Rapid Visual Seismic Vulnerability Assessment Tool for Kathmandu Valley, Nepal

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Vulnerability, FEMA,
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1. INTRODUCTION

Nepal is ranked 11th in terms of vulnerability to earthquake (UNDP, 2004). Damage of buildings and loss of life in Kathmandu Valley from the recent earthquakes in Nepal has demonstrated the need for seismic risk assessment that is capable of predicting the consequences of earthquakes. Rapid population growth, poor land use planning, precarious settlement patterns, and inadequate enforcement of building code make Kathmandu vulnerable against earthquakes.

There is an urgent need to asses the seismic vulnerability of the buildings in Kathmandu Valley. There exist many approaches for vulnerability assessment from very detailed and complicated ones, e.g. detailed Finite Element Method (FEM) to very simple ones such as Rapid Visual Screening of buildings developed by Federal Emergency Management Agency (FEMA). These approaches can not be used in the context of Kathmandu Valley because of difference in building types and social acceptance level. The general objectives of this study are to develop a Rapid Visual Seismic Vulnerability Assessment Tool suitable for the buildings in Kathmandu Valley and apply the tool for seismic risk assessment of an area in Kathmandu Valley.

2. STUDY AREA

For the development of the vulnerability assessment tool, Kathmandu Valley is taken as a research area. For application of developed tool, Duwakot Village Development Committee (VDC), Bhaktapur in Kathmandu Valley as shown below in Figure 1 is taken. This VDC is consisted with varieties of buildings in terms of use of building materials and age of buildings.

Building inventory data collected by JICA (2002) shows that there are basically following five types of buildings in Kathmandu Valley.

1. Adobe and Stone Masonry Buildings (AD & ST)
2. Brick Masonry in Mud Mortar (BM)
3. Brick Masonry in Cement Mortar (BC)
4. Reinforced Concrete Buildings with/without Masonry Wall more than Three Stories (RC5)
5. Reinforced Concrete Buildings with/without Masonry Wall less than or equal to Three Stories (RC3)

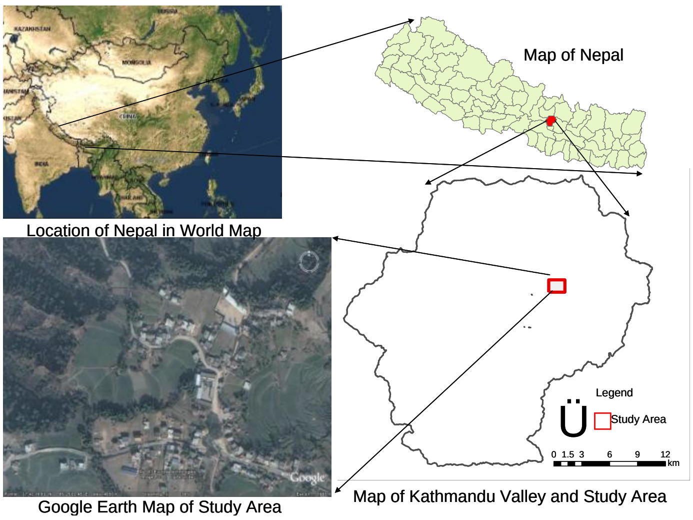

Figure 1 Study Area

3. METHODOLOGY

The methodology adopted in this study mainly consists of analysis of past earthquake damage data similar with Kathmandu Valley, analysis of fragility curve developed by Japan International Cooperation Agency (JICA) in 2002 for buildings of Kathmandu Valley, Nepal. For analysis, Geographic Information System (GIS) was used as tool. This assessment tool was prepared after reviewing FEMA-154 and other different analysis tools given by experts with some modification in Nepal's context. This tool mainly contained the basic structural score and modifiers score. The final score of a building will be calculated by adding or subtracting the modifiers score from basic score depending upon the types of modifiers. The basic scores represent comparative vulnerability of buildings without consideration of different elements of buildings such as plan irregularity or vertical irregularity.

According to the Nepal National Building Code 1994 (NBC 105, NBC 202, 1994), two story brick masonry with cement sand mortar building without any irregularities can resist scenario earthquake (9-10 MMI) without collapse. For such building a basic structural score 2 is assumed which is also taken as cut-off score for the evaluation of building vulnerability. Vulnerability of building is evaluated based on the total score of the building. Generally, score less than 2 indicates vulnerable buildings requiring detailed evaluation and score greater than 2 indicates non-vulnerable buildings and hence safe and can sustain life threatening damage.

In calculation of basic structural score for different types of buildings, the fragility curve prepared by JICA (2002) was studied. Basic score was calculated on the basis of the assumed score 2 for above type building. The score for performance modification factors were analyzed based on the existing scoring given in FEMA 154 and score given by experts in different methods for similar type of buildings of Kathmandu Valley. For verification purposes, some sample of buildings were taken and final score of the buildings were calculated and verified with Nepal Building Code, 1994.

4. ANAYSIS AND RESULTS

For vulnerability assessment purposes, one of the villages in Kathmandu Valley as shown in figure 1 - was selected. The creation of the building database in this study was based on the interpretation of Google Earth Image together with field survey. Total 104 buildings were surveyed and analysis of the data was done to find their vulnerability. The results obtained after analysis of building type and age of building are presented in figure 2 and figure 3. From those figures, it is understood that the most dominant type of buildings in the study area are adobe and brick masonry and more than 42 percentage buildings are recently constructed. The results of vulnerability assessment of buildings are presented in figure 4 and figure 5. From those figures, it is understood that 84 percentage buildings are vulnerable and all the adobe buildings are severely collapsed.

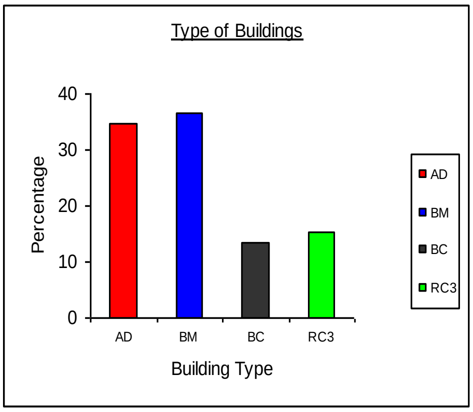

Figure 2 Types of Buildings in Study Area

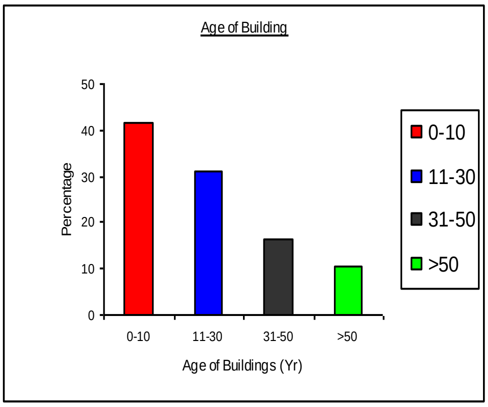

Figure 3 Ages of Buildings in Study Area

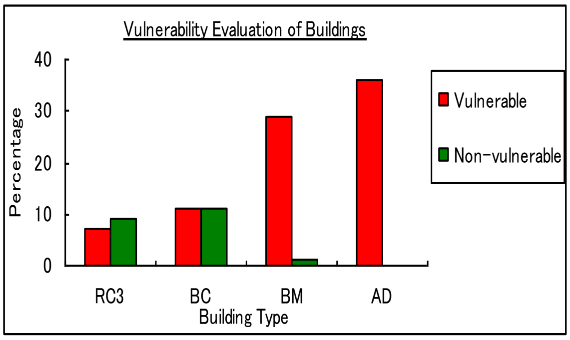

Figure 4 Vulnerability of different types of Buildings

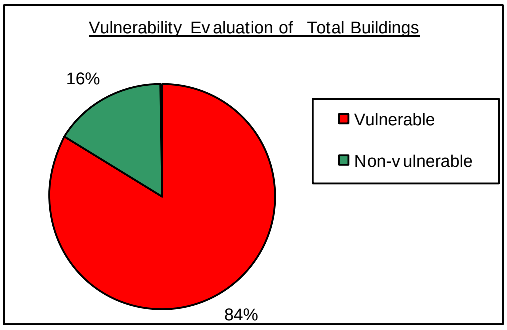

Figure 5 Vulnerability of total Buildings

5. CONCLUSIONS

After processing and analyzing the data, the following important conclusions were drawn.

1. There exist many approaches for vulnerability assessment from very detailed and complicated ones to very simple ones. Detailed analysis of individual buildings is not a feasible option because of its time consuming feature and unavailability of detailed design and drawing of buildings. Although the simple method such as the one developed by FEMA is very useful tool, it cannot be used for the context of Kathmandu because of difference in building types and social acceptance level.
2. The basic score basically depends upon the type of buildings. The simple two story rectangular brick masonry building constructed with cement sand mortar without any irregularities can sustain the maximum scenario earthquake without collapse (life sustaining damage). From these types of buildings a minimum structural safety can be achieved. For such buildings a basic structural score 2 is assumed which is also taken as cut-off score for the evaluation of building vulnerability.
3. Based on the result obtained from the analysis of vulnerability of building in the area, it is understood that most of the buildings are highly vulnerable to earthquake. This is because the most dominant types of buildings in that area are adobe and brick masonry. The current construction practices are still using mud mortar in brick masonry buildings without earthquake resistant features.

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