginable what may happen with an attack of earthquake. The location and condition of public buildings are not up to the standards because of its informal settlements.

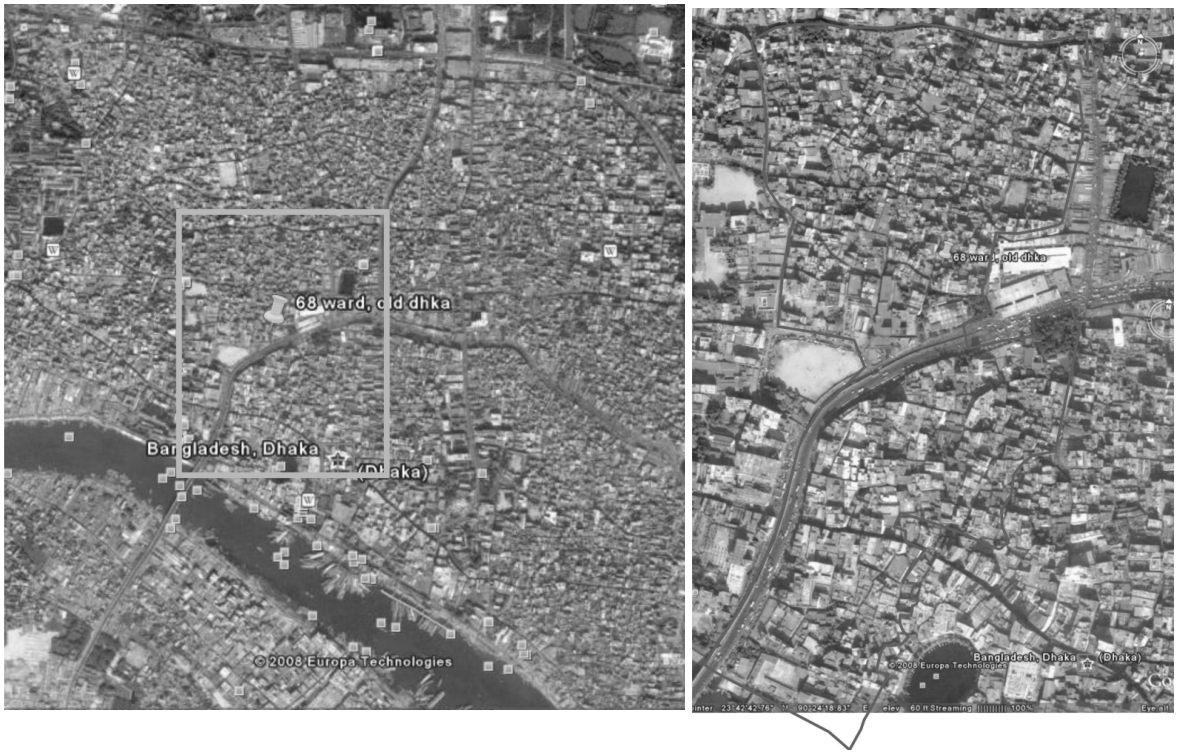


Figure 1: Aerial view of the study area (Ward no. 68, Old Dhaka)

Figure 2: Building height of the study area

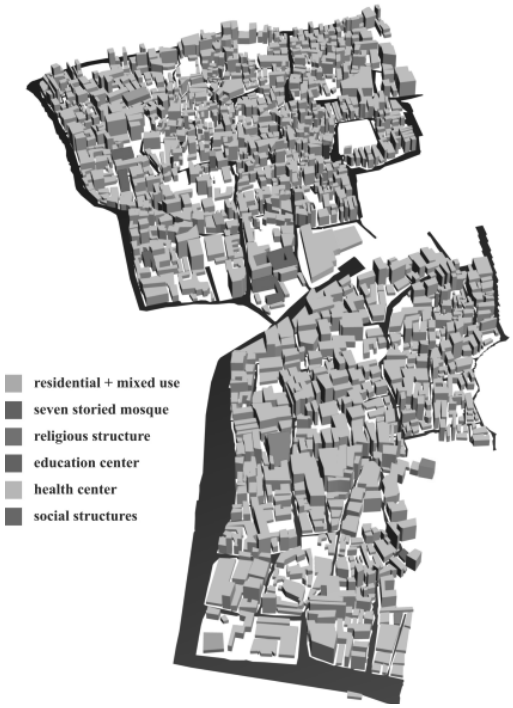


Figure 3: 3D view showing public building in study area

Figure 4: View showing public building & road layout in Ward no. 68.

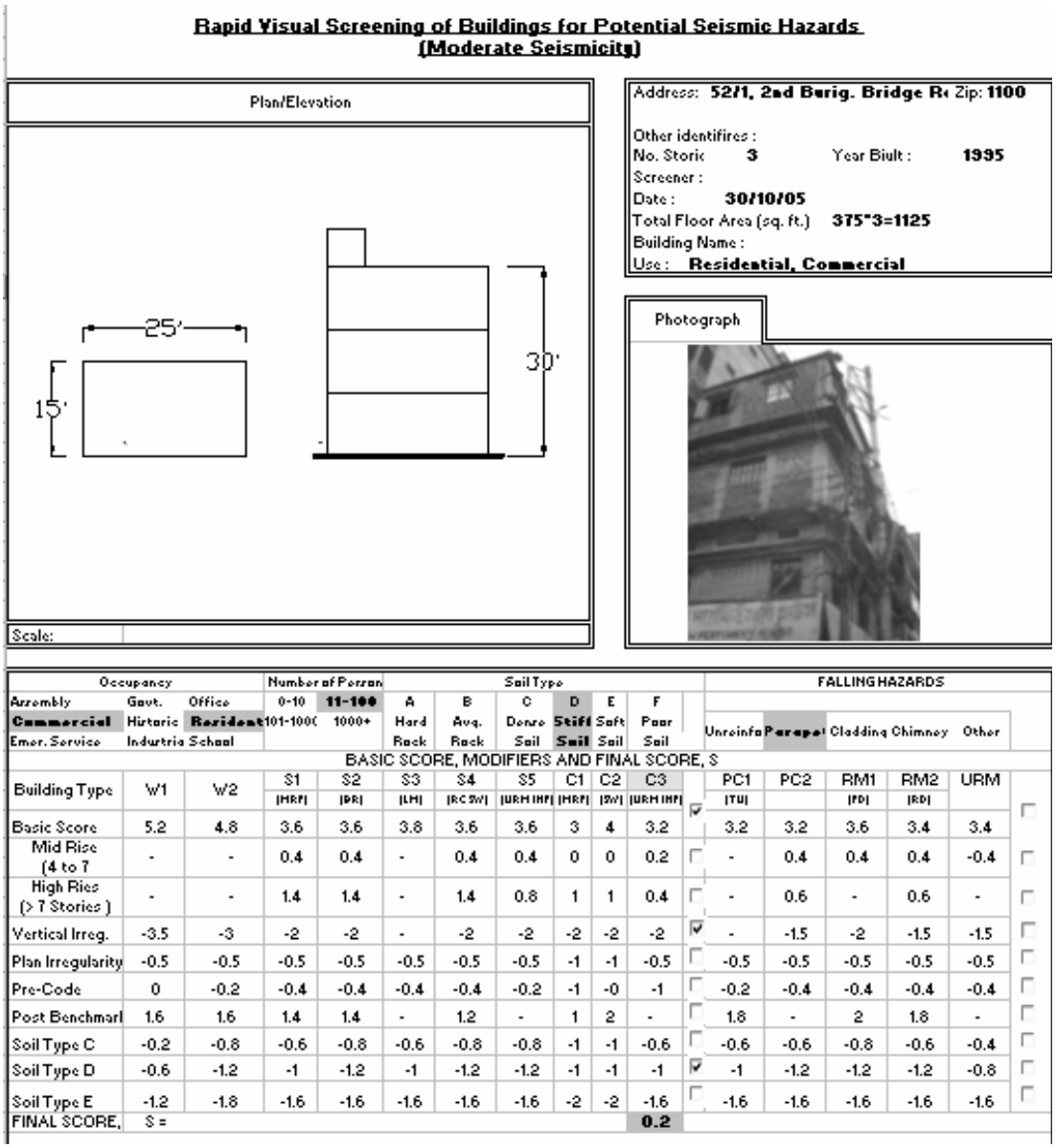
METHODOLOGY

It is a very difficult and time-consuming task to assess the vulnerability of the existing buildings in any target area. The study includes two different visual screening methods, i.e. FEMA-RVS and Turkish Simple Survey (Level-I & Level-II) Procedure. The Level-I Turkish method is almost similar to the RVS method. The rapid visual screening (RVS) method has been used in this research to assess all public buildings in 68 word and the Turkish Level-I & Level-II, a more detail analysis of the building, is used to assess the structures proposed to be used as evacuation place. The religious place like mosques, the community centers, educational institutes like schools, colleges and other public places along with the open spaces like park, playground are considered as evacuation sites .

FEMA Rapid Visual Screening

The Federal Emergency Management Agency (FEMA) of the United States of America has developed pre-earthquake screening method of potential seismic hazard assessment of buildings based on rapid visual screening method, widely known as RVS method originated in 1988, with the publication of the FEMA 154 Report. It is generally used for rapid evaluation of seismic vulnerability profiles of existing building stocks. RVS method is used to quickly determine if detail evaluation of existing building is required. The objective of these methods is to identify, make inventory and rank all high-risk buildings in a specified region so that a strategy of priority based interventions to buildings can be formed. This screening methodology is encapsulated in a one page form, which combines a description of a building, its layout and occupancy, and a rapid structural evaluation related to its seismic hazard. This procedure requires only visual inspection and limited data collection. It is a "sidewalk survey" approach that enabled users to classify surveyed buildings into two categories: those acceptable as to risk to life safety or those that may be seismically hazardous and should be evaluated in more detail by a design professional experienced in seismic design.

The Data Collection Form of RVS includes space for documenting building identification information, including its use and size, a photograph of the building, sketches, and documentation of pertinent data related to seismic performance, including the development of a numeric seismic hazard score. Basic Structural Hazard Scores based on Lateral Force
Resisting System for various building types are provided on the form and the screener circles the appropriate one. The screener modifies the Basic Structural Hazard Score by identifying and circling Score Modifiers related to observed performance attributes, by adding (or subtracting) them a final Structural Score, 'S' is obtained (Imtiaz et al, 2007).
The scoring system of RVS is shown in Figure 5.



Rapid Visual Screening of Buildings for Potential Seismic Hazards
(Moderate Seismicity)

Plan/Elevation

25'
15'
30'
Scale:

Address: 52/1, 2nd Burig. Bridge R Zip: 1100
Other identifires :
No. Storic 3 Year Biult : 1995
Screener :
Date : 30/10/05
Total Floor Area (sq. ft.) 375*3=1125
Building Name :
Use : Residential, Commercial

Photograph

Occupancy			Number of Perso		Soil Type						FALLING HAZARDS					
Assembly	Govt.	Office	0-10	11-100	A	B	C	D	E	F						
Commercial	Hirtoric	Resident	101-1000	1000+	Hard Rock	Avg. Rock	Dense Soil	Stiff Soil	Soft Soil	Poor Soil	Unreinfo	Parapet	Cladding	Chimney	Other	
Emer. Service	Industria	School														
BASIC SCORE, MODIFIERS AND FINAL SCORE, S																
Building Type	W1	W2	S1 [MRF]	S2 [PR]	S3 [LM]	S4 [RC SW]	S5 [URM INF]	C1 [MRF]	C2 [SW]	C3 [URM INF]	PC1 [TU]	PC2	RM1 [PD]	RM2 [RD]	URM	
Basic Score	5.2	4.8	3.6	3.6	3.8	3.6	3.6	3	4	3.2	3.2	3.2	3.6	3.4	3.4	
Mid Rise (4 to 7	-	-	0.4	0.4	-	0.4	0.4	0	0	0.2	-	0.4	0.4	0.4	-0.4	
High Rise (> 7 Stories)	-	-	1.4	1.4	-	1.4	0.8	1	1	0.4	-	0.6	-	0.6	-	
Vertical Irreg.	-3.5	-3	-2	-2	-	-2	-2	-2	-2	-2	-	-1.5	-2	-1.5	-1.5	
Plan Irregularity	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-1	-1	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	
Pre-Code	0	-0.2	-0.4	-0.4	-0.4	-0.4	-0.2	-1	-0	-1	-0.2	-0.4	-0.4	-0.4	-0.4	
Post Benchmarl	1.6	1.6	1.4	1.4	-	1.2	-	1	2	-	1.8	-	2	1.8	-	
Soil Type C	-0.2	-0.8	-0.6	-0.8	-0.6	-0.8	-0.8	-1	-1	-0.6	-0.6	-0.6	-0.8	-0.6	-0.4	
Soil Type D	-0.6	-1.2	-1	-1.2	-1	-1.2	-1.2	-1	-1	-1	-1	-1.2	-1.2	-1.2	-0.8	
Soil Type E	-1.2	-1.8	-1.6	-1.6	-1.6	-1.6	-1.6	-2	-2	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	
FINAL SCORE,	S =									0.2						

Figure 5: Sample RVS Scoring Form (FEMA-154, 2002)

The score below which a structure is assumed to require further investigation is termed as "cut-off" score. The value of "cut off" score and choice of RVS form depends on the seismic zonation of the area. It is suggested that buildings having an S score less than the "cut-off" score should be investigated by an experienced seismic design professional experienced in seismic design. If the obtained "final score" is greater than the "cut-off" score the building should perform well in a seismic event. A score of 2 is used in this study as a "cut-off" score.

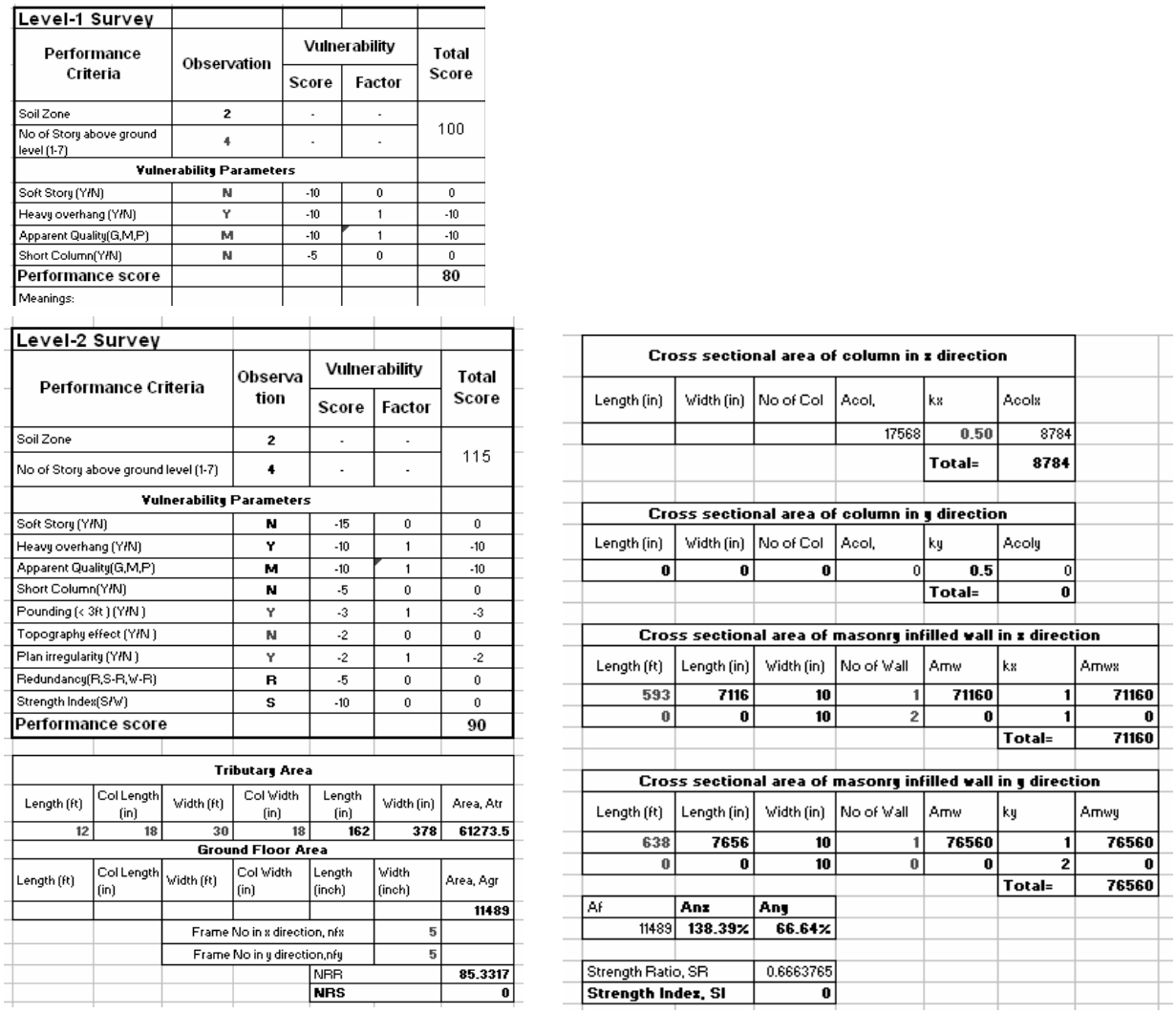
Turkish Simple Survey Procedure

Another approach of rapid visual screening was employed for assessment of seismic vulnerability of structure in Turkey. The Turkish Simple Survey procedure is a two level seismic risk assessment procedure which has been proposed on the basis of statistical correlations obtained by employing a database of 477 damaged buildings surveyed after the 1999 earthquake in the cities of Kocaeli and Düzcec in Turkey (Sucuoglu and Yazgan, 2003).

The method uses two levels seismic assessment based on several building parameters that can be easily observed or measured during a systematic survey. The first level incorporates recording of building parameters from the street side regarding a structural form and the ground condition and involves the observation of the parameters, the number of stories above ground, presence of a soft story, presence of heavy overhang, apparent building quality, and presence of a short column.

In the second level, these are extended by structural parameters measured by entering into the ground story. In the second level the parameters of first level are confirmed or modified through closer observations. Then a sketch of the framing plan at the ground story is made and the dimensions of columns, concrete and masonry walls are measured. The added parameters in this stage are pounding between adjacent buildings, topography effect, plan irregularity, redundancy, and strength index. The consistency in distribution of lateral loads to frame members is judged by redundancy and the strength index figures out the influence of size of the vertical members of the building, material strength, frame geometry etc. on the lateral strength of the building. The results of the Level - II procedure can be used to determine the potential status of the selected buildings and to further short-list the buildings requiring detailed vulnerability assessment.

The basic scoring for both the levels are based on the Height of the building (number of stories) and Local Soil Conditions where three intensity zones are specified in terms of associated PGV (Peak Ground Velocity) ranges (Imtiaz et al, 2007). Once the vulnerability parameters of a building are obtained from two-level surveys and its location is determined, the seismic performance and vulnerability scores are calculated as defined in Figure 6.
A “cut-off” performance score of 50 has been suggested for both survey levels.



Level-1 Survey

Performance Criteria	Observation	Vulnerability		Total Score
		Score	Factor	
Soil Zone	2	-	-	100
No of Story above ground level (1-7)	4	-	-	
Vulnerability Parameters				
Soft Story (Y/N)	N	-10	0	0
Heavy overhang (Y/N)	Y	-10	1	-10
Apparent Quality(G,M,P)	M	-10	1	-10
Short Column(Y/N)	N	-5	0	0
Performance score				**80**
Meanings:				

Level-2 Survey

Performance Criteria	Observation	Vulnerability		Total Score
		Score	Factor	
Soil Zone	2	-	-	115
No of Story above ground level (1-7)	4	-	-	
Vulnerability Parameters				
Soft Story (Y/N)	N	-15	0	0
Heavy overhang (Y/N)	Y	-10	1	-10
Apparent Quality(G,M,P)	M	-10	1	-10
Short Column(Y/N)	N	-5	0	0
Pounding (< 3ft) (Y/N)	Y	-3	1	-3
Topography effect (Y/N)	N	-2	0	0
Plan irregularity (Y/N)	Y	-2	1	-2
Redundancy(R,S-R,W-R)	R	-5	0	0
Strength Index(S/W)	S	-10	0	0
Performance score				**90**

Tributary Area

Length (ft)	Col Length (in)	Width (ft)	Col Width (in)	Length (in)	Width (in)	Area, Atr
12	18	30	18	162	378	61273.5

Ground Floor Area

Length (ft)	Col Length (in)	Width (ft)	Col Width (in)	Length (inch)	Width (inch)	Area, Agr
						11489
		Frame No in x direction, nfx			5	
		Frame No in y direction,nfy			5	
				NRR		85.3317
				NRS		0

Cross sectional area of column in x direction

Length (in)	Width (in)	No of Col	Acol,	kx	Acolx
			17568	0.50	8784
				Total=	8784

Cross sectional area of column in y direction

Length (in)	Width (in)	No of Col	Acol,	ky	Acoly
0	0	0	0	0.5	0
				Total=	0

Cross sectional area of masonry infilled wall in x direction

Length (ft)	Length (in)	Width (in)	No of Wall	Amw	kx	Amwx
593	7116	10	1	71160	1	71160
0	0	10	2	0	1	0
					Total=	71160

Cross sectional area of masonry infilled wall in y direction

Length (ft)	Length (in)	Width (in)	No of Wall	Amw	ky	Amwy
638	7656	10	1	76560	1	76560
0	0	10	0	0	2	0
					Total=	76560

Af	Anx	Any
11489	138.39%	66.64%

Strength Ratio, SR	0.6663765
Strength Index, SI	**0**

Figure 6: Tables and general equation of Turkish Procedure (Sucuoglu and Yazgan, 2003)

DATA INTERPRETATION AND ANALYSIS

Vulnerability Assessment of Public Buildings by RVS Method

The earthquake vulnerability of the buildings is assessed using the Rapid Visual Screening (RVS) Method and detail evaluation of the proposed evacuating buildings is made using the Turkish Level I and Level -II method. A total number of 1064 Buildings have been analyzed using Rapid Visual Screening (RVS) method. On a general view, the soil type of Ward no. 68 has been considered as Stiff. RVS score '0' is given to the buildings that showed negative results, that means the buildings are in emergency need of detail evaluation by any structural engineer and take further actions like retrofitting, etc. based on the result found.

The results show that 44% score for buildings was found to touch the cut off value according to FEMA method and all of them require further detailed analysis on vulnerability to determine the level of actual risk.

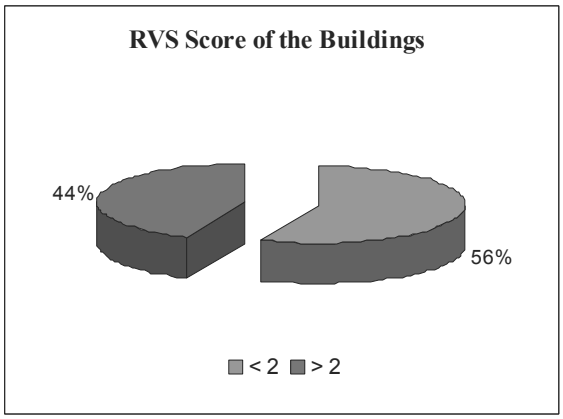


Figure 7: Buildings according to the RVS cut-off Score

Considering the existing site condition, it can be assumed that such a large number of buildings may not be vulnerable if an earthquake hits and if 1.5 is considered as the cut-off score then most of the buildings fall in the safe region and do not require detail structural analysis. Figure 8 shows that with the cut-off value 1.5, 67% of the total surveyed buildings are not vulnerable in any earthquake disaster.

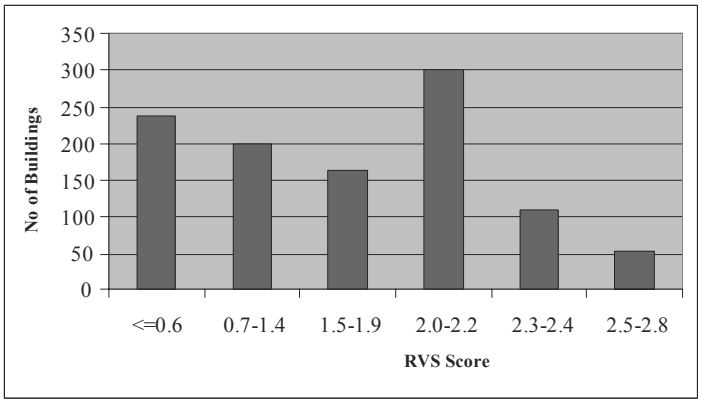


Figure 8: Buildings classified on the RVS Score

Vulnerability Assessment of Public Buildings by Turkish Method

A more detail analysis of buildings is done in Turkish Level-I & Level-II method in comparison with the RVS method. It has been found from studies that the Turkish method is more compatible in the circumstances of our country. The detail evaluation of 11 structures proposed to be used as evacuation sites are done.

Review of building configuration analysis against Earthquake

Architectural consideration, Geometric configuration

The following briefly describes the most relevant aspects of the impact of geometric configuration on the seismic response of buildings, as well as the corrective measures required. Due to their complexity and their close relationship with buildings' use of space and form, configuration problems must be taken into account from the very earliest stages of architectural design. Architects and designers should have a thorough understanding of the relevant issues.

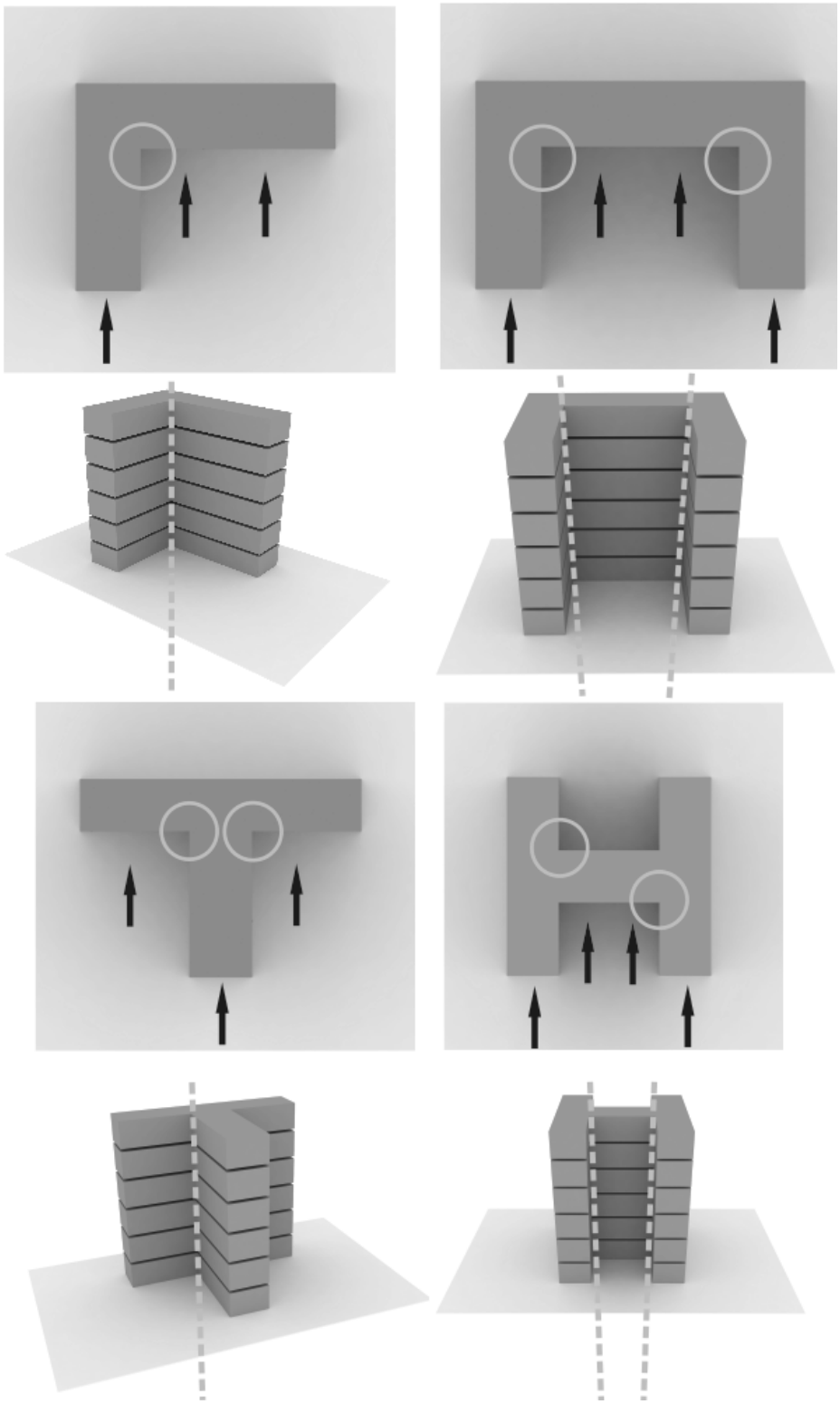
The problems mentioned below refer to the plan (i.e., horizontal layout) of the structure in relation to the form and distribution of architectural space.

The length of a building determines its structural response in ways that are not easily determined by the usual methods of analysis. Since ground movement consists of the transmission of waves, which occurs with a velocity that depends on characteristics of the soil on which the structure stands, the excitation that takes place at one point of support of the building at one time differs from the excitation at another time, a difference that is greater to the extent that the length of the building is greater in the direction of the seismic waves. Short buildings adjust more easily to the waves than long buildings, and undergo similar excitation at all supports. The usual correction for the problem of excessive building length is to partition the structure in blocks by the insertion of seismic expansion joints in such a way that each block can be considered a shorter building. These joints must be designed to permit adequate movement of each block without the danger of their striking or colliding with each other. Long buildings are also more sensitive to the torsion or horizontal rotation resulting from ground movements, because the differences in the transverse and longitudinal movements of the supporting ground, on which this rotation depends, are greater.

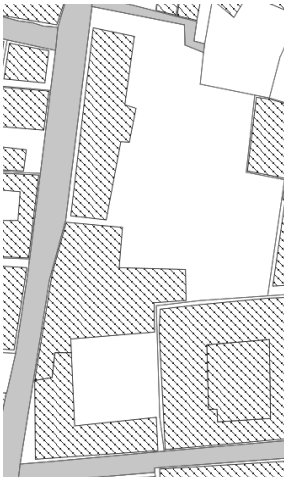
Concentration of stress arises in buildings with complex floor plans. A complex plan is defined as that in which the line joining any two sufficiently distant points lies largely outside of the plan. This occurs when wings of significant size are oriented in different directions, for instance in H, U, or L shapes.

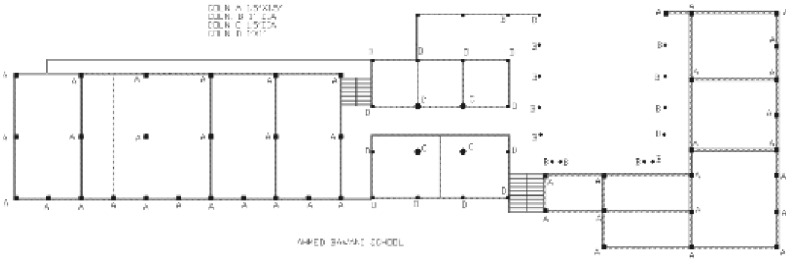
Configuration characteristics & their effects

Undesirable configurations



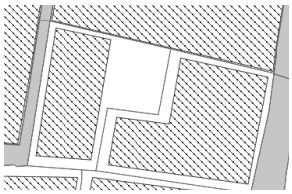
Location & plan of the public buildings in Ward no. 68:

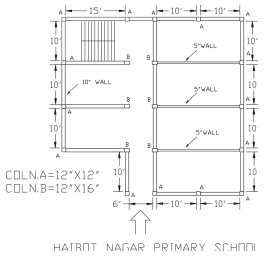




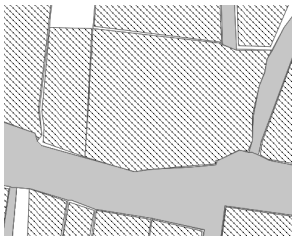
rectangle + U shape plan

Ahmed Bawyani School

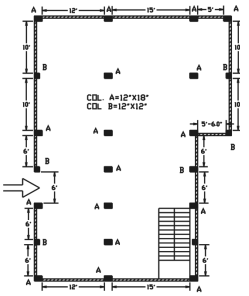


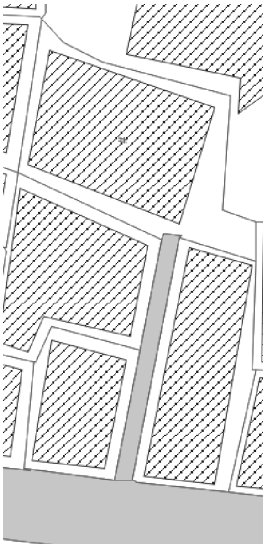


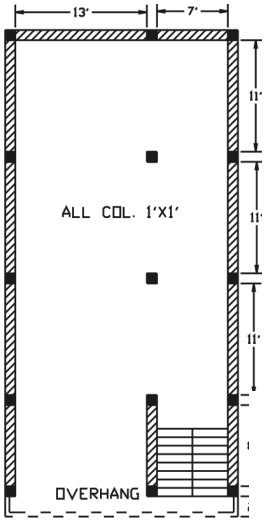
Haybat nagar Dewan School



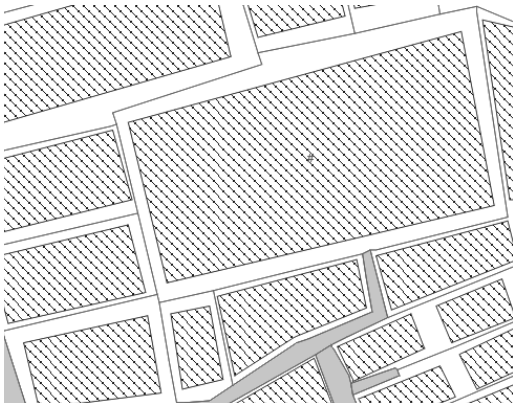
Islampur Jamme Mosque

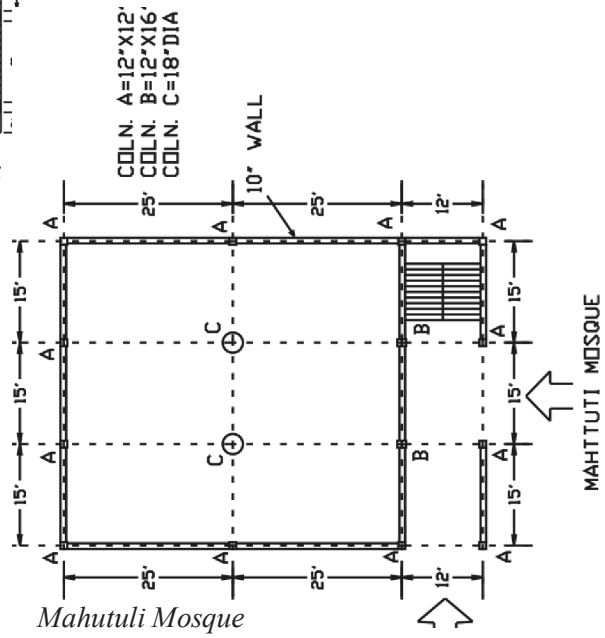




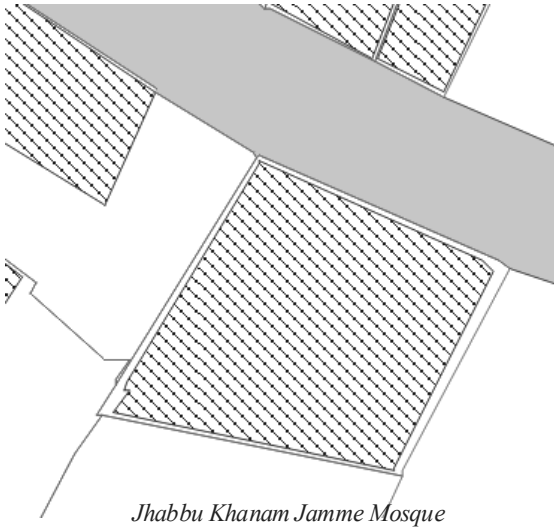


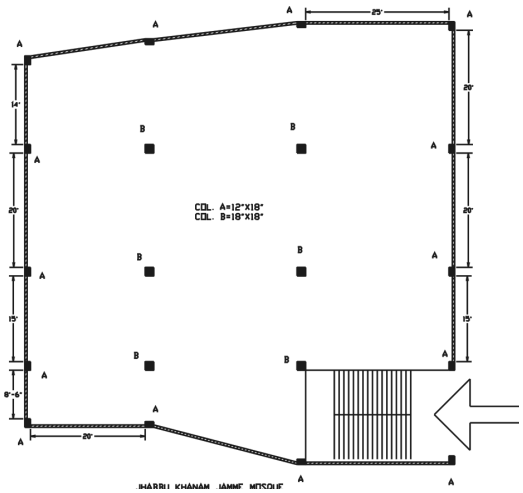
Zindabahar 2nd lane Jame Mosque



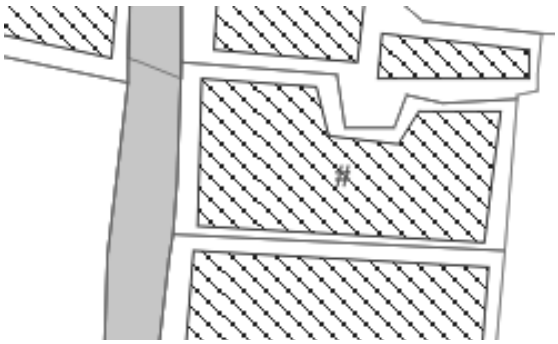


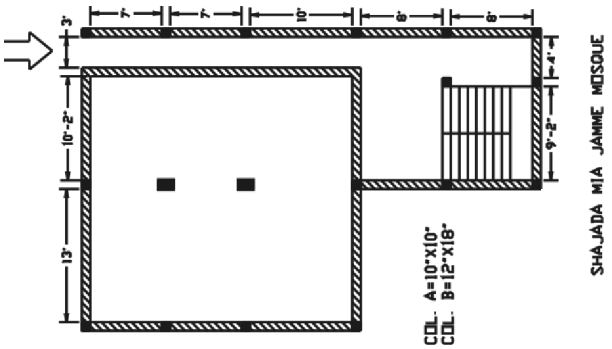
Mahutuli Mosque



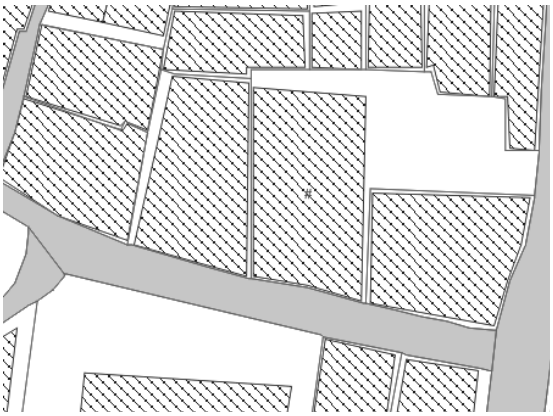


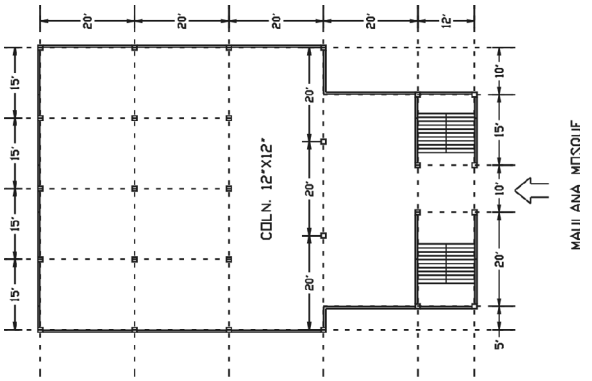
Jhabbu Khanam Jamme Mosque





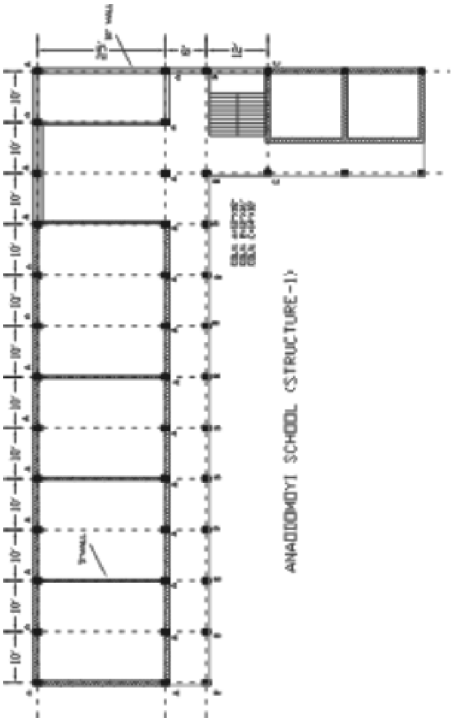
Shahjada Mia Jame Mosque

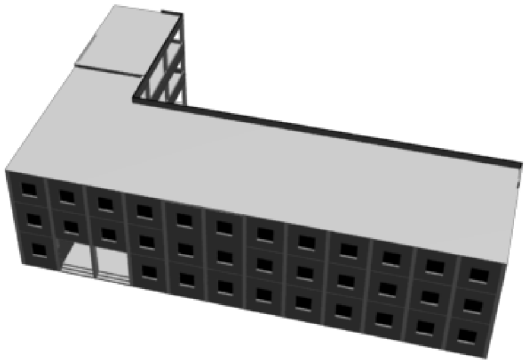




Maulana Mosque

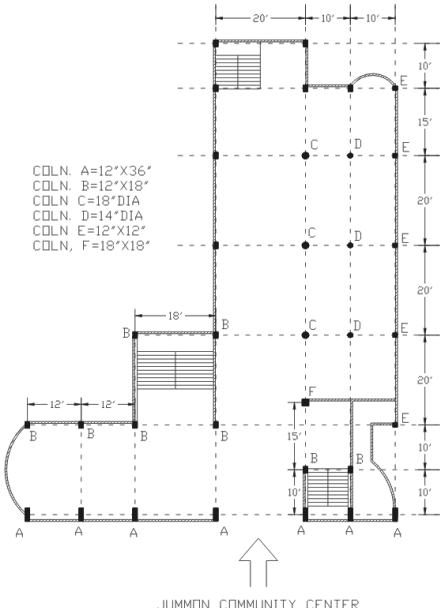
Anandomoyee Girls' High School

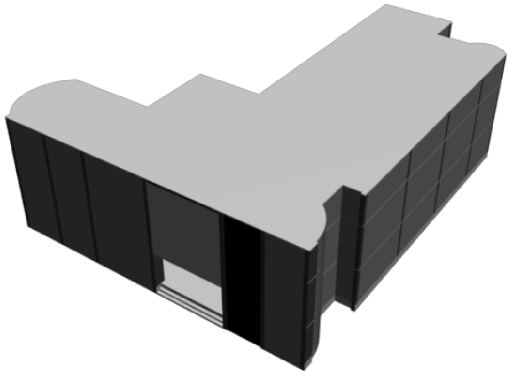




L-shape

Jumman Community Center & Ward Commissioner's Office





irregular

Comparative analysis of public buildings by RVS Method, Turkish Method & building configuration

The detail evaluation of 11 structures proposed to be used as evacuation sites are done. Table 1 shows a comparative view of these two methods.

Table 1: Comparison of RVS method and Turkish Method

Sl. no.	Name & Address	RVS Score	Score in Level-I	Score in Level-II	Shape
01	Ahmed Bawyani School	0	75	85	Rectangle+ U-Shape
02	Anandomoyee Girls' High School : Structure 01	2.2	110	108	L-Shape
	Structure 03	2.2	115	120	
03	Haybat nagar Dewan School	1.7	115	113	Square
04	Zindabahar 2nd lane Jame Mosque	2.4	50	47	Rectangular
05	Jumman Community Center & Ward Commissioner's Office	1.7	125	125	Irregular
06	Mahutuli Mosque	2.2	125	130	Square
07	Maulana Mosque	2.2	125	130	Square
08	Shahjada Mia Jame Mosque	1.7	105	106	L-Shape
09	Jhabbu Khanam Jamme Mosque	1.9	90	100	Irregular
10	Islampur Jamme Mosque	0.4	65	57	L-Shape
11	Kamranga Mosque	0	110	106	Square

It is clear that most of the structures fall below the cut-off score in the RVS method but in the Turkish Method, most of them fall above the cut-off score i.e. they don't need further detail analysis. The Zindabahar 2nd lane Jame Mosque requires more detail structural analysis based on Turkish method although it's RVS score resulted above the cut-off value. In contrary, some structures resulted in detail evaluation by RVS method while the Turkish methods showed they do not need any further analysis by specialist. Again the Islampur Jamme Mosque has just passed the cut-off score and the RVS score is also negative. So it also requires detail evaluation.

CONCLUSION

This paper only represents the methods of earthquake vulnerability assessment and tries to draw a picture of the public buildings of word no. 68 in old part of Dhaka city and tries to realize the situation what may happen if an earthquake occurs. Both of the methods have limitations in terms of incorporating the parameters relevant to the design and construction practices in Bangladesh and many other countries. But initially it provides a general idea and knowledge on the vulnerability of the buildings based on which an effective evacuation shelter or post disaster shelter can be prepared to reduce loss caused by any attack of disaster.
Finally after collecting data from field level, A GIS based evacuation plan needs to be prepared based on the existing site condition like buildings, road network system, and proposed public building use as a earthquake resistant disaster shelter etc. The whole area must be segregated into different groups according to vulnerability and capacity of evacuation places. Finally Over all a 3D elevation model of the area showing the escaping route with the shortest path directing to evacuation shelter from each specified group segment

is to be prepared. This paper only describes the vulnerability of the existing public buildings focusing on the actual site condition.

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3. Imtiaz, A. B. A., Sutra dhar, A. and Ansary, M. A. and Ahmed, M. Z. (2007) "Visual Screening Methods for Earthquake Vulnerability Assessment" Proceedings of International Conference on New Technologies for Urban Safety of Mega Cities in Asia, Dhaka, Published in CD.

BANGLADESH NETWORK
OFFICE FOR URBAN SAFETY

PART-VII

EARTHQUAKE VULNERABILITY REDUCTION STRATEGIES FOR UNPLANNED URBAN AREAS

BANGLADESH NETWORK OFFICE FOR URBAN SAFETY (BNUS), BUET, DHAKA

Prepared by: Md. Yousuf Reza
Mehedi Ahmed Ansary

ABSTRACT

Earthquake vulnerability reduction for cities (EVRC), Metropolitan earthquake prevention plan and many other initiatives have been taken throughout the world at recent past to make their cities free from huge loss. Though, Bangladesh is at high seismic zone, but still no significant initiative has been taken for urban areas. So, reduction of urban vulnerability for seismic hazards is one of the priorities right now in Bangladesh.

Chittagong city, one of the major urban areas, is experiencing physical vulnerability like informal or unplanned settlements, poor infrastructure, existences of vulnerable built environment and so on. Rapid urban growth is causing deterioration and increasing the vulnerability of human lives, economy and infrastructures. If a strong earthquake affecting Chittagong city which may result in damage and destruction of massive proportions and may have disastrous consequence for the entire country. This study aims to analyze the issues related to physical urban vulnerability in detail to arrive at strategies or policy based solutions that are necessary to support the redevelopment of urban areas in Chittagong and Bangladesh and how hazard motivated land use planning reduce the earthquake risk.

This case study is on Nondon Kanon area, where urban physical vulnerability is identified. Risk assessment analysis has been done by RADIUS (Risk Assessment tools for Diagnosis of Urban areas against Seismic disasters) and also part of analysis --visual survey, secondary data collection and analysis, configuration analysis and building typology study based on earthquake vulnerability. At the end, a redesign alternative design solution is proposed showing the possibilities of earthquake vulnerability reduction.

INTRODUCTION

No one can prevent nor accurately predict earthquakes but by preparing earthquake disaster prevention plan for urban areas and implementing it, the loss of life and property from an earthquake can be significantly reduced. In order to create a city for the 21st century where inhabitants can feel secure, all parties need to come together to promote disaster resistant urban development through the mutual integration of livability. The term “Physical Urban Vulnerability for Earthquake Hazard” is defined strictly. To create safe built environment, every professional who is related with it should know about urban vulnerability and earthquake risk. Present urban trends of Bangladesh, especially Dhaka, Chittagong has high population density as well as built environment and also unplanned urbanization, where physical urban vulnerability exist. The present research tries to formulate sustainable earthquake vulnerability reduction strategies for urban designers and architects by identifying physical urban vulnerability. As part of its spatial interpretations the study tries to interpret the selected articles “Urban Earthquake vulnerability reduction for urban areas” based on gathered knowledge from multi disciplinary secondary sources (urban design, urban redevelopment strategy, Metropolitan earthquake prevention plan & policy, disaster management etc) to formulate an actionable idea that would be physical in nature.

CONCEPTULIZATION OF THE ISSUE

“Earthquake vulnerability reduction” (EVR) is a concept of action that has developed to ensure safety of human lives and reduce losses from earthquakes that may occur tomorrow. Some historical earthquakes like California taught us that earthquake vulnerability reduction and preparedness works. Lives were saved, injuries were reduced and business disruption was

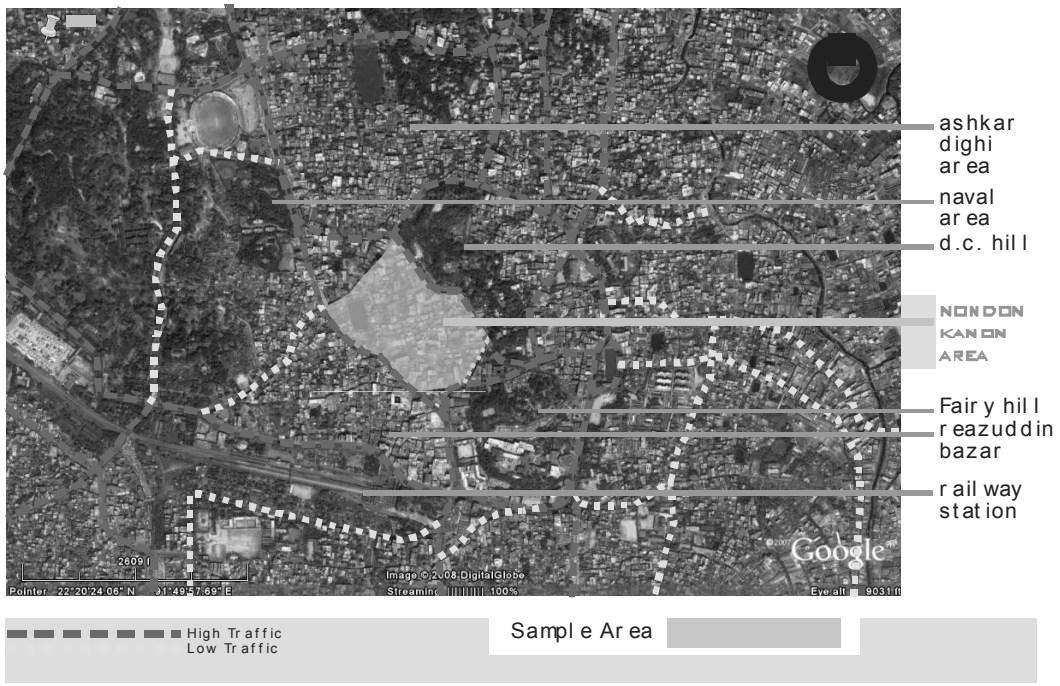
limited by being prepared for earthquakes. We need to evaluate and promote the vulnerability reduction strategies making our urban areas safe and secured.

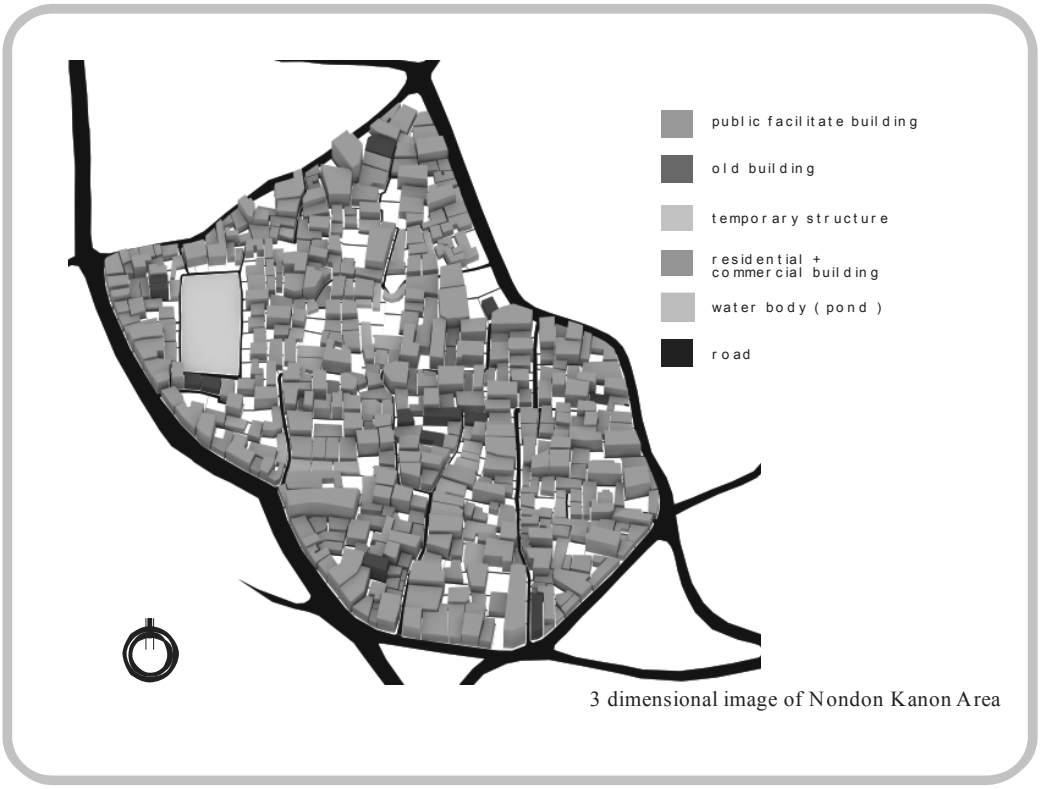
These generalized aims necessitate involvement of multi disciplinary professionals to work with common objectives of better urban designers have great role to play in this field, because urban design and architecture deal with space and built environment. By preparing sustainable land use planning and urban earthquake vulnerability reduction strategies, we can build a seismically resistant urban area.

study area

Sample Area

Sample Area
residential & mixed use
hilly area





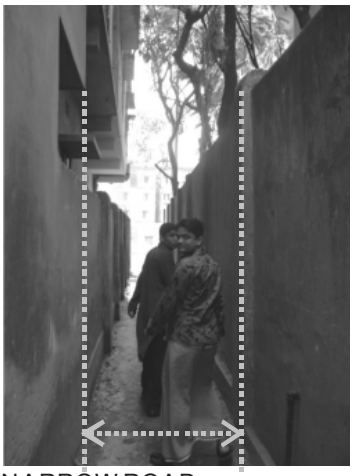
3 dimensional image of Nondon Kanon Area

Urban Earthquake Risk:

- unplanned urban areas or informal settlements in urban areas
- poor infrastructures or poor condition of road pattern and lifeline facilities
- lack of open spaces
- existence and designing of vulnerable buildings

- poor condition of public facilitate buildings
- violation of rules and regulations
- contiguous building character

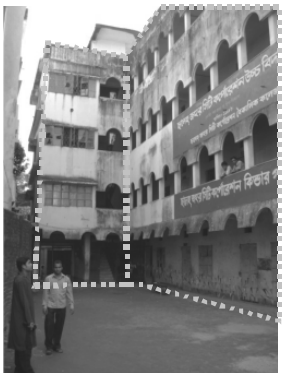
Physical Earthquake Urban Vulnerability



NARROW ROAD WIDTH (3'-0" WIDTH)

ADJACENCY OF BUILDING / POUNDING

BOUNDARY WALL

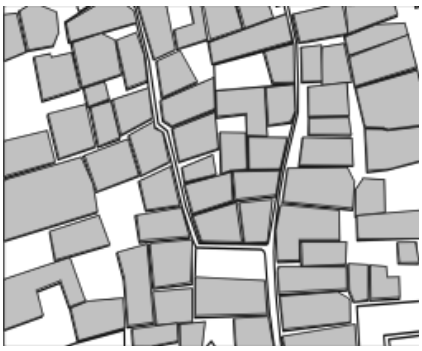


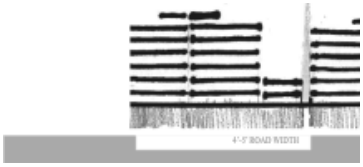
PUBLIC FACILITATE BUILDING(in terms of shape)

SOFT STORY

Strategies to reduce earthquake vulnerability:

scenario of physical vulnerability





strategy in written format

Evacuation path / emergency road -----

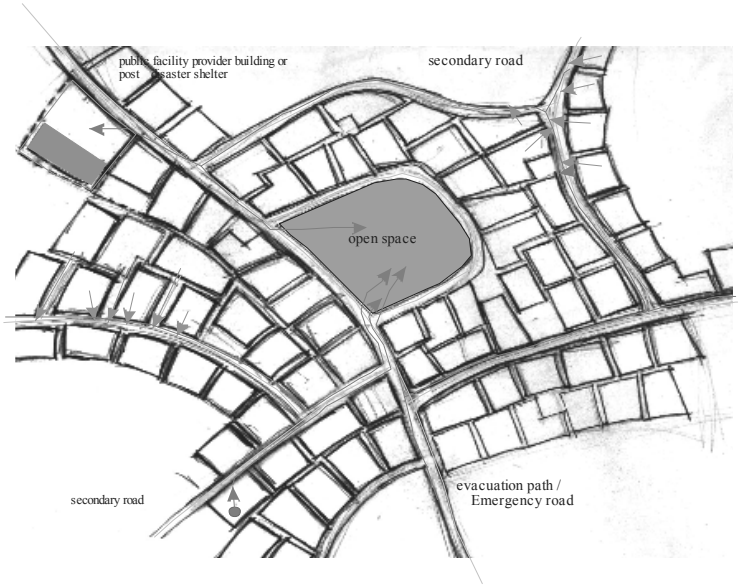
an evacuation path or an emergency exit route should be designed in a highly dense urban area specially for those which have been identified as earthquake vulnerable zone.

this emergency path should lead towards or connect the major open space & some public facility provider building thus it could be used as post disaster shelter.

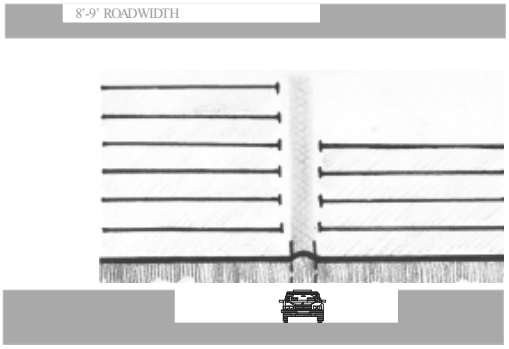
any water body or any source of water should be a part of this emergency path due to after earthquake fire hazard.

for better action after earthquake, this path should be free from all kind of damage related to disaster, thus building adjacent to this road should be earthquake resistant.

schematic solution



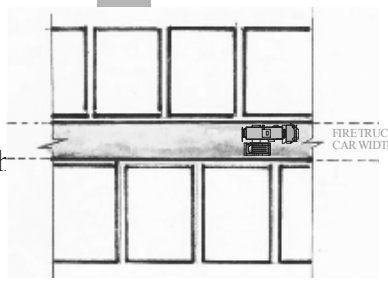
scenario of physical vulnerability

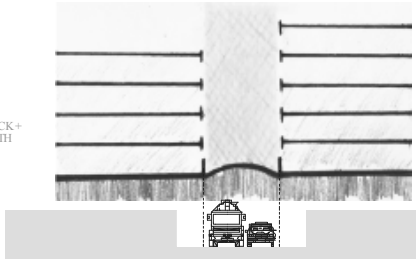


schematic solution

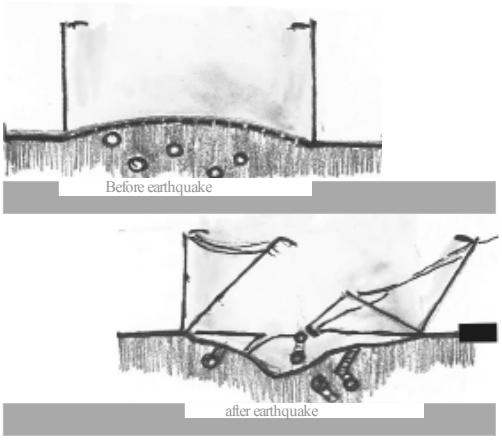
Width of the path ----

- Min width =
  fire truck [vehicle] width
  + car width





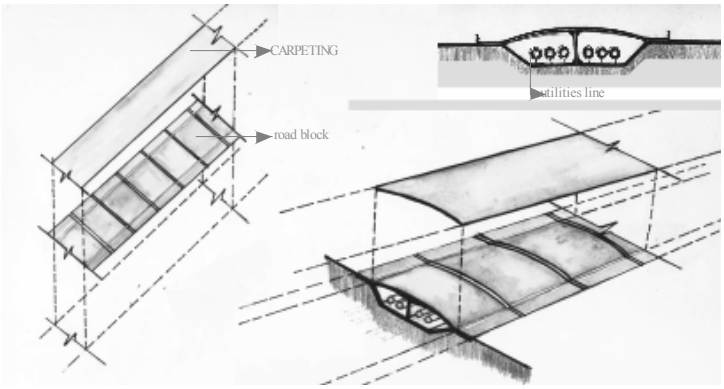
scenario of physical vulnerability



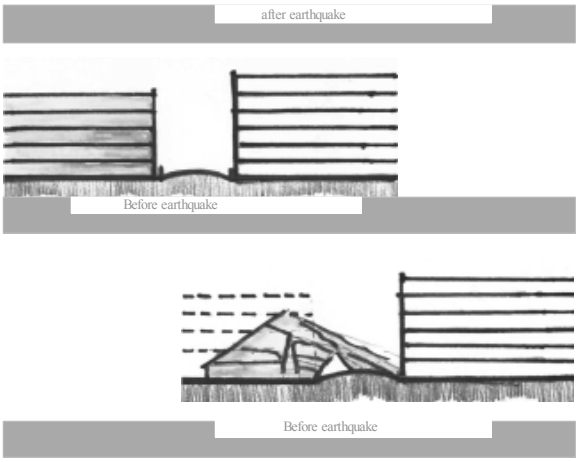
schematic solution

PATH DESIGN ----

It should be designed as such that all life line facilities those go beneath the street should be safe after earthquake & least damage will occur.



scenario of physical vulnerability



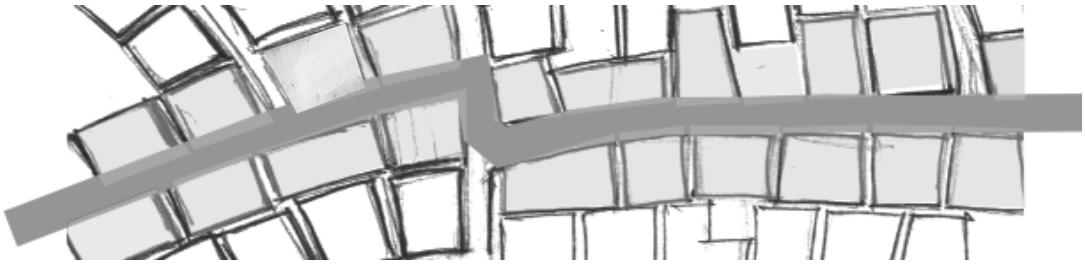
strategy in written format

building beside the evacuation/ emergency path ----

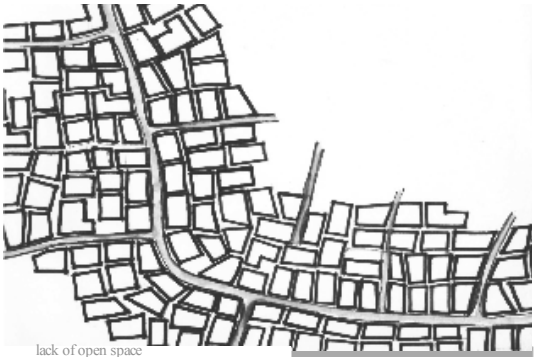
For better action after earthquake, this path should be free from all kind of damage related to disaster, thus building adjacent to this road should be earthquake resistant.

special measure should be taken to retrofit the vulnerable one or destroy the most risky builform.

schematic solution



scenario of physical vulnerability



lack of open space

strategy in written format

Open Space ----

this space could be a first stage of shelter during or after earthquake.

SIZE of the OPEN SPACE -

X = Number of people x 10.76 sq.ft./ 1 sqm
[area needed for each person]
[source - Tokyo metropolitan earthquake disaster prevention plan]

CATCHMENT AREA ---

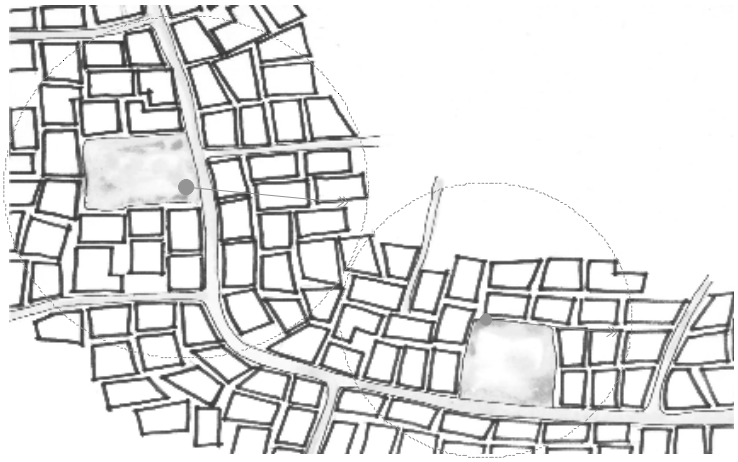
Diameter of the area = at what extent a person can walk or how long at what rate.

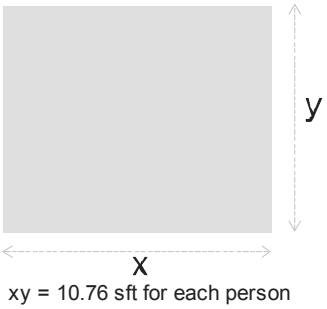
OPEN SPACE DESIGN---

building adjacent to this open space should be earthquake resistant or retrofitted.

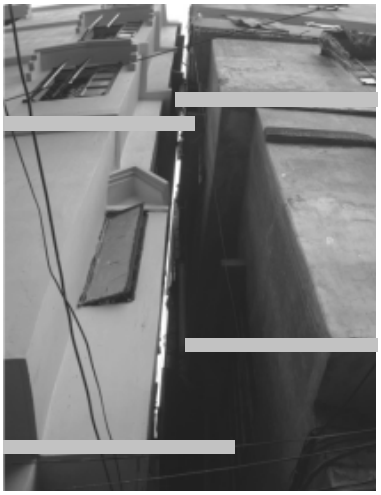
this open spaces can also be spread out or split in an organized and connecting manner

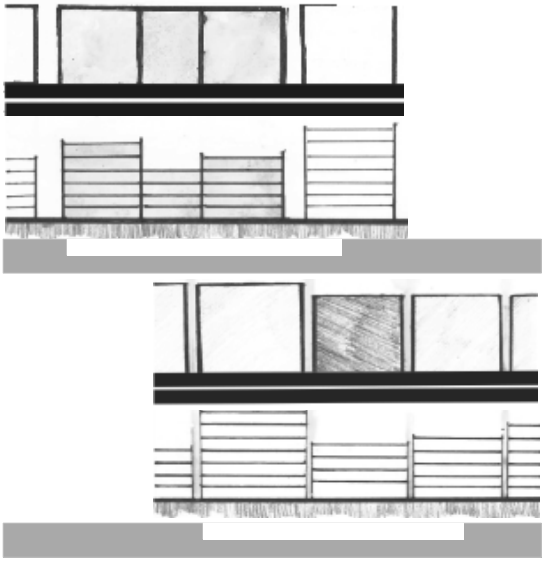
schematic solution





scenario of physical vulnerability



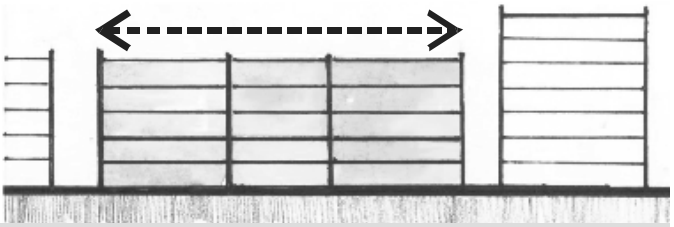


strategy in written format

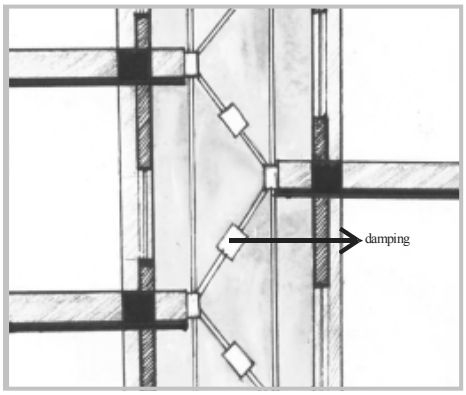
Adjacency of building / pounding ----

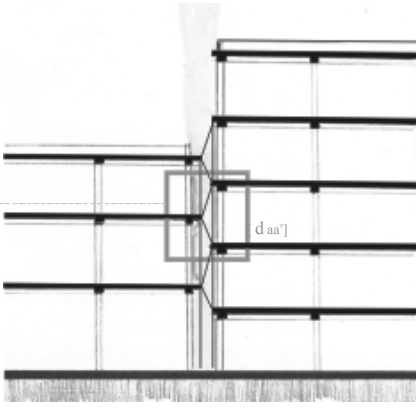
Closely spaced building should be retrofitted by making all the building at same height thus they will shake as a single unit during earthquake.

schematic solution

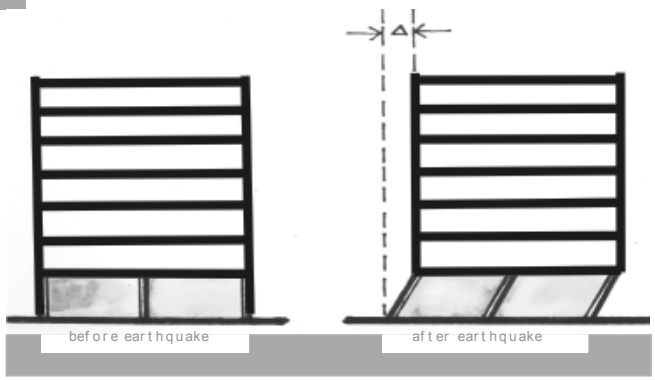


retrofit the build structure [blow up d aa']



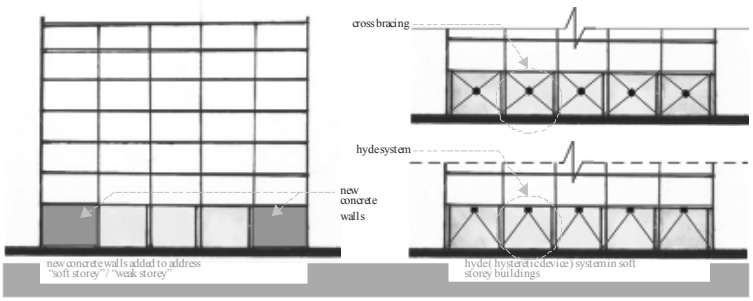


scenario of physical vulnerability

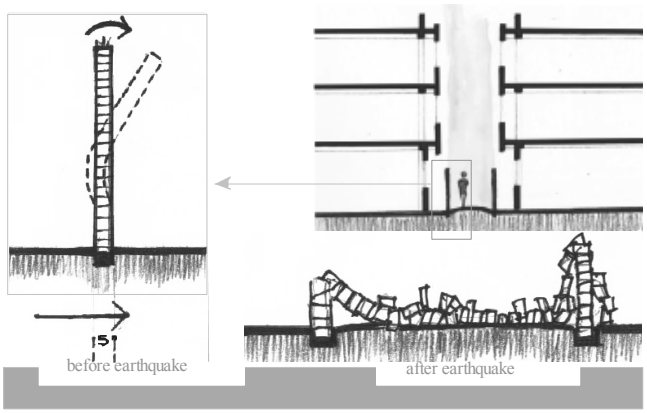


schematic solution

SOFT STOREY OR SHORT COLUMN-------

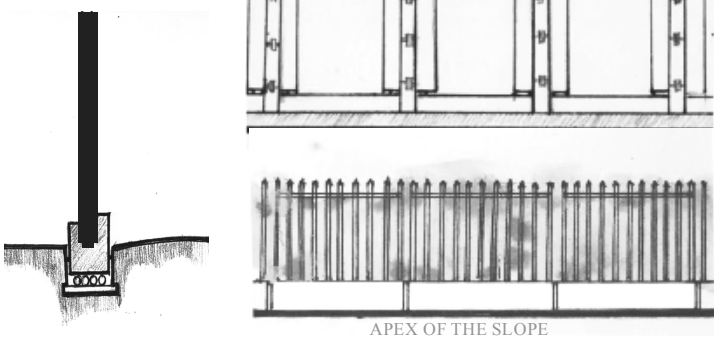


scenario of physical vulnerability



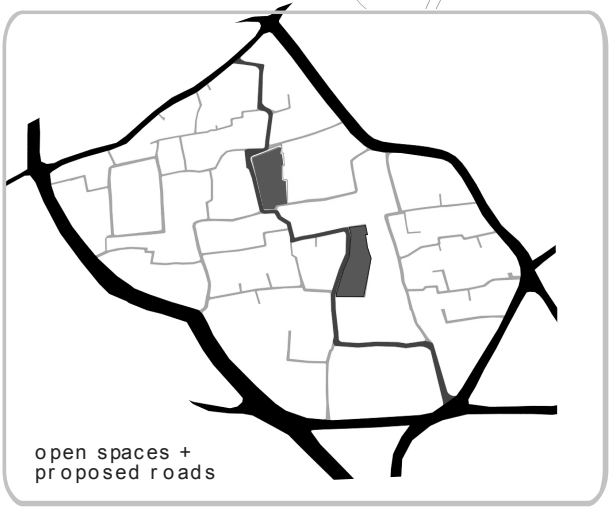
schematic solution

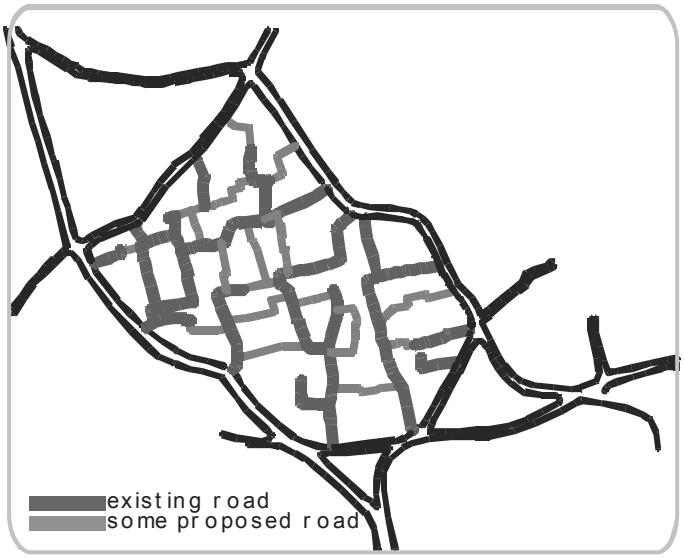
BOUNDARY WALL--------

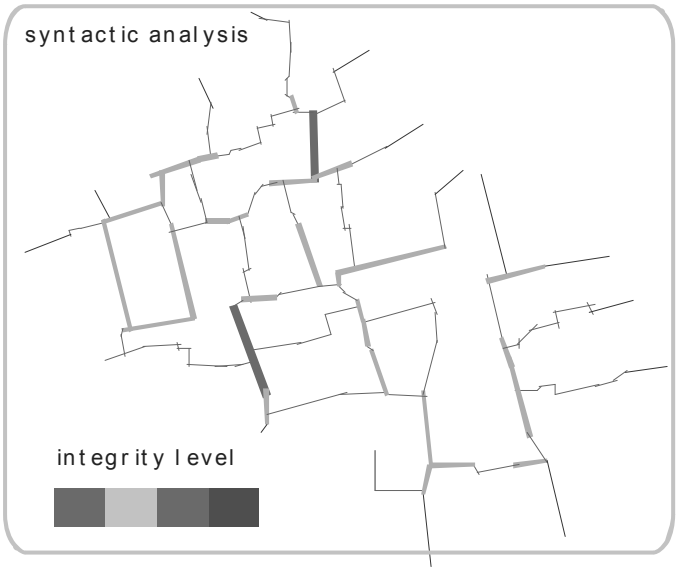


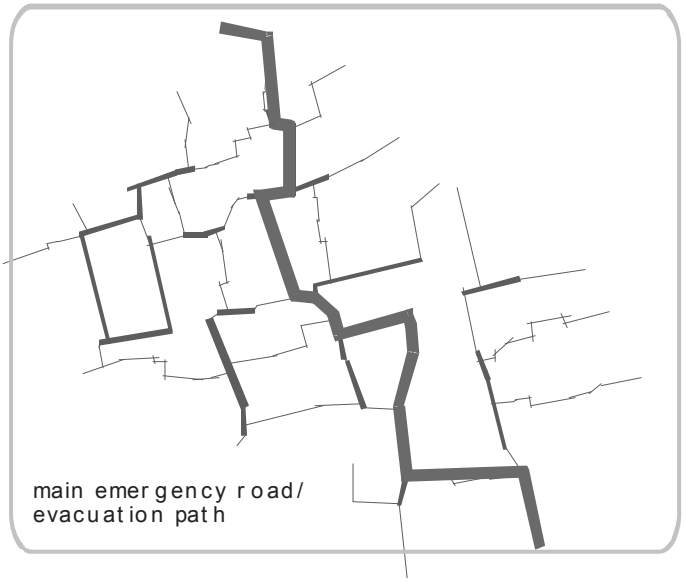
PROPOSED RE-DESIGN OF OPEN SPACE & EMERGENCY ROAD

At Nonodon Kanon Area (applying strategies):

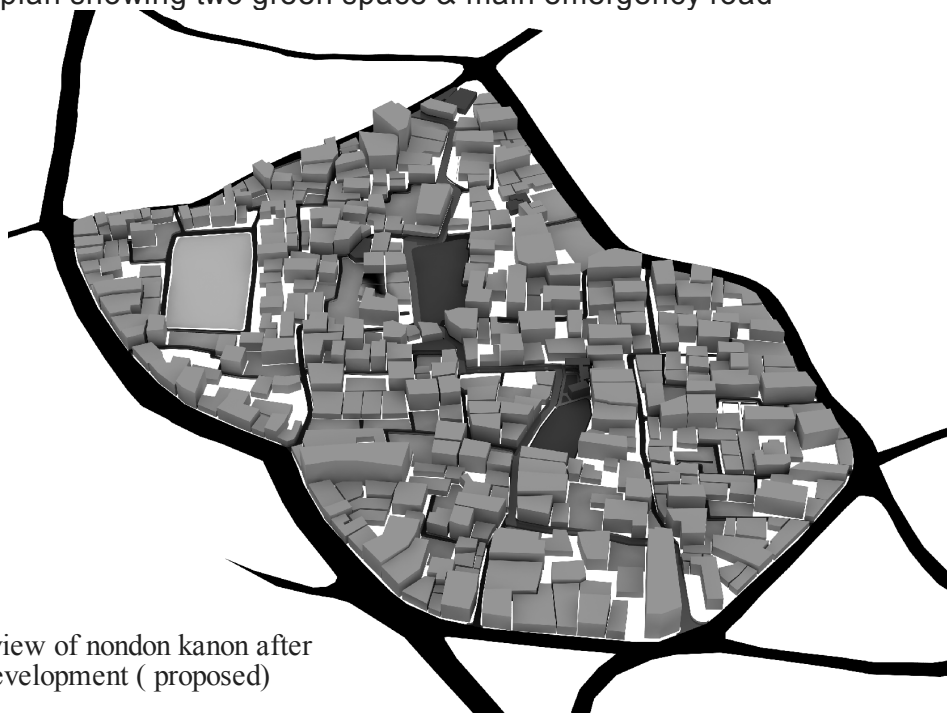



existing road
some proposed road


syntactic analysis
integrity level


main emergency road/
evacuation path

site plan showing two green space & main emergency road



3d view of nondon kanon after redevelopment (proposed)

CONCLUSION

Earthquake vulnerability reduction strategies are of utmost importance in mitigating risk for any part of the country especially for Metropolitan cities. Bangladesh falls in high seismic zone but still no significant initiative has been taken in advance to face the disaster in time. Therefore, initiatives in reducing the loss due to any hazard must be taken into consideration. Cities may face immense sufferings due to concentration of high density of population in vulnerable structures with low preparedness to disastrous attack. In order to reduce urban vulnerability and safe the cities from seismic hazards, at present, earthquake vulnerability reduction strategies is one of the priorities for policy makers in Bangladesh. The case study analyses the present scenario of a major port town, Chittagong city in Bangladesh, in response to an earthquake. Some policy strategies are recommended that may be effective in loss reduction to a great extend.

The rapid urban growth is causing deterioration and increasing the vulnerability of human lives, economy and infrastructures. If a strong earthquake strikes Chittagong city which may result in damage and destruction of massive proportions, it may have disastrous consequence for the entire country. This study aims to analyze the issues related to physical urban vulnerability in detail to arrive at strategies or policy based solutions that are necessary to support the redevelopment of urban areas in Chittagong and whole of Bangladesh. We conclude with remarks on how hazard motivated land use planning reduce the earthquake risk. The study also proposes an alternative redesign solution showing the possibilities of earthquake vulnerability reduction.

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