SEISMIC VULNERABILITY ASSESSMENT OF EXISTING BUILDING IN CHITTAGONG CITY: A CASE STUDY ON GOSAILDENGGA WARD

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ABSTRACT
Bangladesh is located in a seismically moderate zone in the world seismic map. The presence of existing fault lines around this region is capable of producing damaging earthquakes in future. No large earthquake has been recorded in these faults for many years, which indicates a huge strength gathered underground that can cause serious earthquakes around the country. The Chittagong city is precarious to earthquake as indicated by proposed seismic map of Bangladesh National Building Code (BNBC). The aim of this paper is to assess the seismic vulnerability of existing buildings of Gosiaildenga ward (Ward no. 36) of Chittagong city by the method Rapid Visual Screening (RVS) following FEMA 154 guideline. A total number of 682 buildings consist of RCC and Masonry is assessed using RVS procedure. It is found from the assessment that about 59\% of the buildings in Gosiaildenga are of less seismic risk whereas rest of the buildings are considered as required to further detailed evaluation.

Keywords: Assessment, Gosiaildenga, Performance, Seismic Vulnerability, RVS.

INTRODUCTION
Bangladesh is the fifth most natural disaster prone country in the world (Martin, 2010) that is affected almost every year by some form of natural disaster much such as flood, river erosion landslides and cyclones earthquake etc. The historical trend of seismicity and some recent tremors occurred in Bangladesh and adjoining areas indicate that the country is also at high risk of earthquake. A powerful earthquake needs at least 100-150 years to be originated for particular region (CDMP, 2010) and in that sense it is overdue for Bangladesh as it experienced a large earthquake last in 1897. Bangladesh has been classified in to three seismic zones in the map according to earthquake hazard i.e. Zone-I, Zone-II, Zone-III. The location of Bangladesh close to the boundary of two active plates: the Indian plate in the west and the Eurasian plates in the east and north. Where Chittagong region has been laid under Zone-II, has seismic coefficient of 0.15 (BNBC, 1993) but new update of national building code (BNBC) proposed this region at Zone-III with a seismic coefficient value of 0.28g. Chittagong is always under a potential threat to earthquake at any magnitude at any time, which might cause catastrophic death tolls in less than a minute. According to Global Hazard Assessment Program (GHAP), the most hazardous division in Bangladesh is the port city Chittagong. About 80-90 percent of buildings and physical infrastructures in Chittagong are valuable to future massive earthquake measuring 6-7 magnitude on the RS, as most of these were no designed to withstand against seismic load.

So this research is too focused on identify, inventory and ranking buildings in Chittagong at Gosiaildenga to assess seismic vulnerability buildings through RVS method. A numerous of guidelines are available from Federal Emergency Management Agency (FEMA) in United States for seismic risk assessment and rehabilitation of buildings. RVS method has been widely implemented in US and other countries as a tool for ranking the buildings regarding seismic vulnerability considerations. For instance, Aritonang, Satyarno, & Supriyadi (2011) applied the RVS method as a preliminary evaluation to determine the level of performance suitability of the emergency care installation buildings of Dr. Sardajito hospitals for the effects of earthquake. Wallace & Miller (2008) screened 1,057 public
buildings in western Oregon counties in US. They implemented RVS to identify potential seismic hazards for Oregon public facilities, including hospitals, schools, police stations, community colleges, and emergency response centers. In addition, Kapetana & Dritsos (2007) used RVS to identify, inventory and ranking all high-risk buildings in a specified region in Greek to from a strategy of priority based interventions to buildings.

The main objective of this study is to prepare a structural database and to evaluate seismic performance of the structural buildings. The study is an attempt to reduce the large number of deaths and severe property damage in Gosaildenga area by the devastating earthquakes and to create awareness to the people how to save their lives and properties. This study also helps to increase the awareness among the inhabitants in construction. It will also help the Engineers, Architectures in planning and other related societies about structural vulnerability. The significant findings may be employed for any decision making in any future development work.

**METHODOLOGY**

Vulnerability analysis of building stocks in a region is a very difficult and time-consuming process. Step by step identification of buildings at most seismic risk can make the whole procedure comparatively simpler. First step in this process can be quickly screening of buildings to determine if evaluation is required. Then detail analysis is performed to confirm status of the building. Assessment of the buildings is usually performed in three levels including preliminary inspection, simplified vulnerability assessment and detail analysis.

**FEMA 154 Rapid visual screening (RVS) procedure**

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. Rapid visual screening (RVS) method for buildings was originally developed by the Applied Technology Council (ATC) in the late 1980’s for potential seismic hazards. This is a simple and almost a quick way of assessing the building seismic vulnerability score based on visual screening. Rapid visual screening (RVS) of buildings for potential seismic hazards, originated in 1988 with the publication of the FEMA 154 Report, Rapid Visual Screening of Buildings for Potential Seismic Hazards a Handbook. RVS provides a procedure to identify record and rank buildings that are potentially seismically hazardous (FEMA 154, 2002). 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. Based on the RVS scores, some buildings are selected for preliminary evaluation and further for detailed evaluation. RVS enables 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. This method has been widely implemented in US and other countries as a practical and simple tool for ranking the buildings regarding seismic vulnerability considerations. The RVS has been developed for a broad audience, including building officials and inspectors, and government agency and private-sector building owners. To identify, inventory, and rank buildings that are potentially seismically hazardous.

According to FEMA 154 procedure the vulnerability parameters are: Soft story, Plan irregularity, Vertical irregularity, Soft story, and Structural system, Overhanging, Year/Age of the building, Pre code, Post benchmark, Soil condition, and apparent quality. Field screening data of individual buildings which consists of:

- Verifying and updating building identification information.
- Walking around the building and Data Collection Form.
- Determining occupancy class, the building use and number of occupants.
- Determining soil type, if not identified during the pre-planning process.
- Identifying potential non-structural falling hazards.
- The lateral resisting system seismic performance attributes Score Modifiers (e.g., number of stories, design date, and soil type).
Determining the Final Score, S (by adjusting the Basic Structural Hazard Score with the Score Modifiers.

The final score is the deciding factor that further evaluation is required or not.

The region seismicity for the screening is classified into three main categories, low, moderate and high. The seismicity region (H, M, or L) is determined by finding the location of the surveyed region on the seismicity map. FEMA 154 has three seismic zones where Chittagong region is fall into moderate seismic zones for the short period structures with spectral acceleration less than 1.0 sec. Soil type was considered as C and D in the FEMA 154 handbook considering expert’s opinion. Figure 1 shows an example of score modifiers for performance score calculation.

![Figure 1: Score modifiers for performance score](image1)

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 zone of the area. According to FEMA 154 a “cut-off” score of 2 is used in this study. 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.

RESULTS AND DISCUSSIONS

Chittagong City Corporation has been divided into 41 Ward where Ward no 36 at Gosaildenga is selected for the vulnerability assessment of earthquake in this research. Ward No. 36 is located on the north-waster bank of Karnafuly River at Chittagong. The ward is under the jurisdiction of Bandar Thana of Chittagong City Corporation (CCC). Ward 38 is situated at south-west, Ward 30 is situated at north-east, Ward 37 is situated at west, and Chittagong Port is situated at east of the study area.

Type of building

There are four type of building which are about 76.25% of concrete frame buildings with unreinforced masonry infill wall (C3), 20.67% of unreinforced masonry bearing-wall buildings (URM), 2.79% of concrete shear-wall buildings (C2), and 0.29% of steel frame buildings with unreinforced masonry infill walls (S5) of all surveyed buildings.

![Figure 2: Type of structural buildings of Gosaildenga.](image2)
No of story of the building

The area mainly comprises of one to eight story buildings where five story buildings are the highest with 25.81% occupancy. The tallest building in the study area is a 15-storey building. 1-storey buildings are 5.72%; 2-storey, 3-storey, 4-storey, 6-storey, 7-storey and 8-storey buildings are 13.34%, 17.16%, 16.86%, 14.81%, 4.25% and 1.47% respectively.

![Percentage of Building according to no. of stories](image1)

![Presence of Building according to no. of stories](image2)

Figure 3: (A) Percentage of Building according to no. of stories, (B) Presence of Building according to no. of stories.

![Percentage of C2, C3, type number of story and no of buildings](image3)

Figure 4: Percentage of C2, C3, type number of story and no of buildings.

![Percentage of URM & S5 type number of story and no of buildings](image4)

Figure 5: Percentage of URM & S5 type number of story and no of buildings.

Irregularities

The irregular pattern in their elevation is more vulnerable to earthquake than buildings with regular form. About 60% buildings of the study area have regular shape and 40% buildings have irregularity in their plan.
Soft Story and heavy overhanging

Soft story is the major vulnerability factor which is described the difference in the stiffness of consecutive story of building. Heavy overhanging floors in multi-story buildings lead to irregularity in stiffness and mass distributions.

Pre-code and Post-benchmark

Pre code is Building design and constructed prior to the year in which seismic code were first adopted and enforced in the jurisdiction. Post-benchmark is Building designed and constructed after significant improvement in seismic code requirement were adopted and enforced; the benchmark year when improved may be different for each building type and jurisdiction.

After completion of the data collection, Basic Structural Hazard Scores for various building types are taken from the values for moderate seismic zone according to FEMA 154. Then the final score is calculated.

Final score of surveyed 682 buildings are divided into two categories which is shown in table 1. The first category buildings are those that are expected to have acceptable seismic performance which is
termed as detailed evaluation not required and other category buildings are those that may be seismically hazardous which should be studied further which is termed as detailed evaluation required.

Table 1: Detailed evaluation required of the total buildings

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<thead>
<tr>
<th>Total number of building</th>
<th>Evaluation required</th>
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<td></td>
<td>Yes</td>
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<td></td>
<td>682</td>
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CONCLUSIONS
Vulnerability assessment is a tool of decision-making of specific stakeholders about options for responding and adapting to the effects of hazard. In this research, vulnerability assessment of existing buildings in a selected area in Gosaidenga Ward. Rapid Visual Screening method using FEMA 154 is a simple method in preliminary screening phase to identifying potentially hazardous buildings, the fastest tool to analyze building, cheaper and easy to use. From the Survey results it’s found that there are maximum C3 structural type building where 4 to 5 stories and Residential occupancy. Most of the buildings in Gosaidenga Ward are still considered as less seismic risk 59%, while another 41% considered in are need to be further evaluation.

REFERENCES


