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SEISMIC VULNERABILITY ASSESSMENT OF PRIMARY SCHOOL BUILDINGS AT CHITTAGONG CITY CORPORATION, BANGLADESH USING FEMA 310

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ABSTRACT
Bangladesh is extremely vulnerable to seismic events because of its position near the boundary of tectonics plates. In this country, the primary school buildings have distinguished structural characteristics which cause them more vulnerable to earthquakes. Many existing government primary school buildings in Chittagong City Corporation were designed only to resist the gravity loads without seismic provisions. Also the seismic awareness among the tender-hearted children is not that much high. Therefore, it is necessary to investigate the vulnerability of these buildings to avoid serious damage and casualties in the future. In this paper, the seismic vulnerability of primary school buildings in Chittagong City Corporation (CCC) area has been evaluation by two phase, i.e., Tier 1 & Tier 2 analysis. Tier 1 analysis is done according to FEMA-154 guideline and Tier- 2 analysis has been conducted on the basis of FEMA-310 guideline. Total ten school buildings in Ward no.3 and Ward no.4 of the CCC area have been investigated. These results are expected to be helpful for administrative body who are going to conduct pre-disaster planning.

Keywords: Seismic Vulnerability; FEMA- 154; FEMA- 310; Soft Story; Chittagong City Corporation.

INTRODUCTION

Bangladesh which is situated in south-asia region, is one of the most seismic vulnerable countries in the world. Even a moderate seismic event can be cause a devastating consequence in the major cities of the country, particularly Chittagong, Sylhet and Dhaka (Alam et al., 2011). The main criteria for assessing an earthquake prone region are geology, topography, density of population and infrastructure and so on. Bangladesh is located in the moderate seismic region in the world seismic map prepared by Global Seismic Hazard Assessment Program (GSHAP, 1992). Geographically the country is situated near the boundary of two active continental plates, i.e., the Indian plate and the Eurasian plate. This country is encompassed by the regions of high seismicity including the northern Shillong Plateau and Himalayan Arc, eastern Arakan Yoma anticlinorium and Burmese Arc and northeast complex Naga-Disang-Jaflong thrust zones. Moreover, the country is located in the Dauki Fault system where numerous subsurface active faults are existed. The largest earthquake event was occurred surroundings this region was Assam Earthquake in 1897 with estimated magnitude 8.7 (Jain, 1998) broadly known as Great Indian Earthquake. Another citable earthquake with an estimated magnitude was 7.6 (Sabri, 2001) in 1918 around Sylhet known as Srimangal Earthquake. Epicenter of this earthquake was about 130 km from Dhaka. In 2003, a 5.2 magnitude earthquake shock the Barkal area of Rangamati district which causes damaged to several buildings, 2 people were killed and more than 100 hundred people were

injured (Ansary and Sadek, 2006). No major earthquake has been take place in this region during last century.

Chittagong City Corporation is roughly 70 km away beyond the above described fault zones in the Bangladesh-Myanmar border zone. The Chittagong–Tripura folded belt experiences recurrent earthquakes (Alam et al., 2006). According to BNBC (BNBC, 2015 draft), Bangladesh has divided into four generalized seismic zones as shown in Fig. 1. The Chittagong region falls in the moderate seismic zone with a seismic coefficient of 0.28g based on 2 percent probability of exceedance in 50 years. The region has a long history of earthquakes. In 1762, one of the most devastating earthquakes occurred at Arakan which caused heavy damage in the southern part of Chittagong division. It also produced Tsunami in the Bay of Bengal. Another big earthquake occurred in 1869 with a surface-wave magnitude of 7.5 at Cachar, Assam. This was powerfully felt in the entire Chittagong division. The 1912 Mandalay earthquake with a surface-wave magnitude of 7.9 strongly felt in this region. The 1950 Assam earthquake with a magnitude of 8.6 was also felt in the same region with a strong shaking. During any natural disasters, the serviceability of lifeline facilities is very important. This lifeline facility includes school buildings, hospital, fire service station, electrical power station, road network, bridges, gas lines etc. The school buildings are the most important structures and any kind of slight collapse of any component of those buildings will cause loss of many lives.

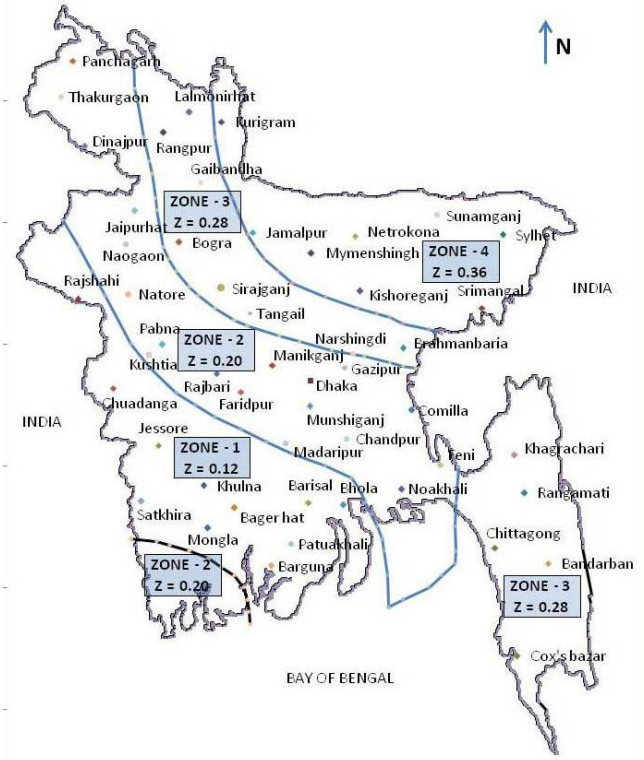

Fig. 1: Seismic zoning map of Bangladesh (BNBC, 2015 draft)

The seismic performance evaluation of the primary school buildings should have a crucial importance as they can be used as a temporary shelter after the occurrence of a major earthquake. However, most of these buildings have inadequate seismic resistance because of not maintaining any seismic provision in construction phase or poor seismic provision and also continuous processes of deterioration. Though, some of the researchers conducted research on evaluation of seismic vulnerability of important buildings in Chittagong city (Sarraz et al., 2015, Mazumder et al., 2018), none of them focused on school buildings. The present study has carried out to evaluate seismic safety assessment of government primary school buildings in Chittagong City Corporation using FEMA 310. In this study, main objective is to prepare a seismic vulnerability database of government primary school buildings in CCC.

STUDY AREA

Chittagong City Corporation (CCC) area covers 160 square kilometres where 41 administrative wards are existed and around 14,000 persons live in per square kilometres. Total number of government primary schools in Chittagong City Corporation is about 215. Among them 14 school are under construction. Most of the schools are comprised of several buildings. The survey areas of this research work are Panchlaish at ward-3 and Chandgoan at ward-4 of the CCC which are located on the edge of the river named Karnaphuli. Total 11 and 15 government primary school buildings are located in ward-3 and in ward-4 respectively. Most of the school buildings established as a reconstruction project under the Saudi financing.

METHODOLOGY

Earthquake is one of the most demolishing natural disasters which cause destructive effect on human lives as well as in infrastructures**.** There are several methods to determine seismic vulnerability assessment such as (FEMA-154, 1988), (FEMA-310, 1998), EURO CODE 8, New Zealand Guideline, Modified Turkish Method, IITK-GSDM etc. In this study, seismic vulnerability assessment procedure is conducted by two tiers. Tier 1 analysis is done according to FEMA-154 guideline and Tier- 2 analysis has been conducted on the basis of FEMA-310 guideline.

Rapid Visual Screening (RVS)

The Rapid Visual Screening has been thoroughly described in FEMA-154. This method is one of the quickest procedures to identify the seismically vulnerable buildings without the use on any expensive detailed evaluation of any particular building. In Rapid Visual Screening a scoring system has been developed that enables the users to identify the primary lateral load resisting system of structure and the seismic performance of the structures. The observation of the building will take an average of 15 to 30 minutes. Moreover, the surveyors can categorize the buildings into two types using a cut off score i.e., buildings safe against probable seismic events or buildings which are seismically hazardous.

FEMA-310

For the evaluation in Tier-2 phase, the professional design engineer can carry on a complete analysis of the building that has been identified as non-compliant, i.e., further evaluation of the individual deficiency of an unsafe building is needed according to Tier-1. This analysis is limited to simplified linear analysis methods and it could be done using one of the common linear static or dynamic analysis methods. After the seismic evaluation has been performed, a final assessment report shall be prepared.

RESULTS AND DISCUSSIONS

In Tier-1, total 10 numbers of primary school buildings have been evaluated using Rapid Visual Screening (RVS) method. Considering Chittagong City Corporation as moderate seismic risk zone, the cut off value is taken as 2.0. Buildings having cut off value less than 2.0, needed to be evaluated further in Tier-2 phase. The following Table 1 shows of the RVS scores of different primary school buildings.

Table 1: Final scores of RVS

Name of the school building	RVS Score	Detailed Evaluation Required
WAPDA colony govt. primary school building-1	1.7	Yes
WAPDA colony govt. primary school building-2	2.2	No
Shamsher para haji chand miya govt. primary school building-1	-0.8	Yes
Shamsher para haji chand miya govt. primary school building-2	2.2	No
Ekhlasur Rahman govt. primary school building	-0.1	Yes
Wajediya govt. primary school building	1.7	Yes
Taiyebiya govt. primary school building	1.7	Yes
Shahed para govt. primary school building	2.2	No
Chandgaon board govt. primary school building	2.2	No
Hajir pul govt. primary school building	2.2	No

Tier-2 evaluation has been conducted using FEMA-310 guideline. FEMA-310 guideline basically focuses on the features like soft story, geometry, mass & torsional irregularity etc. In the following Table 2 the summary of the deficiency of the individual has been shown.

Table 2: Summary of the deficiency exist

Name of the school building	Deficiency
WAPDA colony govt. primary school building-1	Re-entrant corners, torsional irregularity
Shamsher para haji chand miya govt. primary school building-1	Soft story, torsional irregularity
Ekhlasur Rahman govt. primary school building	Soft story, plan irregularity, vertical geometric irregularity, mass & torsional irregularity.

CONCLUSIONS

Seismic vulnerability assessment of the primary school buildings at the Panchlaish ward (No. 3) and Chandgaon ward (No. 4) has been conducted by two tiers. Tier 1 evaluation process has been done by FEMA-154 which has the combined description of a building, its layout, occupancy and a rapid evaluation of seismic hazard related to structural elements. In the study 10 primary school building has been screened out. Among them 3 school buildings have been investigated further using Tier 2. Tier 2 evaluation has been conducted using FEMA-310 guideline. FEMA-310 guideline basically focuses on the features like: soft story, geometry, mass & torsional irregularity. From the study it has been found that WAPDA colony govt. primary school at 3 no. ward has the vulnerability parameters, i.e., re-entrant corners and torsional irregularity. Shamsher para haji chand miya govt. primary school building at 4 no. ward, has the soft story and torsional irregularity. Ekhlasur Rahman govt. primary school building has severe irregularity problem like soft story, plan irregularity, vertical geometric irregularity, mass irregularity and torsional irregularity. As the vulnerability parameters exist at these three buildings, it can be said that WAPDA colony govt. primary school building-1, Shamsher para haji chand miya govt. primary school building-1 and Ekhlasur Rahman govt. primary school building are required further detailed analysis to determine the actual seismic risk level.

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