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COMMUNITY VULNERABILITY ANALYSIS OF CHITTAGONG CITY CORPORATION AREA, BANGLADESH DUE TO EARTHQUAKE HAZARD

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ABSTRACT

Due to rapid rate of urbanization and unplanned growth of urban centers; disasters like earthquake have become a menace for Chittagong. Most of the structures are owner built, non-engineered in nature and structurally vulnerable for earthquake. South Agrabad ward no 29 which acts as CBD of Chittagong has been selected for community vulnerability assessment of earthquake hazard. A sample of 86 buildings has been analyzed by a FEMA-RVS method for structure vulnerability assessment, fire hazards vulnerability assessment done with the help of method developed by ADPC (2004) and social vulnerability assessment done with the help of method developed by World Bank (2014). Finally, a composite vulnerability score has been developed by comprising Structure and fire hazard as well as social vulnerability condition of the study area. It has been found that most of the structures are very highly vulnerable to earthquake, fire hazard and low social impacts against earthquake.

Introduction

Chittagong is the second largest and commercial city of Bangladesh. But in the basic seismic zoning map of Bangladesh, Chittagong region has been shown under Zone II (BNBC, 1993) and recent repeated shocking around this region indicating the possibilities of potential threat of even much higher intensity than projected (Sarraz.et. al, 2015) On the other hand, 80-90% buildings and physical infrastructures in Chittagong are vulnerable to future massive earthquakes, as most of these were not designed to withstand this. Since there is a great possibility of occurring high magnitude of earthquake in this region (Bilham et. al, 2001), it has become necessary to analyze that how many buildings are highly and moderately vulnerable due to earthquake hazard in order to make proper attempt or policy for saving the life of people. It is also necessary to analyze that how many buildings are vulnerable to fire hazard by identifying the fire sources in and around the buildings, because there is always a great possibility of occurring fire hazard during earthquake (Rahman, 2015). There are always some social factors which influence the earthquake vulnerability such as literacy, disability, number of children etc. (World Bank, 2014). For this reason it is necessary to identify the potential factors which influence the community vulnerability.

Methodology and Data

Study Area Selection

South Agrabad (ward no 27) is selected for community vulnerability assessment on basis of hazard and economic importance. South Agrabad falls into high seismic risk zone (CDMP, 2009, Masud 2007). Agrabad is considered as a CBD of Chittagong city and eastern part of the area (west of Sk. Mujib road) has been identified as a Special Commercial Area in DPZ-2 and western part of Sheikh Mujib road of Agrabad in DPZ-3 was declared as special commercial area in Chittagong area (CMMP-1995). So, considering this above factor South Agrabad is selected for community vulnerability assessment.

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Data Collection

Primary data has been collected through a field survey in September 2016. The total number of buildings of Ward 27 (South Agrabad) is 2,908 (CDA, 2009). To conduct both physical and socio-economic survey, a sample of 86 buildings have been selected by Simple random sampling procedure keeping the confidence level at 90% (Gupta & Gupta, 2006). Secondary data has been collected from journal & BBS.

Structure Vulnerability Assessment

Structure vulnerability score has been calculated by FEMA-Rapid Visual Screening (RVS) method in this research. This RVS method is developed by Federal emergency Management Agency (FEMA) of United States of America. FEMA 154 Data collection form of high seismicity is used for data collection which is applicable for Bangladesh (FEMA, 2015; Sarraz et. al, 2015 and Rahman et. al, 2015).

Fire Hazard Vulnerability Assessment

Fire hazard vulnerability is analyzed by developing Fire hazard Vulnerability Score (FVS). FVS is carried out with the help of methodology developed by ADPC for developing countries of Asia under the Urban Disaster Mitigation Project. In that project fire hazard vulnerability analysis has been done using factors like construction type, number of storey, floor area, fire source in building, fire source around building and accessibility. Data has been collected through a household Survey. Fire hazard vulnerability score (FVS) of each sample building was calculated using the following formula:

FVS = Construction Type × 0.140 + Number of storey × 0.113 + Floor Area × 0.070 + Fire source in building × 0.327 + Fire source around building × 0.091+ Accessibility × 0.259………………………………………………………………………………… (1)

(Rahman et. al, 2015)

Social Vulnerability Assessment

Social vulnerability assessment has been done by developing the Social Vulnerability Score (SVS). SVS is carried out with the help of methodology developed by World Bank for Dhaka City in order to develop Urban Disaster Risk Index under the Bangladesh Urban Earthquake Resilience Project in 2014. Since the socio-economic and cultural conditions are same in Dhaka and Chittagong city, the weightage which was developed for Dhaka city can be applicable for Chittagong city. Data has been collected through a household Survey. SVS of each sample building was calculated using the following formula:

SVS = Population density×0.3 + Gender×0.05 + Age below 5×0.17 + Age 65 and over×0.11 + Disability×0.34 + Illiterate×0.03 ……………………..……………………. (2)

(Rahman et. al, 2015)

Development of Composite Vulnerability Score (CVS)

The methodology of Composite vulnerability score is developed form the study of Cardona et al. (2005) and Rahman et. al (2015).The composite score of vulnerability is the combination of Structure vulnerability score, Fire Vulnerability Score and Socio-economic Vulnerability Score. Though these three scores are in different scale, it is necessary to convert them into a common scale for calculation of composite score. After interpolating RVS data range is differing from 0.4 to 3.27 where lower values means high vulnerability and higher value means low vulnerability. FVS data range is differing from where 0.69 to 1.67 lower values means low vulnerability and higher value means high vulnerability and SVS data range is differing from 0.01 to 0.47 lower value means low vulnerability and higher value means high vulnerability.

Table 1: Common vulnerability category

Vulnerability category	New Scale	RVS score	FVS score	SVS score
Very Low Vulnerability	0.20	2.8 - 3.4	0.463 – 0.7046	0.001 – 0.0986
Low Vulnerability	0.40	2.2 – 2.8	0.704601 – 0.94620	0.0.8601 – 0.19620
Moderate Vulnerability	0.60	1.6 – 2.2	0.94621 – 1.1878	0.196201 – 0.2938
High Vulnerability	0.80	1 – 1.6	1.1878 – 1.4294	0.293801 – 0.391400
Very High Vulnerability	1.00	0.4 – 1.6	1.42941 – 1.67100	0.391401 – 0.489

Composite vulnerability score (CVS) of each sample building was calculated using the following formula:
CVS = PVS (1+ SVS)………………………………………………….. (3) (Cardona et. al. 2005)
Here,
PVS= Physical Vulnerability Score; SVS= Social Vulnerability Score
Physical Vulnerability Score (PVS) can be calculated using the following formula.
PVS = 0.6*Structure Vulnerability score + 0.4* Fire Vulnerability score …… (4) (Rahman et. al, 2014)

Analysis of Community Vulnerability

Structure Vulnerability Assessment

With the help of RVS method the structure vulnerability of the buildings show that almost 96 percent buildings of the South Agrabad are very highly vulnerable, only 2 and 3 percent of the buildings have low and very low vulnerability and no buildings are found as highly and moderately vulnerable (Field survey, 2016).

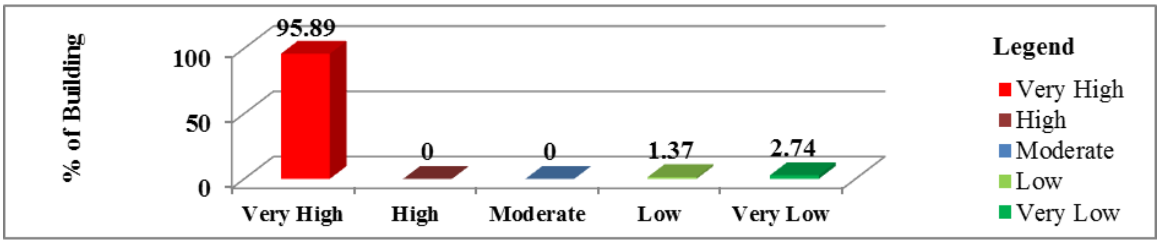

Figure-1: Vulnerability Assessment of Building According to RVS Score

Fire Vulnerability Assessment

After completing the field survey using equation (1) the fire hazard vulnerability assessment has been done and found that most of the buildings are highly vulnerable and moderately vulnerable to fire hazard which are 33.72 and 31.4 percent respectively. It is a found that 11.63 percent buildings are very high and 18.6 percent are low vulnerable to fire hazard (Field survey, 2016).

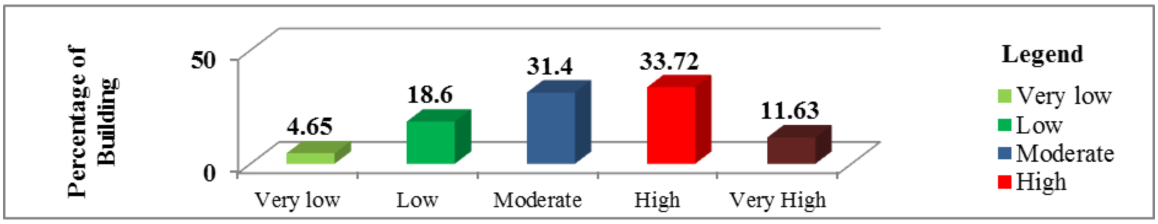

Figure-2: Vulnerability Assessment of Building According to FVS Score

Social Vulnerability Assessment according to SVS

After completing the field survey using equation (2) social vulnerability assessment has been done and found that almost all the buildings have very low and low vulnerability, only few percent of the buildings are moderately and very highly vulnerable which are both 2.33 percent vulnerable (Field survey, 2016).

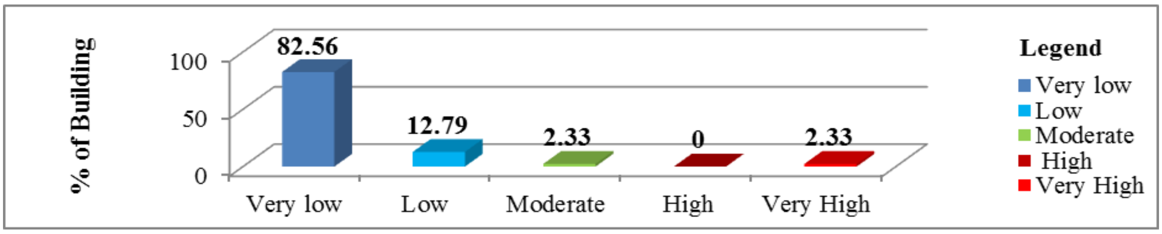

Figure-3: Vulnerability Assessment of Building According to SVS Score

Vulnerability Assessment of Building according to CVS

From the composite vulnerability assessment (using equation 3 and 4) it is found that most of the buildings in South Agrabad are moderately vulnerable which is almost 62 percent, few percent of the buildings are highly and very low vulnerability which are both 15.12 percent and 1.16 percent buildings are found as very highly vulnerable.

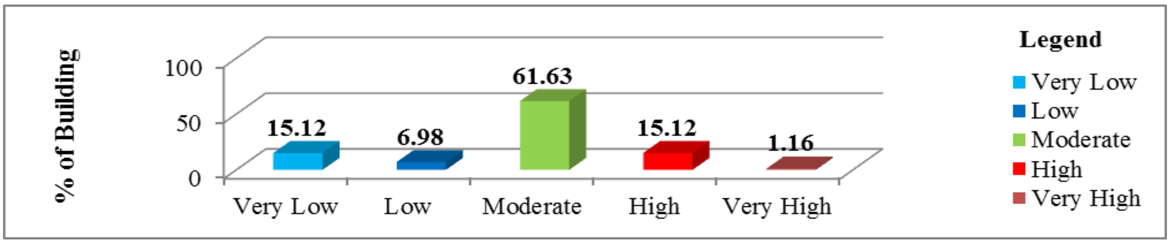

Figure-4: Vulnerability Assessment of Building According to CVS Score

Conclusions

The vulnerability assessment of earthquake is done in a selected area in CCC by developing Composite Vulnerability Score. The buildings and physical infrastructures in Chittagong are vulnerable to future massive earthquakes, as most of this was not designed to withstand this. So, considering the situation it has become necessary to make vulnerability analysis of the buildings of those areas. The study has been carried out to a small portion of CCC. Using the same methodology whole CCC vulnerability can be done. Finally, on the basis of the study it can be concluded that if the government and other concerned authorities take necessary steps, vulnerability of earthquake hazards can be reduced to an extent tolerable to the city people.

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