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EARTHQUAKE VULNERABLE SECTORS IN BANGLADESH AND SOME MEASURES FOR RISK REDUCTION: AN OBSERVATION

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ABSTRACT

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Bangladesh has one of the highest levels of seismicity in Asia and world also, it is potential for the largest earthquake for its geographical location and geological formation of earth. This paper aims to explore the earthquake vulnerable sectors and some measures for risk reduction especially before the disaster phase. Many sectors in Bangladesh are very vulnerable to earthquake because of unplanned structural and infrastructural activities. Various types of building and structure and their construction material, design, susceptibility to damage are also discussed here. The way to reduce earthquake's risk also mention in this article. Qualitative methods of research methodology used for this study.

Key words: *earthquake, vulnerable, risk reduction*

INTRODUCTION

Many civilizations had totally ravaged by unanticipated shaking of earth. Recently the Haiti Earthquake is one of them which had a boundless devastating scenario. The Haiti earthquake was a catastrophic magnitude 7.0 Mw with an epicenter near the town of Leogane, approximately 25 km west of Port of Prince (Haiti's capital city), and the earthquake occurred on 12 January 2010. By 24 January, at least 52 aftershocks measuring 4.5 or greater had been recorded. An estimated three million people were affected by the shake; the Haitian government reported that an estimated 316,000 people had died. 300,000 had been injured and 1,000,000 made homeless. The death toll has also been suggested to be much lower at somewhere between 92,000 and 220,000, with around 1.5 million to 1.8 million homeless. The Haitian government also estimated that 250,000 residences and 30,000 commercial buildings had collapsed or were severely damaged (http://en.wikipedia.org/wiki/ Haiti_ earthquake_2010, 24 January 2011).

Historically earthquake is a demoralizing natural phenomenon which is also a geological natural event. As a lacking signal hazard, great earthquake ranks as one of nature's most catastrophic and devastating events. Earthquakes and related hazards have destroyed large cities and taken thousands of lives in a matter of seconds, landslides, tsunami, fire, liquefaction, floods and long-range effects such as regional subsidence or emergence of land masses and regional changes in groundwater levels. Far-East is the most familiar earthquake prone area in the world where most of the devastating earthquake occurred. Japan, China, South Korea, North Korea, Mongolia, and south-east Asia's regions-Indonesia, USA also faced most devastating earthquake in the recent history. Most of the earthquake's damages were unbelievable.

In sixteenth century earthquake in China reportedly claimed 850,00 lives; in 1923, an earthquake near Tokyo claimed 143,000 lives; and in 1976, a catastrophic earthquake in china claimed several hundred thousand lives. Among the South Asian regions, Bangladesh is the highest earthquake vulnerable area and absolutely the world's number one. The delta islander Bangladesh is earthquake vulnerable because of its geographic location. Bangladesh is well within the tropics bounded by latitude 20º34'N to 26º38'N and longitude 88º01'E to 92º41'E. This country's geographic location is delimited by three tectonic plate boundaries such as-Indian plate, Eurasian plate and Burmese Plate. It is also vulnerable to earthquake for Sub-dauki (Sylhet), Bogra, Tripura, Shillong, Assam and Moddhupur (Tangail) fault zone. Earthquake specialists have divided the country into three regions according to earthquake vulnerability.

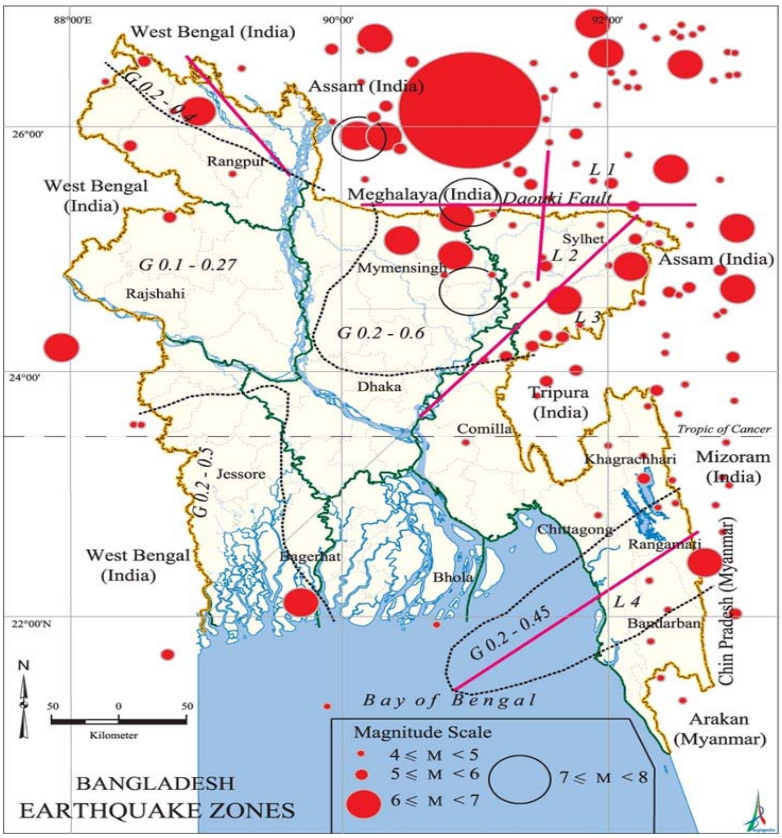

Fig. 1. Earthquake prone zones and affected areas of Bangladesh
Source: Banglapedia 2012

These three earthquake vulnerable regions are-High Risk Area (Sylhet, Mymensingh, Chittagong and Rangpur); Mid-Range Risk Area (Dhaka, Tangail, Bogra, Sirajgonj, Comilla, Rajshahi) and Low Risk Area (Coastal Region of Bangladesh). Many times Bangladesh has faced earthquake of various magnitude which is also potential for earthquake hazards according to its recorded history. In 1548s Earthquake, affected area -Sylhet and Chittagong, magnitude-unknown; 1742s earthquake, affected area -Dhaka and Chittagong, magnitude-unknown; 1885s Bengal earthquake, magnitude-7.0; 1889s earthquake, affected area-Sylhet, magnitude-7.5; 1897s great Indian earthquake, affected area-Sylhet, magnitude-8.7; 1918s earthquake, affected area -Srimongol (Sylhet), magnitude-7.6; 1930s Dhubri earthquake, affected area -Rangpur, magnitude-7.1; 1934s Bihar-Nepal earthquake, affected area-Rangpur, magnitude-8.3; 1997s earthquake, affected area- Chittagong, magnitude-6.0; 1999s earthquake, affected area- Moheshkhali (Chittagong), magnitude5.2; 2003s earthquake, affected area-Barkolupazilla, magnitude-5.1 (Rahman 2009).

METHODOLOGY

Methodology of the study describes the strategy adopted and the steps followed to achieve the ultimate goal and objectives of the study. In short, it is the complete crystallization of the research work. As this study is mostly subject to secondary data so it becomes very necessary to explore data from respected sources without an appropriate methodology. The aim of this study is to develop a standard methodology for assessing the contribution of corporate sector in the field of disaster risk reduction. In simple terms we can think of two approaches to investigations in disaster research: qualitative and quantitative. This study is mainly depended on the data collected from secondary sources. Secondary data were collected from different journals, books, research publications and other documents by using qualitative methods.

Earthquake vulnerable sectors in Bangladesh

In generally we can split the earthquake vulnerable elements into followings two sectors. 1) Structural sector, 2) Infrastructural sector. These two sectors include various types of sub-sector. United Nations (1991) categorizes the elements which are vulnerable to earthquake by following sectors and sub-sectors: 1) Conventional and modern buildings, 2) Traditional buildings 3) Infrastructure (UN 1991). Here we want to discuss the elements of various earthquake vulnerable sectors in Bangladesh.

Structures

Structural elements of buildings in Bangladesh differ from region to region, buildings material, geological evidence of earth system and other related phenomenon. The vulnerability of structure depends on its building materials of various buildings. Stone masonry buildings; wooden buildings; earthen buildings; brick masonry buildings; reinforced concrete buildings and lightweight structures (UN 1991).

Most of the structures in the rural area of Bangladesh are wooden and earthen (adobe). These two types' structures have different magnitude of vulnerability and risk. UN (1991) explains the vulnerability of structures to damage and collapse as such word "Earthen or adobe construction/1-storey/small window/good construction, widespread collapse>70%, collapse<30%, structural damage<30%. Wooden building/two floors/solid construction, collapse<30%, structural damage>70%, structural damage 40-60%". In this context we can say that most of the structural elements in the rural area of Bangladesh are in severe vulnerable position.

Buildings designs of the most earthquake prone cities of Bangladesh are particularly vulnerable to seismic forces because of its plate boundaries and earthquake fault line. Most of the buildings of these cities are L-shaped and split level buildings, or those with a tower rising from a lower structure which can easily tear apart. But the buildings of Dhaka city are vulnerable to earthquake for other reasons. Old Dhaka's buildings are vulnerable for their old constructive masonry buildings. L-shaped and split level buildings are also found in old town which are extremely susceptible to earth shaking.

On the other hand, New Dhaka is vulnerable to earthquake for other causes. Most of the buildings of the new town constructions are on wet land by earth filling that make the area susceptible to earthquake because of surface earth materials such as mud, alluvium bedrock behave differently in response to seismic shaking of various frequencies. For example, the intensity of shaking may be much more severe for unconsolidated sediment than for bedrock and therefore, shaking may be stronger for sites underlain by mud and alluvium than for bedrock sites much closer to the fault.

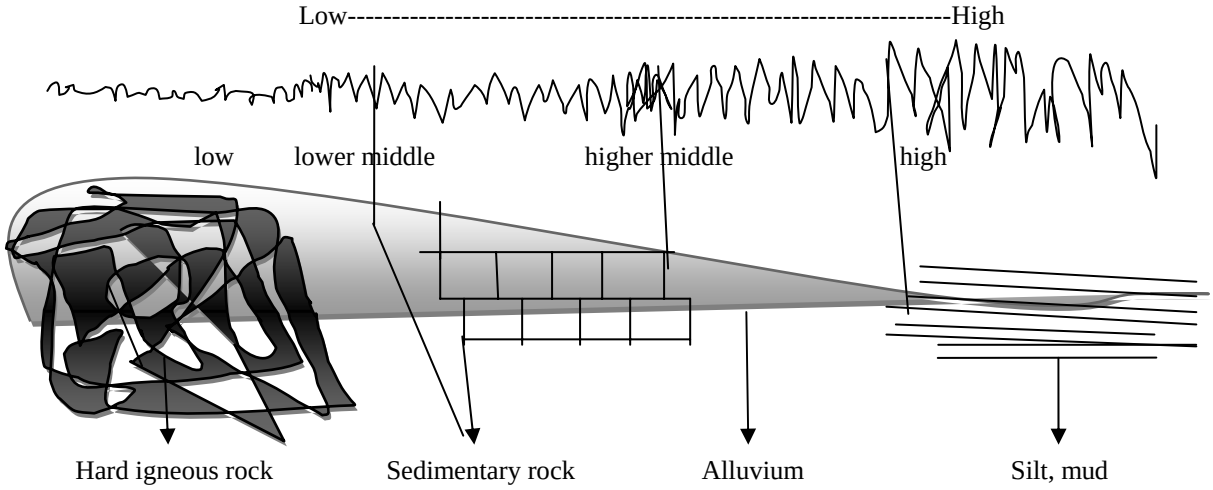

Fig. 2. Amplification of shaking (surface waves)
Source: Keller 1992

For example, a large earthquake on the San Andreas Fault near San Francisco could conceivably heavily damage the city of Sacramento, 130 km away, where the sub-strata are composed of alluvial deposits likely to accentuate seismic shaking. Other earthquake on October 1989 in the USA that's earth shaking also depended on soil type. The Loma Prieta earthquake was predicted that should a large earthquake occur in the Sanfrancisco Bay region, damage would be most severe in areas of bay fill and mud. The magnitude was 7.1 and killed 62 and the cost of property damage was about $5 billion.

In this regard we can say that new town of Dhaka city is obviously vulnerable to high magnitude earth shaking following the Mexico City that is built on ancient lake beds consisting of clays, silts, and sands are greatly intensified the seismic shaking.

The Bay offshore buildings of Chittagong is clearly vulnerable to earthquake hazard for its earth materials (alluvial sediment, silt and mud) and seismic shaking, liquefaction and fire destroys many structures. An ideal example of Loma Prieta earthquake of Sanfrancisco bay area where extensive damage occurred over a wide area and generate seismic shaking, liquefaction and fire which destroyed many structures. The buildings of coastal belt are also vulnerable to tsunami (secondary effect of earthquake). Further example, the tsunami of Indian Ocean engrossed the coastal belt of Indonesia, Sri-Lanka, Andaman-Nikobar islands, Malaysia, India, Thailand,

Maldives, Kenya, and Somalia. Indian Ocean Tsunami in December 2004, Location of origin- Tectonic earthquake created near the Sumatra islands of Indonesia in the deep of Indian Ocean, damaged many structures and killed about 300000 people most of them were in Indonesia (Rahman 2009).

The Hilly regions of Bangladesh are vulnerable to landslides (subsidence in plain area) are the secondary effects of earthquake. The people of hilly areas (migrant from plain land) of Bangladesh do not know how to use the hilly lands properly except the indigenous people. An example, in 1970s Peru earthquake generates landslides which destroyed many buildings and killed 20,000 people by gigantic avalanche. Numerous landsides associated with the 1989 Loma Prieta earthquake caused extensive damage to buildings and roads in the Santa Cruz Mountains south of Sanfrancisco (Hays 1981). From these two landslides associated with earthquake experiences it is unambiguous that most of the structures beside hills are vulnerable to earthquake in the hilly regions of Bangladesh.

Disruption of electrical power lines and broken gas lines can start fires that are difficult to control because firefighting equipment may be damaged and essential water supply may be broken due to earth shaking in Bangladesh especially in Dhaka City. For example, in 1906s Sanfrancisco fire caused by earthquake which damaged 80 per cent of total devastating. The Table 1 describes the structural types and rating of susceptibility of damage.

Table 1. Earthquake ratings for common building type

Simplified description of structural types	Relative damageability in order of increasing susceptibility to damage
Small wood-frame structures, i.e., dwellings not over 3,000 sq ft., not over 3 storeys	1
Single or multi-storey steel-frame buildings with concrete exterior walls, concrete floors, and concrete roof. Moderate wall openings	1.5
Single or multi-storey reinforced concrete buildings with concrete exterior walls, concrete floors, and concrete roof. Moderate wall openings	2
Large area wood-frame buildings and other wood-frame buildings	3 to 4
Single or multi-storey steel-frame buildings with unreinforced masonry exterior wall panels; concrete floors and concrete roof	4
Single or multi-storey reinforced concrete frame buildings with unreinforced masonry exterior wall panels, concrete floors and concrete roof.	5
Reinforced concrete bearing walls with supported floors and roof of any materials (usually wood)	5
Building with unreinforced brick masonry having sandlime mortar; and with supported floors and roof of any materials (usually wood).	7up
Bearing walls of unreinforced adobe, unreinforced hollow concrete block, or unreinforced hollow clay tile	Collapse hazard in moderate shocks

Source: UN 1991

According to the above table building with unreinforced brick masonry having sandlime mortar; and with supported floors and roof of any materials (usually wood) and bearing walls of unreinforced adobe, unreinforced hollow concrete block, or unreinforced hollow clay tile types of buildings are usually found in Bangladesh except of the buildings of New Dhaka.

Infrastructures

Various types of infrastructures that are susceptible to earthquake hazard in Bangladesh but generally we can explain it by following major sectors. a) Public services; b) Water supply; c) Transportation; d) Telecommunication and e) Energy supply. These five general categories can be subdivided by a) Object-oriented systems and b) Network-oriented systems which are as same as the Table 2 below.

Table 2. Objects and Network oriented systems

Object-oriented systems	Network-oriented systems
Hospitals, Police-stations, Fire-stations, Central food distribution centres, Airports, Modular telecommunication, Petrol, Gasoline, Bridge.	Water supply, Sewers, Roads, Highways, Railways, Ports, Surface based telecommunication, Electricity, Gas, Petrol, Gasoline.

Source: Studer 2000

Most of the service network system (transportation, water supply and sewer, energy supply or telecommunication) in Bangladesh is not well designed in any case to face earthquake vulnerability. Earthquake damages all types of service network system when Bangladesh has a long supply line of gas, electricity, water

supply and sewer; telecommunication systems especially in Dhaka and Chittagong are really vulnerable to earthquake hazard. Centralization of all facilities also makes extra exposure to earthquake hazard although Bangladesh has the problem every sector.

Hospitals and schools play an important role to provide basic needs of population of Bangladesh and all over the world also but of the well renowned hospitals and schools located in Dhaka city which makes it very vulnerable to earthquake hazard.

Lack of link between different sectors of economy and diversification of the economy is a known feature of Bangladesh which provides the country to earthquake vulnerability. Shortage of strong economic support makes the country earthquake vulnerable because the government is not able to maintain an earthquake resistant infrastructure and provide incentives to encourage institutions and individuals to take risk mitigation measures.

Transportation sectors

There are various sectors that are very vulnerable to earth shaking in Bangladesh for their structural strength. These sectors are as follows: a) Highways; b) Railways; c) Waterways; d) Ports and e) Airports.

a) Highways: Highway is vulnerable to earth shaking for its several components such as pavements, bridges, overpasses, tunnels, embankments, slopes, avalanche and rock shelters, retaining walls, and maintenance facilities. Roadways and bridges are of primary concern, since their loss of function will have the greatest impact on the ability to move people and equipment after the earthquake. For example, in 1964, nearly every bridge along the partially completed Cooper River Highway in Alaska was seriously damaged or destroyed. Seven years later, the San Fernando earthquake damaged more than 60 bridges on the Golden State Freeway in California. It is estimated that it cost the state approximately $100 million to repair and replace these bridges, including the indirect costs due to bridge closures (Central United States Earthquake Consortium, 2000). Various categories of roads and highways have the potentiality to earthquake damage that's why the country will be totally disconnected.

Table 3. Different types of road that is vulnerable to earth shaking over the Bangladesh

Type	Description
National Highway	Highways linking Dhaka with Divisional Headquarters or sea ports or land ports
Regional Highway	Highways linking district Headquarters or river ports or land ports with each other connected by National Highways
Zilla Road	Roads linking District Headquarters with Upazilla Headquarters with another Upazilla Headquarters by a single main connection with National/Regional highways.
Upazilla Road	Roads linking Upazilla Headquarters with Growth Center/s or one Growth Center with another Growth Center by a single main connection or linking Growth with higher road system.
Union Road	Roads linking Union Headquarters with Upazilla Headquarters, growth Centers or local markets or with each other.
Village Road	a) Roads linking villages with Union Headquarters, local markets, farms, ghats or with each other. b) Roads within a village.

Source: Rasheed 2008

b) Railways: Currently, the sate-owned Bangladesh Railway operates a railway network of 2,768 km. Railways' bridges and tunnels are vulnerable to earthquake. As a network-oriented system railway has many bridges in Bangladesh which are not made up of suitable constructive methods to prevent shaking risk. So if the earth shakes, this sector will face a devastating situation.

c) Waterways: Bangladesh has over 24,000 km of rivers, streams and channels, most of which are part of the three major river systems of the country can be blocked by the secondary effects of earthquake (landslides, rock falls, liquefaction etc). The reason is that in Bangladesh the major components of inland waterways such as channels, banks, levees, and locks and dams – are vulnerable to ground shaking and liquefaction which could lead to their failure. This in turn would have a significant impact on navigability. There is strong relationship between the waterway systems in Bangladesh that one's may the causes for other components. It also notable for Bangladesh that landslides and bank failures could block channels, debris from fallen trees and other materials could hinder navigation, uplift and subsidence, could result in changes in channel depth or the course of the river, liquefaction could result in large lateral flows that could block channels, channels can also be blocked by the collapse of bridges.

d) Ports: The inland waterways and rivers ports are vulnerable to earth shaking. This is due to three reasons: a) the river sections system of Bangladesh is within areas that are eligible to generate strong ground shaking and liquefaction; b) most of the rivers of Bangladesh are used to transport huge volumes of essential commodities; c) the rivers have massive direct and indirect consequences for our national economy. But these waterways provide

an economic source of transportation for the movement of bulk goods across the country; can suddenly become dysfunctional as a result of an earthquake. Ports are vulnerable to earthquake for a secondary impact of it's such as liquefaction. The damage sustained to the Port of Kobe in the 1994 earthquake drew the world's attention to the key role of ports in national and international trade and commerce, and the vulnerability of these facilities to earthquakes. Within seconds, the Port of Kobe, one of the largest container facilities in the world, sustained major damage, primarily due to massive liquefaction (Central United States Earthquake Consortium, 2000).

Emergency responders need to be concerned with potential environmental risks associated with possible spills of hazardous and toxic materials in Bangladesh. Fire is another real problem at port facilities.

e) Airports: Nine airports are earthquake vulnerable infrastructural sector in Bangladesh like all other transportation facilities. Six components of airports are most vulnerable: a) terminals; b) runways; c) power; d) communication and radar; e) liquid fuel and f) transport. The functionality of an airport will depend, to a large extent, on what happens to these key components. As an earthquake potential area airports of Bangladesh have various types of risk of mentioned components. For example, A study (ACT 25, 1991) of the impact of magnitude 8.0 New Madrid (USA) earthquake in1678 airports in Illinois, Missouri, Arkansas, Tennessee, Kentucky and Mississippi determined that 474 experienced light to destructive damage, with 60 of these experiencing heavy to destructive damage(Central United States Earthquake Consortium, 2000).

Resources

Energy sector: Most of the gas fields of Bangladesh are located in the highly earthquake potential area of Sylhet (earthquake zone no.1). These gas fields reserve billions cubic of gas that may be affected by fire the secondary effect of earthquake.

Table 4. The earthquake vulnerable gas fields and reserve

Gas field	Reserve in billion cubic feet (as of June 2006)	Gas field	Reserve in billion cubic feet (as of June 2006)
Sylhet	302	Feni	74
Chhatak	448	Kamta	29
Rashidpur	1,016	Fenchuganj	254
Titas	2,578	Jalalabad	510
Kailashtila	1,540	Narsingdi	150
Habiganj	2,494	Meghna	84
Bakhrabad	394	Saldanadi	69
Semutang	150	Bibiyana	2,401
Begumganj	33	Moulvibazar	313
Beanibazar	129		

Source: GOB 2007

Garments industry: About 80% of the ready garment factories are located in around Dhaka, while the rest are found in Chittagong and other towns (Rasheed 2008). Most of the garment factory buildings are not structured properly according to the National Building Code although the buildings are situated in highly earthquake vulnerable areas (earthquake zone no.2).

Water supplies: These normally consist of underground pipelines (especially across Dhaka city), pumping stations (all over the Dhaka), and sewage and water treatment plants (Chandni and Sayedabad water treatment plants in Dhaka city). Restoration of safe drinking-water supplies will be the first priority in most disasters. Even in the immediate aftermath of disaster, water is needed to prepare food, bathing, cleaning of wounds and often to fight fires.

Electricity and gasoline: A power system consists of generators, high-tension cables, transformers and low-tension connections which are available in Dhaka city and most of the part of Bangladesh. During earthquakes, the vulnerability of oil/gas pipelines depends on their strength and flexibility that will be affected by fire secondary impact of earthquake.

Earthquake's preparedness measures for risk reduction for Bangladesh

As an unpredictable hazard Bangladesh has not faced a devastating earthquake in the near past like Haiti earthquake of 2010. But this country has the greatest potentiality to earthquake hazard for its geographical location and geological formation of earth. In Bangladesh sophisticated earthquake monitoring is not available. The lone observatory is located in the port city of Chittagong. Even though precise prediction about earthquakes is not possible, a sound preparedness strategy and program at the national level could minimize loss of lives and property. It is widely believed that the overcrowded city of Dhaka could experience devastating loss of lives if an earthquake of moderate or high intensity occurs in the region. In spite of the vulnerability of Bangladesh to earthquake there has no significant earthquake risk reduction plan. By the help of the experiences of other countries' earthquakes we can make a particular plan for our country.

Earthquake prediction and warning: United States Geological Survey has proposed an earthquake prediction and warning information flow to predict the earthquake hazard which we also propose (Fig. 2) for Bangladesh. We can design an earthquake prediction and warning proposed information flow by the help of the *USGS's information flow*.

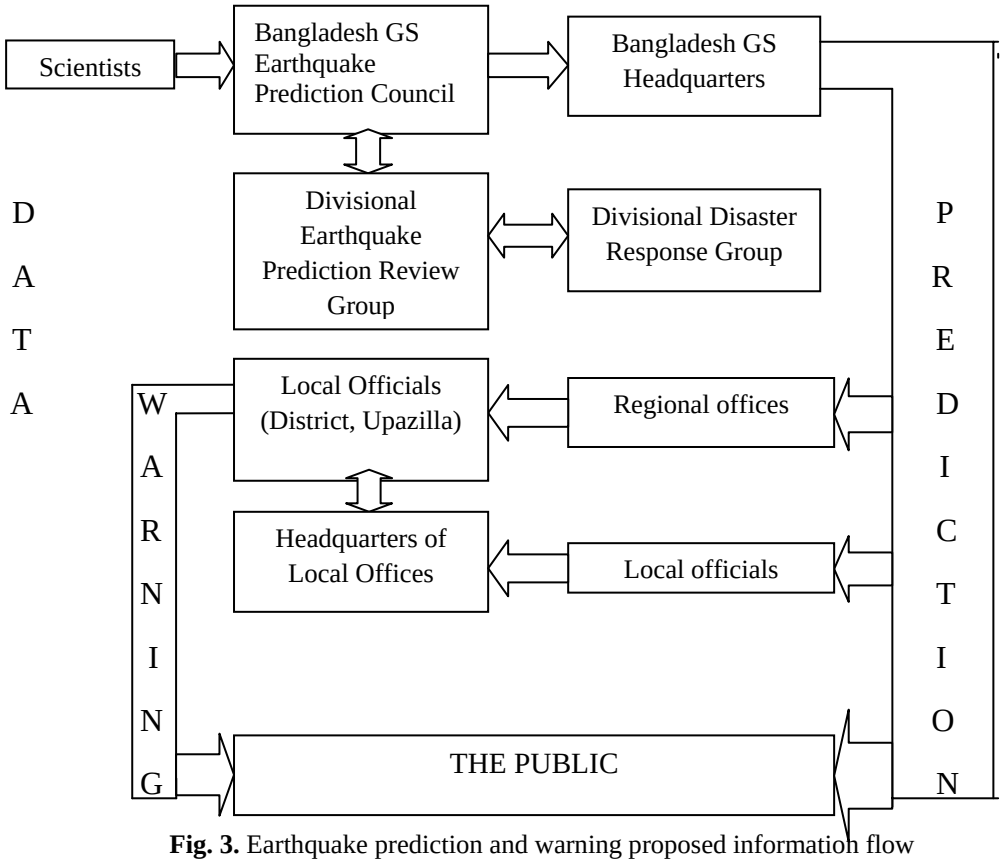

Fig. 3. Earthquake prediction and warning proposed information flow
Source: Keller 1992

Implementing building code: Bangladesh has a dynamic buildings' code which can reduce the ultimate risk of the structures by its' appropriate implementation. Tougher legislation for highly earthquake risk areas (Dhaka, Sylhet, Mymensingh, Tangail, Chittagong, Bograetc). This is especially true because most of the buildings in the city have been built without conforming to the requirements of the 1993 Bangladesh National Building Code (amended and revised in 2006). The code provides guidelines for earthquake resistant design for construction. However, most multistoried buildings in the city have been constructed without following the guidelines and requirements, and hence, are susceptible to damage mitigation approach, the following measures should be undertaken for buildings of Bangladesh. Rasheed (2008) recommended the measures such as a) increasing public awareness about earthquakes; b) updating and full legal enforcement of the building code; c) seismic strengthening of large and critical structures and facilities; d) developing low-cost seismic strengthening techniques for individual house owners; and e) preparing a national post-earthquake rescue and recovery plan.Not all structures of Bangladesh especially Dhaka, Sylhet, Chittagong and Mymensingh these high earthquake risk zone for various causes are not being designed or built in compliance with seismic codes. Unless a code compliance monitoring mechanism is put in place, many of the other capacity building measures will be futile.

Ensure accountability of various stakeholders: Government have to ensure a mentionable clear protocol defining the responsibility and accountability of various stakeholders such as the structural designer, contractor, construction engineer/supervisor, builder/developer, municipal engineer or government in the event of failure of a structure in Bangladesh to reduce the devastating risk of earthquake. So we have to address motivation for every player to exactingly and carefully perform their roles and responsibilities.

Form an earthquake safety commission: To minimize earthquake risk it is necessary to provide Special Capacity Building Technical Assistance projects. A Commission, in line with the California Seismic Safety Commission, may be established which besides drafting a seismic safety policy for the State, would be responsible for commissioning and monitoring research and development in earthquake related fields. Further, it would make recommendations to the State regarding projects, programs, legislation and policies required for seismic vulnerability and risk reduction for Bangladesh.

Ensure the Safety of Essential Services: Essential facilities such as schools, colleges, universities, fire service offices, water treatment plants, telecommunication services, and hospitals which provide to the needs of a special section of society and which are desired to be functional after a seismic event requires special specifications for design and performance. The government of Bangladesh may consider putting in place performance criteria for all hospital and health care facilities which are to be conformed to by a realistic deadline. A proper seismic survey of all such facilities may be mandated to recognize the extent of the problem. Making all public utilities like water supply systems, communication networks, electricity lines etc. earthquake-proof. Side by side creating alternative arrangements should manage for reducing damages to infrastructure facilities.

Insurance: In the current Bangladesh scenario there is no requirement of seismic code compliance to procure a housing insurance. The premium for insuring a house against an earthquake remains the same irrespective of whether the structure has been designed for earthquakes or not. In such a scenario, a possible incentive for ensuring seismic safety is lost. The government may work along with the insurance companies to remedy this situation.

Strengthening of buildings: Most of the buildings of Bangladesh are not earthquake resistant. To reduce earthquake risk we have to incorporate earthquake resistant features in all buildings at high-risk areas. Most of the recently constructed building in Dhaka city stock comprises of multistory reinforced concrete frame structures. Buildings of regular and symmetrical form are much vulnerable than the structural separated buildings. So, avoid the buildings of regular and symmetrical form to reduce earthquake risk. In Bangladesh especially in Dhaka city, constructing earthquake-resistant community buildings and buildings (used to gather large groups during or after an earthquake) like schools, colleges, universities hospitals, prayer halls, etc., especially in earthquake risk zones of moderate to higher intensities to reduce massive seismic risk. For Dhaka city retrofitting of weak structures may be considered as a preventive measure to reduce earthquake risk.

Appropriate syllabus for civil engineering and architecture programs: A typical undergraduate civil engineering curriculum of earthquake engineering should include all engineering institutions (BUET and others) in Bangladesh and even at the post-graduate level, there provider of structural engineering to the students to study earthquake engineering and design. The government must provide formal training in earthquake engineering during the undergraduate or post-graduate studies. It is well felt that this situation needed correction through introduction of topics of seismic engineering into the curriculum of diploma, degree and post-graduate programs in civil engineering and architecture.

Education programs for practicing engineers in all sectors: It is important to reduce earthquake risks that continue exercise of engineers in all sectors (government and private) of Bangladesh who are closely related to every kind of construction activities; such as structures and infrastructures. Most of the practicing engineers should expose to earthquake engineering in their academic curriculum, there is a need to acquaint them with basic concepts of earthquake engineering and the current earthquake codes. Government should arrange serials programs on earthquake engineering and make opportunities for engineers to attend various related training programs.

Raising community awareness and develop of skills in unorganized construction sector: The aggressive campaign to familiarize the public with seismic measures will spread among all types of community. Most of the masons in unorganized construction sector of Bangladesh are not trained up with earthquake measures. In most non-urban areas, the mason is the master builder, architect and structural engineer of a typical masonry home. In view of the important position held by the mason, the need to educate him about seismic features of masonry construction became paramount. Government and private sector should provide numerous mason-training programs which will be helpful to reduce earthquake risk.

CONCLUSION

“Prevention is better than cure” which is applicable to earthquake risk management in Bangladesh. Various sectors of Bangladesh are vulnerable to earthquake for growing unplanned urbanization and avoiding National Building Code while constructed the structures and infrastructure facilities. To prepare a more or less earthquake risk free civilization, government and private sectors have to take immediate measures jointly and minimize the buildings and population densities of Dhaka city by decentralizing public facilities. Import technological knowledge from other countries that are successful to reduce earthquake risks and apply it in all vulnerable sectors. Most of the structural and infrastructural sectors of Bangladesh are vulnerable to earthquake although there is no appropriate earthquake risk reduction and its implementation. To protect our country (especially Dhaka city) from earthquake hazard we have to make all vulnerable sectors to earthquake resilient by government and private assistance where public awareness is remarkable.

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