Proceedings of the 5th International Conference on Civil Engineering for Sustainable Development (ICCESD 2020), 7~9 February 2020, KUET, Khulna, Bangladesh (ISBN-978-984-34-8764-3)

A STUDY ON SEISMIC VULNERABILITY ASSESSMENT OF BUILDINGS OF A SELECTED AREA IN DHAKA SOUTH CITY CORPORATION BY RVS METHOD

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ABSTRACT

The structures which are vulnerable or prone to collapse in an earthquake can cause loss of life and property. To increase earthquake resilience, it is important to know the condition of the existing structures. This study is focused on identifying the seismic vulnerability of buildings. The paper represents a scenario of the structural vulnerability of the buildings which are situated in ward No 35 in Dhaka South City Corporation, Bangladesh. The approach is based on the rapid visual screening (RVS) procedure which is described in FEMA 154. In the RVS procedure an analyzed building is entitled to a score (S) based on some parameters. Major parameters that have effects on the building score are primary structural lateral-load-resisting system, construction material, and other seismic related characteristics such as soil type and building irregularities. Building with higher S scores corresponding to a better seismic performance. The result of this study will show the percentage of buildings that are vulnerable to seismic risk in the selected area as well as in need of further detail assessment.

Keywords: *Earthquake, RVS, FEMA 154, Seismic vulnerability*.

1. INTRODUCTION

Bangladesh is one of the calamities prone country. It's prevailing among the most at risk countries in the world with its high population density and rapid urbanization. Dhaka South City Corporation lies in an active earthquake prone area of Bangladesh. In Great Indian Earthquake of 12 June 1897, this city was damaged severely due to a surface wave magnitude of 8.1 (Sarker et al., 2010). According to World Risk Report (2016), Bangladesh is the fifth most vulnerable country to disasters (UN, 2016). Earthquake causes comprehensive destruction of life and property. For providing seismic safety in building structures, it is needed to ensure their conformance to the current seismic design codes which is valid approach for new buildings. Often, rapid assessment of seismic vulnerability in an area is done through visual inspection of the buildings and by providing a performance score using predefined forms based on adequate seismic resistance features usable in the building. This process is known as rapid visual screening (RVS), as one can cover large number of buildings within a short period of time. FEMA (Federal Emergency Management Agency) 154 provides the detailed procedure for carrying out RVS of buildings. Rapid Visual Screening (RVS) is a qualitative seismic vulnerability assessment method (Yadollahi, Adnan & Zin, 2012). RVS method is popular in US and other countries as a tool for ranking the buildings regarding seismic vulnerability consideration. The RVS method was applied 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 (Aritonang, Satyarno & Supriyadi, 2011). Another study was also carried out which include screening of 1,057 public buildings in Western Oregon in US (Wallace & Miller ,2008), they implemented RVS to identify potential seismic hazards for Oregon's public facilities including hospital, school, police station, fire station, community college and emergency response center. Further, RVS was used to identify, inventory and rank all high-risk buildings in a specified region in Greek to form a strategy of priority-based interventions to buildings. (Kapetana & Dritsos ,2007). This research is focused on identifying and ranking of buildings in particular area of Dhaka South City Corporation to assess seismic vulnerable buildings through RVS method and will prescribe further detail assessment requirement against earthquake force. These types of assessments were previously conducted by many researchers (Wahid et al., 2005). However, the study area was different.

1.1 Study Area

The initial step is to select a community or group of Buildings. The study area is chosen as old Dhaka under the Dhaka south city corporation since it is the most seismic vulnerable portion of Dhaka city. The study area consists of ancient buildings which are located very close to each other. The assessment is carried out only considering the buildings situated both sides of the selected roads. The survey was started from Bangshal Road to end of the Abul Hasnat Road. It turned right to Aga Sadek Road, and ended up with Sikkatuli Lane and Abdul Hadi Lane of 35 no. ward in the Dhaka South City Corporation. Figure 1 shows the map of the study area and representative buildings.

Figure 1: Map and representative buildings on the study Area (ward no.35 under DSCC)

2. METHODOLOGY

Rapid Visual Screening (RVS) method was originally developed by the Applied Technology council (ATC) in the late 1980 and published in 1988 in the FEMA 154. It is a side walk survey approach that enabled users to classify surveyed buildings into categories: a. Buildings those are risk to life and property; b. Those seismically hazardous buildings that should be investigate extensively by a design professional experienced in seismic design. Total one hundred and two buildings were screened for the building vulnerability assessment. The screening process was conducted by filling up a data collection form includes building identification, information comprising its use and size, a photograph of the building, sketches, and documentation of pertinent data.

3. RESULTS AND DISCUSSION

The survey was mainly concentrated on earthquake issues such as identifying building type, plot size and shape, clear distances from surrounding structures, road width and basic information of the building, year of construction, no. of story, no. of inhabitants etc. Digital photographs of each building from at least two directions were taken. A database was compiled in MS Excel among the 102 structures in the aforementioned study area. From the surveyed buildings around 78 buildings are R.C.C structures, 12 of them are soft storied and the rest 24 buildings are un-reinforced masonry (URM). The findings of the survey are tabulated in Table 1 and Table 2. Table 1 shows the percentages of different parameters considered for the seismic vulnerability assessment of buildings and table 2 shows the total number and percentages of buildings used for different purpose.

Table 1: Percentages of Different Parameters

	Total Number	**Percent**
Total Number of Building	102	
Number of Pre-Code Building	22	21.57 %
Number of Post-Benchmark Building	80	78.43 %
Number of Pounding Type Building	80	78.43 %
Falling Hazards from taller adjacent building	1	0.98 %
Number of C1 Type Building	64	62.75%
Number of C2 Type Building	14	13.73%
Number of URM Type Building	24	23.53 %
Number of Additions Type Building	16	15.69 %
Number of Soft Story Type Building	12	11.76 %
Number of Plan irregularity Type Building	23	22.55 %
Number of Vertical irregularity Type Building	51	50 %
Number of 2^{nd} Story Building	6	5.88 %
Number of 3^{rd} Story Building	22	21.57 %
Number of 4^{th} Story Building	11	10.78 %
Number of 5^{th} Story Building	26	25.49 %
Number of 6^{th} Story Building	24	23.53 %
Number of 7^{th} Story Building	11	10.78 %
Number of 8^{th} Story Building	1	0.98 %
Number of 10^{th} Story Building	1	0.98 %
Final level 1 score (0.3)	3	2.94%
Final level 1 score (0.6)	1	0.98%
Final level 1 score (0.9)	3	2.94%
Final level 1 score (1.0)	11	10.78%
Final level 1 score (1.1)	2	1.96%
Final level 1 score (1.6)	6	5.88%
Final level 1 score (1.7)	2	1.96%
Final level 1 score (1.8)	1	0.98%
Final level 1 score (2.6)	6	5.88%

Final level 1 score (2.8)	1	0.98%
Final level 1 score (3.3)	4	3.92%
Final level 1 score (3.4)	23	22.55%
Final level 1 score (4.1)	31	30.39%
Final level 1 score (4.8)	8	7.84%
Number of One-unit building	52	50.98 %
Number of Two-unit building	49	48.04%
Number of Four-unit building	1	0.98 %

Table 2: Usage of buildings

Usage of Buildings	**Total number of Buildings**	**Percent**
Residential	26	25.49%
Commercial and Residential	66	64.71%
Industrial and Residential	4	3.92%
Office and Residential	1	0.98%
Commercial, School, Office and Residential	1	0.98%
Office, Industrial and Residential	2	1.96%
Industrial, Commercial and Residential	1	0.98%
School	1	0.98%

From Table 1 the parameters can be illustrated as follows. The illustration can be started with the Pre code and Post benchmark parameters. Figure 2 shows the first parameter mentioned as the comparison between pre code and post benchmark parameters. From figure 2 it is found that 21.57 % Buildings are pre-code building which means 21.57 % of total buildings are constructed before the code was gazetted where 78.43% buildings were built after the BNBC code was published.

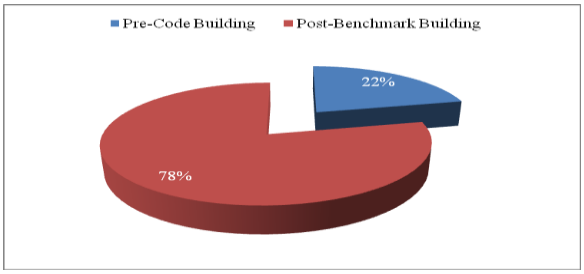

Figure 2: Comparison of Pre-Code & Post Benchmark Buildings.

The second parameter is pounding which represents the minimum separation gap between two consecutive buildings. Figure 3 shows the percentages of pounding and without pounding buildings.

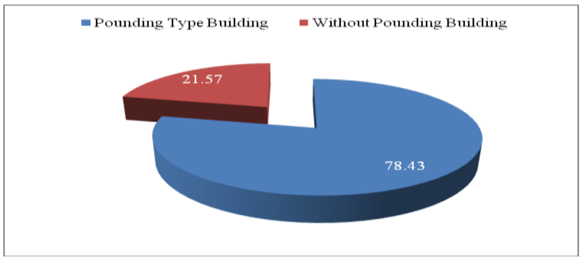

Figure 3: Comparison between pounding type buildings.

From the figure 3 it is found that 78.43 % buildings are pounding type building which means 78.43 % of total buildings do not obey the minimum separation gaps between adjacent buildings which is mentioned in the code.

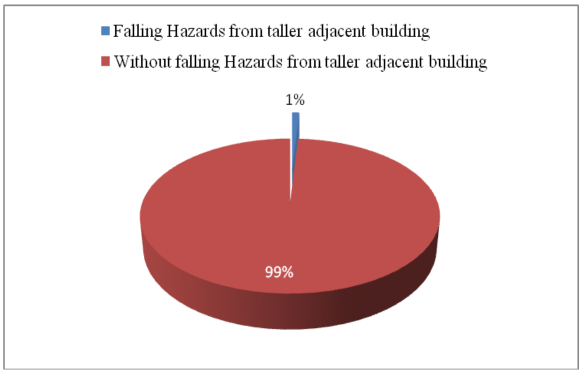

Figure 4: Comparison of falling hazards from taller adjacent buildings.

Again, the third parameter is possibly falling hazardous vulnerability from adjacent buildings. From the Figure 4, it is found that approximate 1% building has falling hazardous vulnerability from the adjacent building.

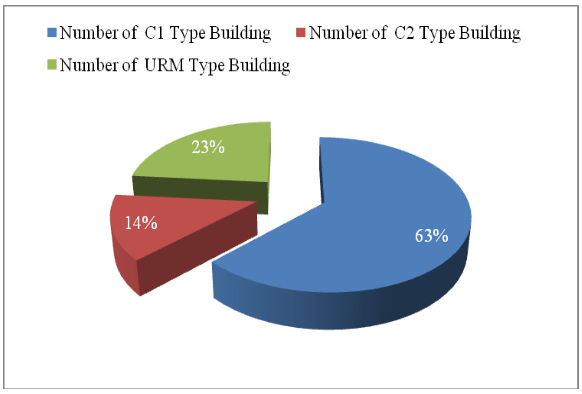

Figure 5: Comparison of C1, C2 & URM Type Buildings.

The fourth parameter is the comparison of C1, C2 & URM type Buildings. Figure 5 shows that, 62.75 % building are C1 type buildings (concrete moment-resisting frame buildings), 13.73 % building are C2 type buildings (concrete shear-wall buildings) and 23.53% are unreinforced masonry buildings (URM).

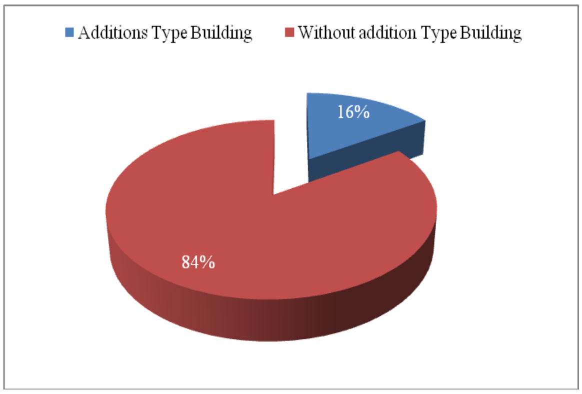

Figure 6: Comparison of Additions of buildings.

The fifth parameter is considered as further addition (buildings are modified with vertical or horizontal additions after the original construction). From the figure 6 it is found that, 15.69 % buildings are additional type buildings.

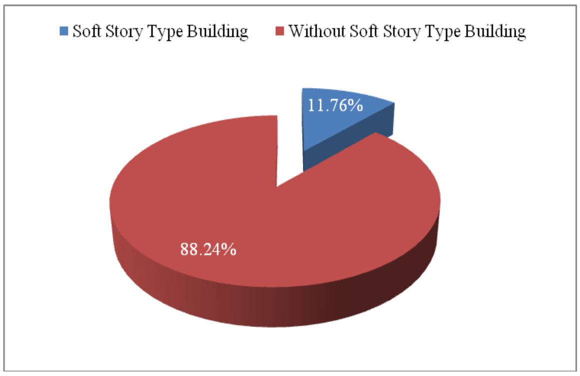

Figure 7: Comparison of Soft story buildings.

The sixth parameter is taken to be the buildings consisting of soft story. Figure 7 shows that, 11.76 % buildings comprise soft story. Soft story can be defined as the buildings which has a ground story or one of other story is built without any interior partition wall used for car parking or market or industry or office.

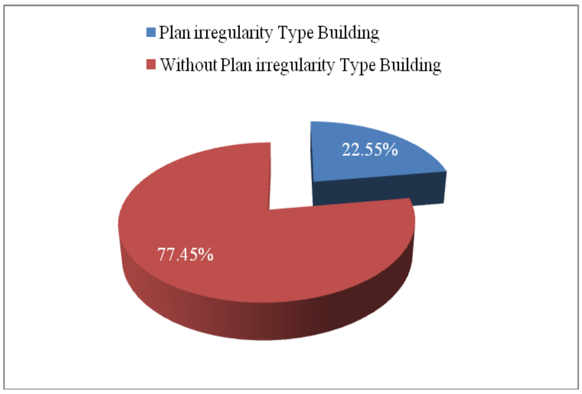

Figure 8: Comparison of plane irregularity of buildings.

The seventh parameter is established according to plan irregularities. From the figure 8 it is found that, 22.55% buildings have plan irregularity.

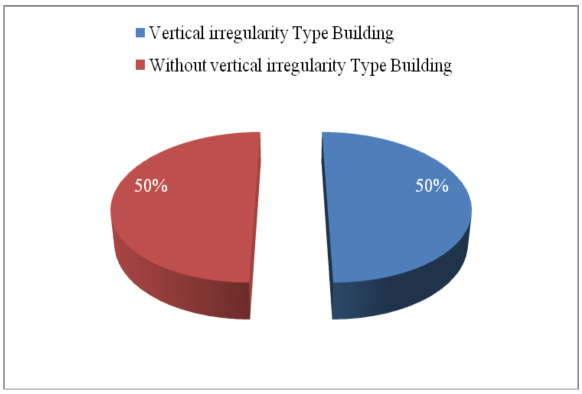

Figure 9: Comparison of vertical irregularity of buildings.

The eighth parameter is considered as vertical irregularities. Figure 9 shows that 50% buildings have vertical irregularity.

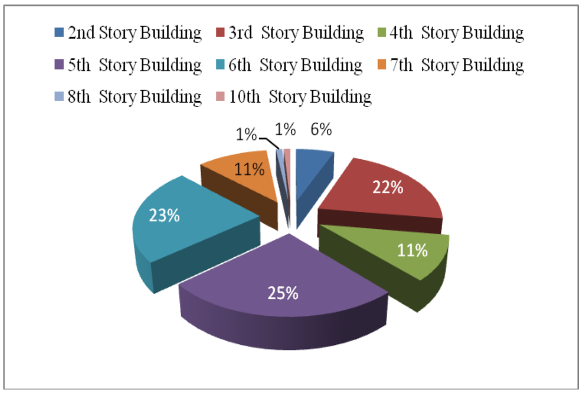

Figure 10: Comparison of story of buildings.

The ninth parameter is based on the story of the buildings. From the Figure 10 it is found that, among the seismic vulnerability assessed buildings, 5.88% buildings has two story, 21.57% buildings contains three story, 10.78% buildings comprises of four story, 25.49% buildings has five story, 23.53% buildings are six storied, 10.78% buildings consists of seven story, 0.98% buildings has eight story and 0.98% building are two storied buildings.

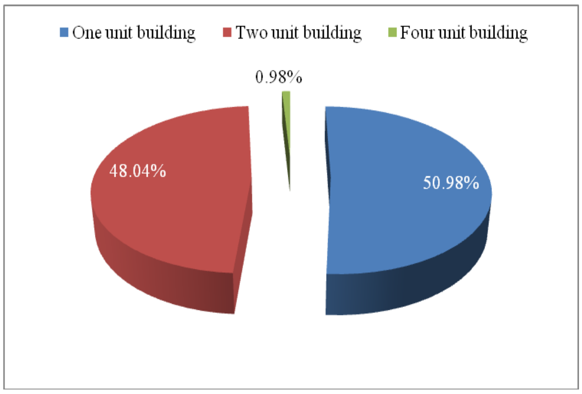

Figure 11: Units of buildings.

The tenth parameter is based on units of buildings. Figure 11 displays that, 50.98 % building has one unit, 48.08% building comprises two unit and 0.98% building consists of four unit.

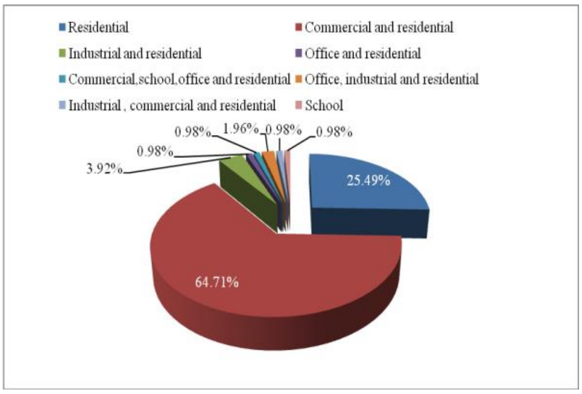

Figure 12: Usage of buildings.

The eleventh parameter is based on the usage of buildings. Figure 12 shows that, around 64.71% buildings are used as commercial cum residential, 25.49% buildings are built for the purpose of residential use, 3.92% buildings are used both as industrial and residential, 1.96% buildings consists three types of usage such as office, industrial and residential, 0.98% building comprises of four types of usage i.e. commercial, school, office, residential, 0.98% building consists of three types of usage resembling as industrial, commercial, residential, 0.98% building have two types of usage such as office and residential and 0.98% buildings are school buildings.

Based on the above parameters all the buildings are entitled to a score. The process of scoring is precisely described in FEMA 154. According to the FEMA 154 manual, if the building has a score less than 2 it will be considered as a seismic vulnerable building.

Figure 13 shows that, 28.43% buildings have final score below 2, on the other hand 71.56% buildings has a final score higher than 2. Moreover, On the basis of building score, the buildings are considered as the most seismic vulnerable which have a score below 1 and need further detail assessment. Further, seismic vulnerable buildings can be enlisted as the buildings which comprises a score below 2. Furthermore, which buildings have the score above 2 can be considered as safe during small magnitude of earthquake.

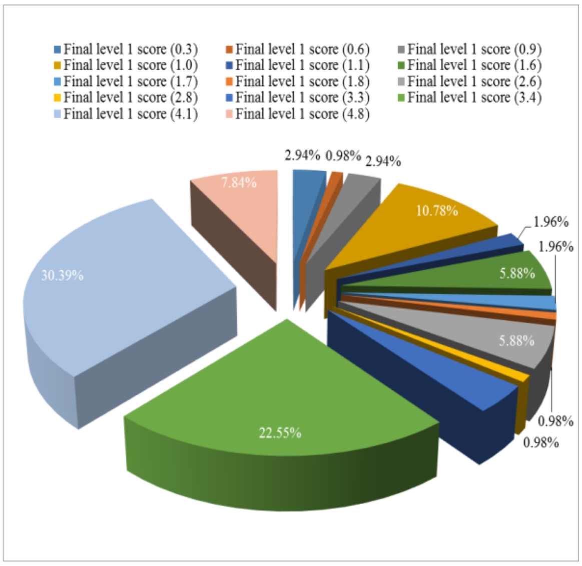

Figure 13: Scoring of buildings.

Figure 14 shows that, 19.61% buildings are the most vulnerable against earthquake, 8.82% buildings are vulnerable and 71.57% buildings are stable during small magnitude of earthquake.

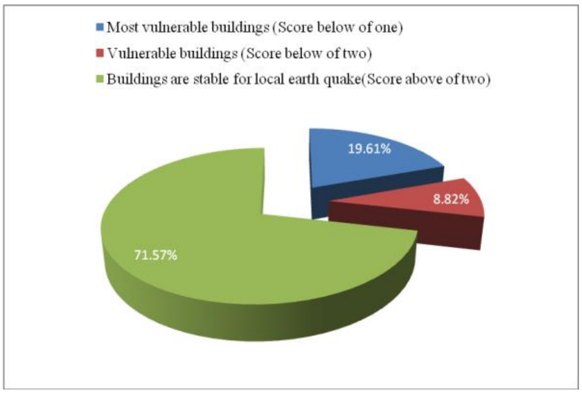

Figure 14: Vulnerability of buildings against earthquake.

4. CONCLUSIONS

This study focused on the structural vulnerability of buildings of the study area. Based on the results obtained from the study, following conclusions and recommendations can be drawn.

1. According to the building vulnerability survey, around 28.43% buildings are in vulnerable condition. To avoid casualties and fatalities in an earthquake, appropriate steps need to be taken for to strengthen of those buildings.

2. Detailed Engineering Assessment (DEA) can be done for those buildings possessing a RVS score below score 2 by an expert in seismic design.

The present study was conducted at a very small area. Further study can be carried out in a large area. From this research approximately 28.43% buildings are found seismic vulnerable. Therefore, details analysis can be carried out for the seismic vulnerable buildings.

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