Rapid Visual Screening: An Assessment of the Impact of Earthquake on Critical Infrastructures in Two Wards of Dhaka City

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Abstract

Earthquake occurs due to the movement of the surface of the earth and various changes in earth crust. When an earthquake of fearful Richter scale occurs, the earth under our feet trembles, buildings collapse causing deaths and injuries, inducing fires, producing floods from collapsed dams and lands and so on. In this paper, hospitals and educational institutions are considered as critical infrastructures vulnerable to earthquake hazard in Dhaka city. Critical infrastructure is a term used by governments to describe assets that are essential for the functioning of a society and economy. Rapid visual screening (RVS) procedure is used here to assess the impact of earthquake hazard on educational institutions and health facilities of two wards in Dhaka City. The results from rapid visual screening can be used for a variety of applications that are an integral part of the earthquake disaster risk management program of a city or a region.

Key words: Earthquake, Rapid Visual Screening, Vulnerability, Infrastructure.

Introduction

Earthquake is increasingly becoming a red alert for Bangladesh and Dhaka has become a red alert city. Bangladesh, being located close to the plate margins of Indian and Eurasian plates, is susceptible to earthquakes. The collision of the Indian plate moving northward with the Eurasian plate is the cause of frequent earthquakes in the region comprising Bangladesh and neighboring India, Nepal and

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Myanmar (Ali, 2005). Historically Bangladesh struck by five earthquakes of large magnitude (M) greater than 7.0 (Richter scale) during the 61 year period from 1869 to 1930. It should be noted here that large earthquakes in the region have not been occurring for quite a long time (around 75 years) and hence, the possibility of a major earthquake occurring soon is quite high (Al-Hussaini, 2005).

The buildings in Dhaka city may be broadly classified into two groups: Unreinforced Brick Masonry (UBM) buildings and Reinforced Concrete Frame (RCF) buildings (Al-Hussaini, 2005). UBM buildings have been observed to behave poorly during earthquakes and these can be more dangerous if constructed 4 or more stories high, or built on 5 inch walls, which is not uncommon in Dhaka. RCF construction can also pose equivalent danger if earthquake resistant design provisions are not followed. Economic reasons, lack of quality control in construction and use of poor quality materials all contributes to the high vulnerability of buildings. A recent building survey funded by Bangladesh Ministry of Science and Technology research grant in parts of Sutrapur, Lalbagh and West Dhanmondi revealed concentration of multi-storied UBM buildings in the older part of the city. While the percentage of UBM buildings in Sutrapur area of the old city was found to be around 65%, the same in the relatively new area of West Dhanmondi was found to be around 42% (Al-Hussaini, 2005).

Earthquakes cannot be prevented, but the damage can be reduced with suitable measures. While Bangladesh has achieved remarkable success in disaster management for frequently occurring hazards such as cyclone, tornado and floods, it is at an infant stage with regard to earthquakes. In the past few years, some encouraging activities have started and are continuing with both individual and institutional efforts. The Government has also stressed the importance for developing a national earthquake management system and has taken steps in this regard (Al-Hussaini, 2005).

Objectives and Methodology of the Study

The objective of this research is to investigate and analyze the possible blow of earthquake hazard on critical infrastructures of Mohammadpur and Mirpur area. In this research hospitals and educational institutions are considered as critical infrastructures vulnerable to earthquake hazard in Dhaka city. It has also attempted to propose some approaches about appropriate earthquake preparedness, risk mitigation plan and policies, emergency response and recovery for critical infrastructures.

Table-1: No. of Critical Infrastructures at Mirpur and Mohammadpur.

		Mirpur (Ward no 8)	Mohammadpur (Ward no 46)
1	Primary Schools	4	1
2	Secondary Schools	5	2
3	College	2	2
4	Other Educational Institutions	2	5
5	Hospital	1	2
6	Health Care Centre	2	--
7	Government shelter centre	1	--

Source: Field survey, 2011

In this study, data collection and processing was conducted at the study areas of Mirpur and Mohammadpur. At Mirpur, Ward no. 8 (Figure-1) and Mohammadpur, Ward no. 46 (Figure-2) the educational institutions and health facilities were surveyed by the RVS or Rapid Visual Screening Method (Table-1).

According to this method, a questionnaire survey is conducted with a particular form, which has some special checklist observables: i) Infrastructural Survey, ii) Building Survey, iii)Year of Construction, iv) Accessibility, v) Building types considered in RVS, vi) Use of building, vii) Checklist of the Observables, viii) Structural Irregularities, ix) Openings and Walls (Large Openings, Irregular openings, Openings at corner), x) Long Walls, xi) Dissimilarities of Buildings, xii) Roof Condition, xiii) Earthquake Bands, xiv) database maintaining.

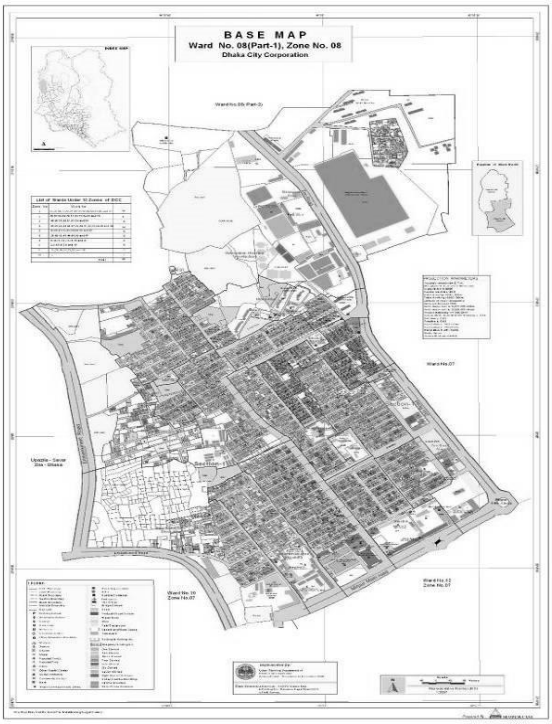

Figure-1: Map of ward no 8
Source: DCC, 2011 and edited by author

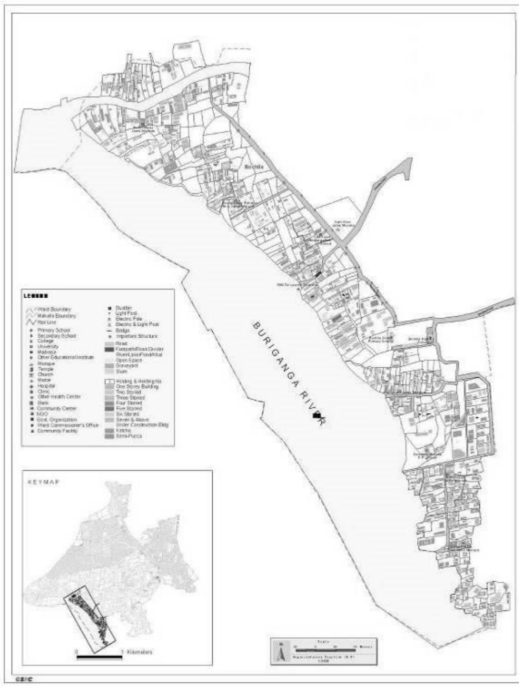

Figure-2: Map of Ward no 46
Source: DCC, 2011 and edited by author

The RVS procedure was carried out successfully and by using the information of the survey, it was quite easy enough to find out the actual result of this study. The existing situation of critical infrastructures and lifeline support was explored by field survey and visiting other associated offices.

A Brief Observation of the Method used in this Research

Planning and Managing RVS

Rapid visual screening (RVS) procedure requires only visual evaluation and limited additional information. The most important feature of this procedure is that it permits vulnerability assessment based on walk-around of the building by a trained evaluator. The evaluation procedure and system is compatible with GIS-based city database, and also permits use of the collected building information for a variety of other planning and mitigation purposes (Sharma, 2005).

The results from rapid visual screening can be used for a variety of applications that are an integral part of the earthquake disaster risk management program of a city or a region (Sharma, 2005). The main uses of this procedure are:

- To identify if a particular building requires further evaluation for assessment of its seismic vulnerability.
- To rank a cities or communities seismic rehabilitation needs.
- To design seismic risk management program for a city or a community.
- To plan post-earthquake building safety evaluation efforts.
- To develop building-specific seismic vulnerability information for purposes such as regional rating, prioritization for redevelopment etc.

- To identify simplified retrofitting requirements for a particular building (to collapse prevention level) where further evaluations are not feasible.
- To increase awareness among city residents regarding seismic vulnerability of buildings (Sharma, 2005).

Method of Rapid Visual Screening

The RVS methodology is referred to as a "Sidewalk Survey" in which an experienced screener visually examines a building to identify features that affect the seismic performance of the building, such as the building type, seismicity, apparent quality and irregularities (Sharma, 2005). According to Sharma the visual survey of a building can be completed in less than 30 minutes and can be accomplished from the street without entering into a building. This survey is carried out based on the checklists (Sharma, 2005). Sharma also mentioned that a performance score is calculated for each building based on numerical values on the RVS form corresponding to the features of the building. This performance score mainly depends on soil type, building condition architectural and earthquake resistance features. Other important data regarding the building is also gathered during the screening, including the Earthquake Vulnerability Assessment of existing buildings (Sharma, 2005).

The RVS methodology is also not intended for structures other than buildings. For important structures such as bridges and lifeline facilities, the use of detailed evaluation methods is recommended. Even in urban areas, some very weak forms of non-engineered buildings are well-known for their low seismic vulnerability and do not require RVS to estimate their vulnerability. These building types are also not included in the RVS procedure.

Building Type Considered by RVS

The basic vulnerability class of a building type is based on the average expected seismic performance for that building type. All buildings have been divided into four vulnerability class, denoted as Class

A to Class D based on the European Macro seismic Scale (EMS-98) recommendations(European Journal of Scientific Research, 2010). The buildings in Class A have the highest seismic vulnerability while the buildings in Class D have lowest seismic vulnerability. A building of a given type, however, may have its vulnerability different from the basic class defined for that type depending on the condition of the building, presence of earthquake resistance features, architectural features etc. It is therefore possible to assign a vulnerability range for each building type to encompass the expected vulnerability considering the different factors affecting its likely performance (European Journal of Scientific Research, 2010).

Earthquake Resistant Features

Earthquake Bands: For integral actions all the walls are to be tied together otherwise the walls will get separated at corners, cracks will be formed, gable end may fall, even the wall may collapse which may cause the fall of heavy roof. To avoid such a tentatively disastrous situation reinforced concrete or wooden earthquake bands (Figure-3) are recommended at various levels (Sharma, 2005).

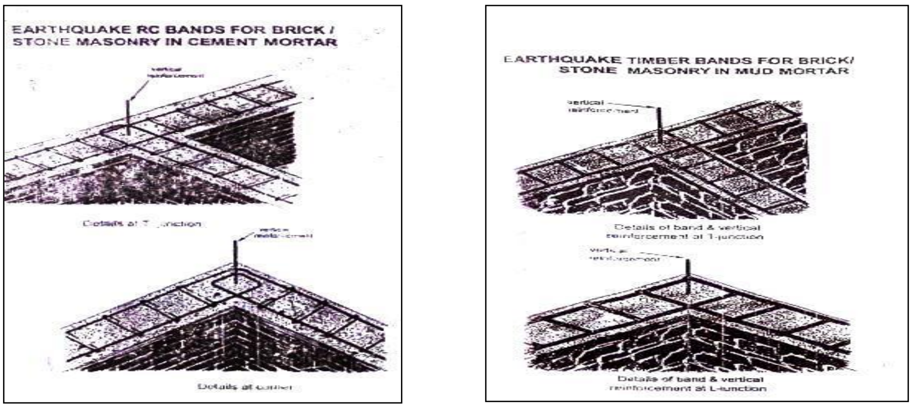

Figure-3: Earthquake band in Cement mortar and Mud mortar
Source: Sharma, 2005

Vertical Steel: Vertical steel is provided near the openings and at the corners and junctions of the walls to increase ductile behavior so that buildings can resist tensile forces and able to deform and bend without collapse (Sharma, 2005).

Construction of Stone Walls: To tie the thick random rubble masonry wall along its thickness, bond stones are provided at regular intervals. These through stones should be long enough to run with the full thickness of walls. Corner bond stones should be well staggered and project out to avoid vertical smooth joints (Sharma, 2005).

Minimum Distance between Openings and Corners: Minimum distance between openings and corners should be provided as per figure (Sharma, 2005).

Roof**:** Heavy roof made of stone or thick layer of mud is more prone to damage as compared to light tin sheet roof (Sharma, 2005).

Bracing in Plan: Horizontal bracings are to be provided at tie level to increase rigid diaphragm action of flexible roofs (Sharma, 2005).

Analysis and Findings of the Study

Types of Buildings at Mohammadpur and Mirpur area

Figure-4 shows the types of the buildings between Mohammadpur and Mirpur are different. Both of the areas contain three types of building like RCC, Masonry and Semi-pacca that varies in number.

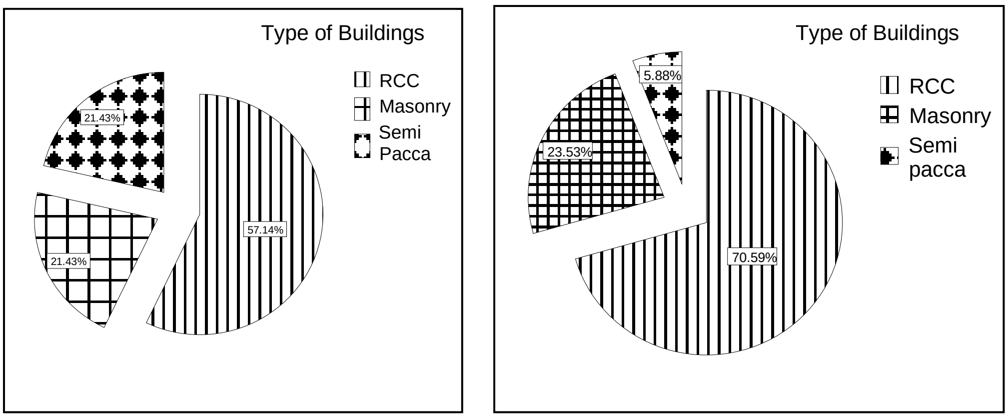

Figure-4: Type of buildings in Mohammadpur and Mirpur
Source: Field survey, 2011

Symmetric characteristics of buildings**:** It is obvious that most of the buildings of Mohammadpur are not symmetric. In Mirpur area, comparing to Mohammadpur, the buildings are more symmetric. The difference can be better shown in the table.

Table-3: Symmetric Buildings of Mohammadpur and Mirpur

Symmetric		%
Mirpur	yes	58.8%
	no	41.2%
Mohammadpur	yes	14.3%
	no	85.7%

Source: Field survey, 2011

Presence of shear wall at the middle: Shear wall is an important feature for any building to resist the building from earthquake hazard (Table-4). Shear wall should be provided at the middle. It was found in the survey that in Mohammadpur, almost all building was constructed without any shear wall. Those which do not have shear wall in the middle are in potential danger. In Mirpur, no building was found which have shear wall. In otherwords, 100% buildings that are surveyed in Mirpur were built without any shear wall.

Table-4: Shear Wall of Mohammadpur and Mirpur

Checklist	Shear wall at the middle		
	Mohammadpur		Mirpur
	No	No shear wall	No shear wall
Count	4	10	17
%	28.6%	71.4%	100%

Source: Field survey, 2011

Presence of cantilever beam: The presence of cantilever beam is might be both harmful or opposite. But these should be properly planned and endowed with proper structural load bearing capacity to withstand shock of Earthquake. In Mohammadpur, it's obvious that almost half of the buildings are without cantilever beam (Table-5), the rest are present but not so harmful and a few buildings have harmful cantilever beam. In Mirpur area the greater part has no cantilever beam and the rest of the part is divided into half in which one part is harmful and the rest of the half is not so harmful.

Table-5: Cantilever Beam at Mohammadpur and Mirpur

Checklist of Count and %	Cantilever beam			Total	Floating column		Total
	present and harmful	present but not so harmful	absent		present and harmful	absent	
Mohammadpur	1	6	7	14	5	9	14
Mirpur	2	3	12	17	1	16	17
Mohammadpur	7.1%	42.9%	50.0%	100.0%	35.7%	64.3%	100.0%
Mirpur	11.8%	17.6%	70.6%	100.0%	5.9%	94.1%	100.0%

Source: Field survey, 2011

Apparent quality of the buildings: The apparent quality of the surveyed buildings of Mohammadpur and Mirpur, are shown below (Table-6). In Mohammadpur greater numbers of buildings are of medium quality, half of the rest are bad and worst and some are in good condition. In Mirpur, almost half of the buildings are good in apparent quality, half of the rest are worst and a few buildings are in bad quality.

Table-6: Apparent Quality Buildings of Mohammadpur and Mirpur

Count and %	Apparent quality				Total	Flat plate		Total
	good	medium	bad	worst		Present	absent	
Mohammadpur	2	6	3	3	14	1	13	14
Mirpur	9	4	1	3	17	2	15	17
Mohammadpur	14.3%	42.9%	21.4%	21.4%	100.0%	7.1%	92.9%	100.0%
Mirpur	52.9%	23.5%	5.9%	17.6%	100.0%	11.8%	88.2%	100.0%

Source: Field survey, 2011

Use of buildings: The buildings of Mohammadpur and Mirpur area, are divided into primary school, secondary school, college, other educational institutions and health care centers.

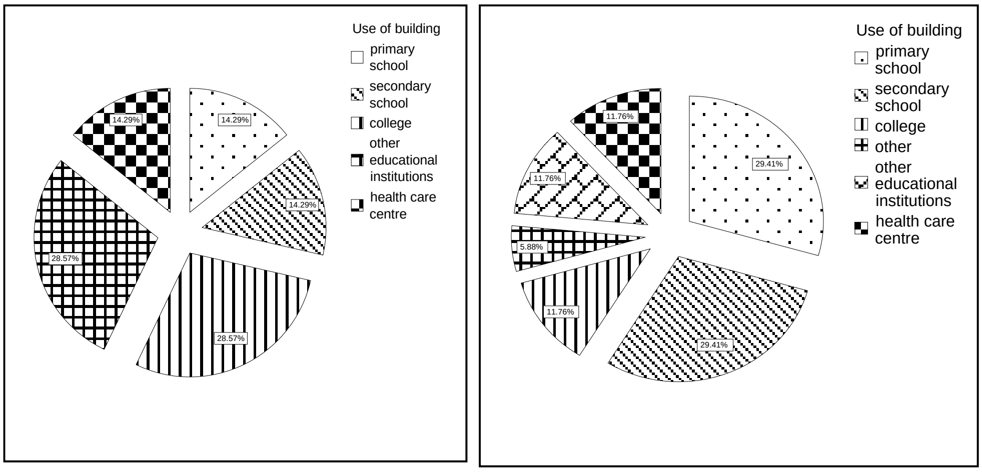

Figure-5: Use of the Buildings of Mohammadpur and Mirpur
Source: Field survey, 2011

Floating columns: Floating columns might be very harmful for the Earthquake Hazard (Figure-6).

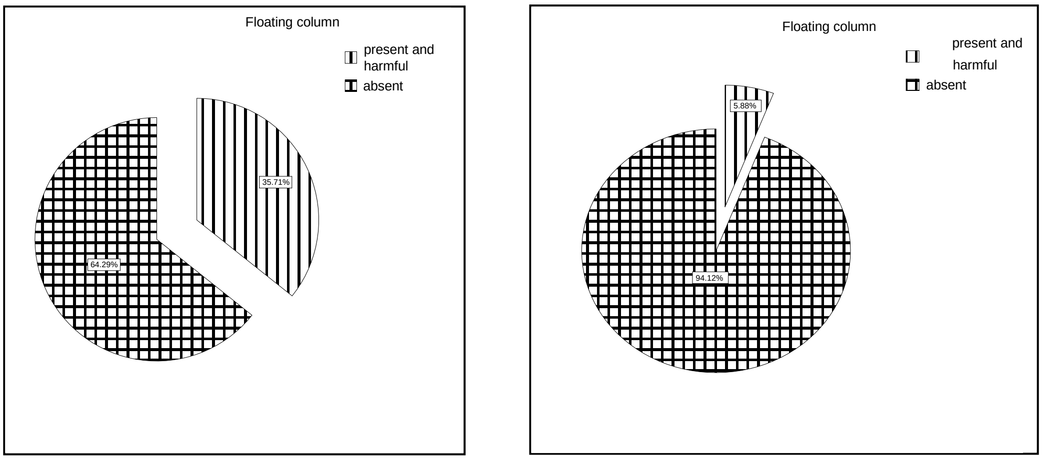

Figure-6: Floating Columns of Mohammadpur and Mirpur
Source: Field survey, 2011

Presence of flat plate: Flat plate is a flat, reinforced-concrete structural member, relatively sizable in length and width, but shallow in depth; used for floors, roofs, and bridge decks. Flat plate means generally, a concrete slab which is provided instead of heavy beams (Figure-7).

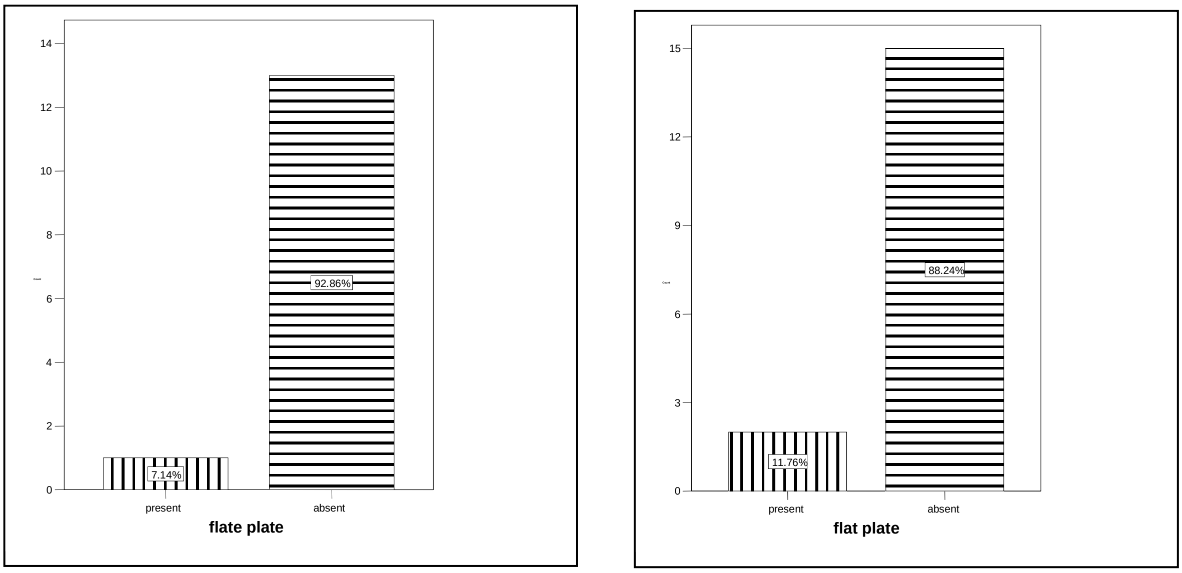

Figure-7: Presence of Flat Plate in Mohammadpur and Mirpur

Source: Field survey, 2011

Large openings, irregular opening and corner openings: Large openings are harmful for buildings during earthquake. In Mohammadpur area large openings are comparatively less than Mirpur area (Table-7). Irregular openings are also harmful for buildings. Mohammadpur area contains more irregular openings in buildings than Mirpur area. An opening at corners of a building is harmful during earthquake. In Mohammadpur area, the openings at corners of buildings are greater than Mirpur area's buildings.

Table-7: Large Openings, Irregular Opening and Corner Openings at Mohammadpur and Mirpur

Checklist of Count and %	Large openings		Total	Irregular openings		Total	Openings at corner		Total
	present	Absent		present	absent		Present	absent	
Mohammadpur	5	9	14	11	3	14	12	2	14
Mirpur	7	10	17	9	8	17	10	7	17
Mohammadpur	35.7%	64.3%	100.0%	78.6%	21.4%	100.0%	85.7%	14.3%	100.0%
Mirpur	41.2%	58.8%	100.0%	52.9%	47.1%	100.0%	58.8%	41.2%	100.0%

Source: Field survey, 2011

Existence of long walls: Existences of Long walls in buildings are harmful also. According to the study, Mohammadpur area consists of greater number of buildings that have Long walls which are harmful, than Mirpur area (Figure-8).

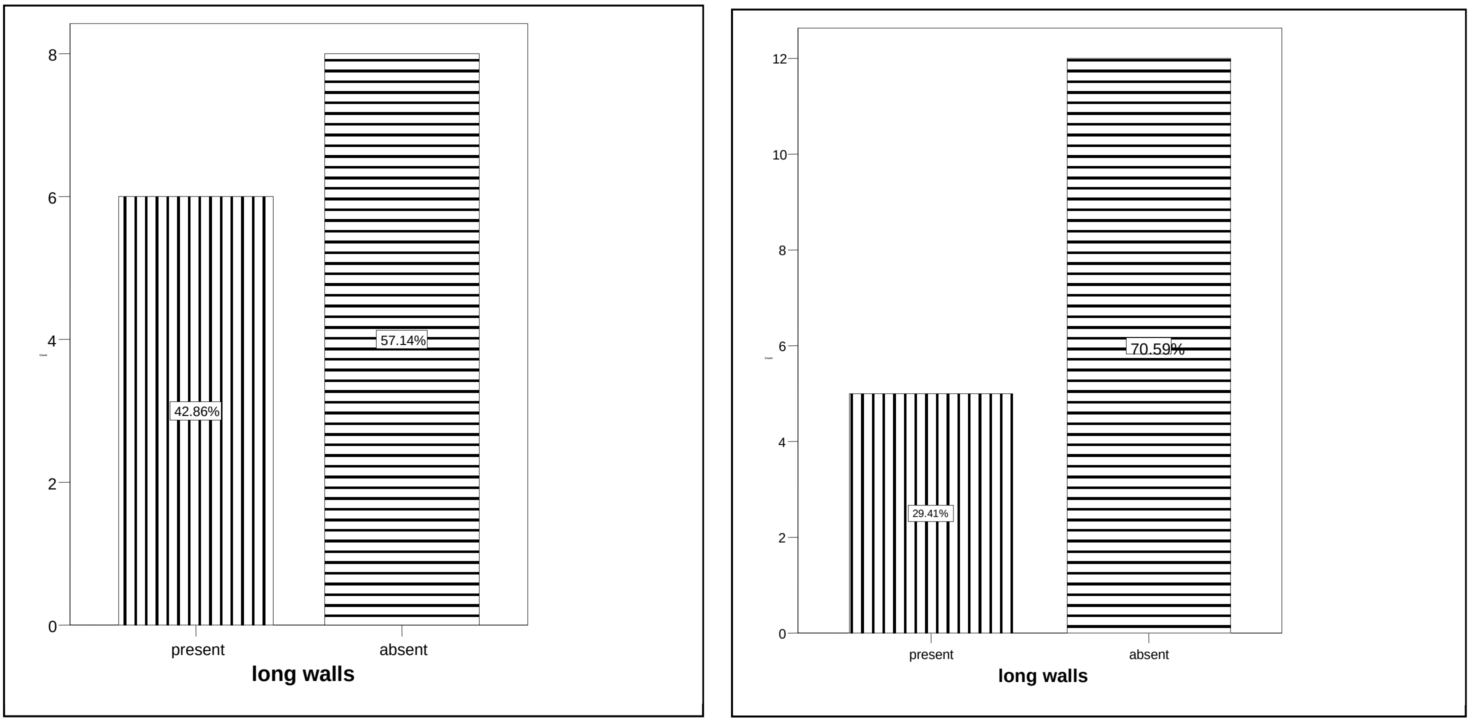

Figure-8: Existence of Long Walls in Mohammadpur and Mirpur
Source: Field survey, 2011

Dissimilar buildings: Dissimilar buildings of Mohammadpur and Mirpur areas are compared below and the result shows that Mohammadpur area included greater part of dissimilar buildings (Table-8).

Table-8: Dissimilar Buildings at Mohammadpur and Mirpur

Checklist	Dissimilar buildings			
	Mohammadpur		Mirpur	
	present	absent	Present	absent
Count	11	3	10	7
%	78.6%	21.4%	58.8%	41.2

Source: Field survey, 2011

Roof condition and Earthquake band: Roof condition of Mohammadpur area are almost medium, the rest of the pie chart is good, worst and tin shade (Table-9). In Mirpur area, most of the building's roof conditions are good, rest of the chart is medium and worst and few buildings have tin shade. According to the survey, the buildings of Mohammadpur contain comparatively more earthquake band in foundation level and three levels of foundation, plinth and lintel.

Table-9: Roof Condition and Earthquake Band at Mohammadpur and Mirpur

	Roof condition				Total	Earthquake bands			Total
Count	good	medium	worst	tin shade		present at foundation level	present in three levels	absent	
Mohammadpur	3	5	3	3	14	3	1	10	14
Mirpur	6	5	5	1	17	3	14	17	6
Mohammadpur	21.4%	35.7%	21.4%	21.4%	100.0%	21.4%	7.1%	71.4%	100.0%
Mirpur	35.3%	29.4%	29.4%	5.9%	100.0%	17.6%	82.4%	100.0%	35.3%

Source: Field survey, 2011

Accessibility of buildings: Accessibility of a building means the entry and exit of any building. In this study, it was prior that, in Mohammadpur almost all buildings have partial access whereas in Mirpur, most of them have full access. But in Mirpur, some of the buildings have no access and they are declared as abandoned (Figur-9).

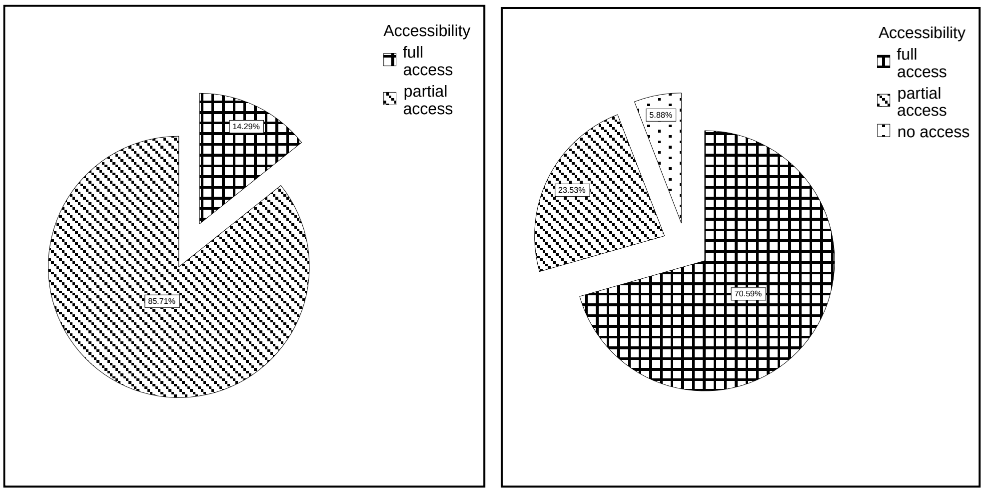

Figure-9: Accessibility of Buildings in Mohammadpur and Mirpur
Source: Field survey, 2011

Seismic Vulnerability Analysis

According to the RVS method, the Vulnerability class is identified by the pie charts and table (Table-10) below of Mirpur and Mohammadpur area.

Table-10: Vulnerability Class of Mohammadpur and Mirpur Area

Checklist of Count and %	Vulnerability class				Total
	A=Highest Seismic Vulnerability	B=Medium Seismic Vulnerability	C=Less seismic Vulnerability	D=Lowest Seismic Vulnerability	
Mohammadpur	5	2	5	2	14
Mirpur	5	2	4	6	17
Mohammadpur	35.7%	14.3%	35.7%	14.3%	100.0%
Mirpur	29.4%	11.8%	23.5%	35.3%	100.0%

Source: Field survey, 2011

Vulnerability to Structure

According to the survey, it was apparent that the vulnerability of the structures is more or less related to their construction materials, soil and land use, building maintenance, proper and planned way of construction etc. Mirpur and Mohammadpur, these two areas are different in their nature of growth. Because, Mirpur, ward no-8, is a planned area and Mohammadpur, ward no-46 is developing now-a-days. So these are quite different in respective building patterns and qualities. From the survey, it is noticeable that highest vulnerable structures in Mohammadpur and Mirpur are five and lowest vulnerable structures in Mohammadpur are only two whereas Mirpur has six structures within the surveyed buildings.

Vulnerability to Place and People

About 1, 30,000 people could be killed right away if an earthquake of 7.5 magnitudes, originating from the Madhupur blind fault; strikes capital Dhaka in the daytime, a survey says (DMB, 2010). The number of deaths will be a touch less, around 1, 22,000, if the tremor takes place at 2 a.m. In this study, it has been observed that Mirpur and Mohammadpur, both are almost residential area. So the structural deficiencies of the buildings of these two areas might become very much harmful and terrific if any strong Earthquake occurs. The people of these areas will be in danger if the vulnerable buildings are not retrofitted or alternated by other buildings. When an Earthquake will occur, both Mirpur and Mohammadpur areas will be in great chaos because both of these are major part of economical, social and cultural activities.

A comparative analysis of these areas is shown below:

Mohammadpur:	**Mirpur:**
a) Mohammadpur area consists of multi-storied buildings of Japan Garden city which is very much dissimilar according to its height and the adjacent other buildings. b) Alonside, the primary schools are very much vulnerable and harmful. Already there are lots of cracks and the glasses of the windows are already broken by some minor earthquake. c) The secondary schools are almost good but other educational institutions are mixed in nature. Some of them are vulnerable.	a) The primary schools of Mirpur are in vulnerable position. Already the buildings are being repaired by the authority but still they are not so satisfactory. b) The secondary schools and colleges are almost good in condition as these are recently built. Hence, the road conditions are not so pleasing for the earthquake rescue team to move during a major earthquake happens. c) The buildings are dissimilar in nature according to their adjacent buildings and the locality.

d) Some roads are very congested which might become problematic for reaching the rescue team while earthquake hazard. Hence, fire hazard may occur from the lifeline and utility services during earthquake. This fire hazard will be also harmful for the people and the place as fire brigade may not reach there at time. e) Beside this, the healthcare centers are not in a good condition which may lead the patients to death or injury when an earthquake occurs.	d) The Government Shelter Centre at Mirpur-1 is a building 100 years ago which was a mosque for the Sunni Muslims. These days it is used as the shelter centre which is vulnerable for lots of girls who are dwelling over here. e) The shopping complexes are also at risk for other critical infrastructures and roads also, for earthquake hazard.

Approaches to Manage Earthquake Vulnerability

Step-1: Securing Now

Reducing and/or eliminating hazards throughout home, neighborhood, workplace and school can greatly reduce risk of injury or death following the next earthquake or other disaster. Conducting a "hazard hunt" might be helpful to identify and fix things such as unsecured televisions, computers, bookcases, furniture, unstrapped water heaters, etc. Securing these items now will help to protect from any hazard.

Step-2: Making a Plan

Planning for an earthquake, terrorist attack, or other emergency is necessary for any family. The emergency plan should include evacuation and reunion plans, the location of emergency supplies and other pertinent information.

Step-3: Making of Disaster Kits

Everyone should have disaster supply kits stored in accessible locations at home, at work place and in their own vehicle. Having emergency supplies readily available can reduce the impact of an earthquake, a terrorist incident or other emergency on a person. The disaster supply kits should include food, water, flashlights, portable radios, batteries, a first aid kit, cash, extra medications, a whistle, fire extinguisher, etc.

Step-4: Ensuring the Safety of Living Place

Most houses are not as safe as they could be. Whether homeowner or a renter the important things that can be improved to maintain the structural integrity of home, should be prior. Some of the things that might be important to check include inadequate foundations, unbraced cripple walls, soft first stories, unreinforced masonry and vulnerable pipes. Consulting a contractor or engineer might be helpful to you identify building's weaknesses and deficiencies.

Step-5: Drop, Cover and Hold on Idea

Learning of the steps to do during an earthquake, at home, at work, at school or just out and about, taking the proper actions, such as "Drop, Cover, and Hold On", can save lives and reduce the risk of death or injury. That means, during earthquake, dropping to the floor; taking cover under a sturdy desk or table, and holding on to it firmly, might reduce the risk.

Step-6: Checking it Out

One of the first things that should be done following a major disaster is to check for injuries and damages that need immediate attention. Training in first aid and in damage assessment techniques will be helpful in this aspect. To administer first aid and to identify hazards such as damaged gas, water, sewage and electrical lines are also important.

Step-7: Communicate and Recover

Following a major disaster, communication will be an important step in recovery efforts. For most presidentially declared disasters, resources will also be available from federal, state, and local government agencies.

Concluding Remarks

As an urban and regional planner, everyone has some roles and responsibilities in pre-disaster and post-disaster situation. In pre-disaster situation, s/he should prepare micro-zoning and vulnerability mapping, optimize population density and some protection strategies for infrastructure facilities and transportation. His duty in the post-disaster situation is to learn from previous disaster and update plans. The above study will be helpful, to emphasize the need of identifying the responsibility that the engineers and planners have to play regarding mitigating efforts of Earthquake. It is not only the basic understanding of the phenomenon of earthquake, its resistance offered by the designed structure, but the understanding of the socio-economic factors, engineering properties of the indigenous materials, local skill and technology transfer models are also of vital importance. In conclusion, therefore, it is vital that the engineering aspects of mitigation should be made a part of public policy documents. Besides this, public awareness and community participation should be built up to improve the condition and the perspective of present earthquake phenomenon.

References

Ali, T. (2005). *Unplanned Urbanisation, Lack of Preparedness: Dhaka extremely vulnerable to earthquake disaster,* The Daily Star, 12 October, Vol 5, Num 491, retrieved from http://www.thedailystar.net/2005/10/12/d510122501118.htm, on January 10, 2010.

Al-Hussaini, Dr. T. M. (2005). *Earthquake risk in Bangladesh: Facing the reality*, The Daily Star, 28 January, Vol. 5, Num. 241, retrieved from http://www.thedailystar.net/2005/01/28/d501281901112.htm, on January 10, 2010.

DMB. (2010). *Disaster Management Bureau*, retrieved from www.dmb.gov.bd.com, accessed on January 2011.

European Journal of Scientific Research, vol. 41, num 3, retrieved from http://www.eurojournals.com/ejsr_41_3_03.pdf, on 22 January, 2010

Sharma, R.K. & Sharma, G. (2005). *Natural Disaster*, New Delhi, India: A. P. H. Publishing Corporation.