International Research Journal of Environmental Sciences ISSN 2319–1414
Vol. 7(9), 36-38, September (2018) Int. Res. J. Environmental Sci.

Short Communication

Seismic risk vulnerability assessment of buildings in Kohima, Nagaland, India

Kedovikho Yhoshü[1*] and Y.V. Krishnaiah[2]
[1]Department of Geography, Nagaland University, Lumami- 798627, Nagaland, India
[2]Department of Geography, Tripura University, India
kedovikho@gmail.com

Available online at: www.isca.in, www.isca.me
Received 30th April 2018, revised 22nd August 2018, accepted 14th September 2018

Abstract

Earthquakes occurrences posed a serious threat to man as they are unpredictable and destructive. The entire states of Northeast, India falls under seismic zone V- the region most susceptible to destructive seismic activity. With this background, it is of utmost importance to study the impact of seismic event on anthropogenic assets. The present study was carried out in Kohima, the capital of Nagaland, India. Estimation of seismic event was calculated based on five time periods for deriving the response spectra. The buildings were classed into four classes (W1, C3L, C3M and C3H) based on parameter such as- material used, number of floor etc. The technique adopted for the study was based on HAZUS model developed by FEMA. The damage probability was further classified into no damage, slight damage, moderate damage, extensive damage and complete damage. The significance of the study lies in the application of HAZUS model for estimating the building responses to an earthquake event.

Keywords: Earthquake, response spectra, HAZUS.

Introduction

One of the most pressing issues related to geo-hazard in North-east India is undeniably the regions vulnerability to seismic activities. North-east India situated in a tectonically active region classed under seismic zone V (most vulnerable to seismic hazard) has experienced four major earthquakes[1]. It therefore becomes important to understand and decipher the various seismic impact on human properties especially buildings since earthquake do not kill but building does. The study area selected is Kohima, the capital of Nagaland, India with a population of 1,14,773 (according to 2011 census). Its geographical extents are 94˚05'04''E and 94˚07'23''E latitude and 25˚38'28''N and 25˚39'24''N longitude with an average elevation of 1444m above MSL. Initially, it was established as a chief administrative centre by British government on July 1878 to control the Angami Naga area and the frontiers of Manipur.

The present day Kohima is rapidly undergoing urbanising (population density is 7059 persons per sq. Km) therefore, it becomes vital to study the impact of seismic waves on the elements at risk- buildings and to analyse its characteristics. Objects (can be social or physical) which are exposed to the danger of hazard are known as elements at risk[2]. The amount of resilient or susceptibility to hazard by socio-economic and physical asset in an urban setting is termed as its degree of urban vulnerability[3]. This study is an attempt to bring out the vulnerability of building basing on the material used, its types, floor number etc.

Various studies on seismic activities in this region have been carried out. The application of semi-empirical technique for estimating and comparing seismic hazard based on peak ground acceleration, showed Kohima experienced 250cm/sec^2 making it highly seismic hazard area[4]. Macro seismic intensity and peak ground acceleration has been used traditionally however, recent studies show building vulnerability based on response spectra[5]. Bhandari in his study stressed on the point that it is not possible to prevent hazard however, its mitigation and estimation of possible risk can be executed by carrying out corrective measures during and after construction for countering disaster[6]. The structural vulnerability of buildings are measured by structural features such as foundation, column, beam etc. which determine the physical rigidity of a building[7]. The response of a building to seismic hazard according to FEMA[8] is represented by its fragility curve to estimate the building damage state probabilities.

Material and methods

To estimate the assessment of building vulnerability on earthquake hazard, a building footprint was generated based on high resolution satellite imageries. The usage of high resolution imageries[9] helped in better identification of buildings. Each building was identified and categorised into four building types namely W1 (wooden), C3L (concrete low-rise), C3M (concrete mid-rise) and C3H (concrete high-rise) building types based on Federal Emergency Management Agency (FEMA) guidelines. W1 total building representing wooden, light frame structure with building materials such as wood, bamboo, tin etc, was 7822. C3L (total building 5331) represented concrete and unreinforced masonry infill buildings with 1-3 storey buildings. C3M with 7208 building stands for mid-rise concrete and unreinforced masonry infill wall with 4-7 storey buildings and C3H (334 number of building) represents high rise concrete and unreinforced masonry infill walls with storeys greater than 7. After the buildings were categorised, basing on the probabilistic seismic hazard analysis[10] the response spectra on pseudo-spectral acceleration (PSA) and spectral displacement was calculated (Table-1).

Table-1: Response spectra of Kohima.

Time period	Spectral acceleration	Spectral displacement
0.04	0.26	0.004
0.17	0.79	0.223
0.34	0.49	0.555
0.7	0.26	1.248
1	0.23	2.254

The capacity curve from FEMA guidelines[8] and the response spectra was then used to calculate the building peak response indicating the strength of a building. It was observed that the peak building response range from 1.1-3.2 m/s for the four building types. The fragility curve indicating the cumulative damage probabilities was classified as no damage, slight damage, moderate damage, extensive damage and complete damage probabilities basing on the following equation-1.

$$P\left({}^{ds}/_{S_d}\right) = \Phi\{\frac{1}{\beta_{ds}} \ln\left(\frac{s-d}{Sd.ds}\right)\} \quad (1)$$

Where: $P(ds/S_d)$ is probability being in or exceeding a damage state ds, Sd.ds is spectral displacement Sd, β_{ds} is lognormal standard deviation of spectral displacement, Φ is standard normal cumulative distribution function.

Results and discussion

The building vulnerability estimate adopted from HAZUS FEMA gives a description about the seismic impact on the structure of the building. The overall damage probability (in percentage) of the study area is summarized in Table-2.

From the study, the numbers of buildings which undergoes damage probability are as follows;

No damage probability: 3511 building number of buildings was under no damage building probability. Out of which 1319 was under W1 building type, C3L building type was 1017 numbers, C3M buildings was 1153 buildings and C3H building type was 22 numbers of buildings.

Slight damage probability: 5910 buildings was under slight damage probability where the building types observed under slight damage was 2835 buildings for W1, C3L building type was 1091, C3M building type was 1903 buildings and C3H building type was 81.

Moderate damage probability: moderate damage probability showed 5641 buildings where 2625 buildings was under W1 building type, C3L was 439 numbers of buildings, C3M buildings was 2448 building and 129 number of buildings as under C3H building type under moderate damage probability.

Extensive damage probability: Total number of building under extensive damage probability was 4035 buildings. 1232 buildings was under W1 building type, C3L building type was 1457 buildings, C3M building type showed 1270 buildings and C3H was 76 number of buildings.

Complete damage probability: 1256 buildings were under complete damage probability. W1 building type observed under complete damage was 297 buildings, C3L building type was 446 buildings, C3M building type was 484 buildings and 29 numbers of buildings was C3H building type.

Table-2: Damage probability of the building types in Kohima.

Building Type	No damage (%)	Slight damage (%)	Moderate damage (%)	Extensive damage (%)	Complete damage (%)
W1	15.87	34.13	31.59	14.82	3.59
C3L	18.41	19.8	27.33	26.38	8.08
C3M	15.87	26.2	33.73	17.52	6.68
C3H	6.68	24.17	3.83	22.77	8.08

Conclusion

From the damage probability it was observed that the maximum number of buildings damage was calculated in the case of slight damage probability and the buildings with highest seismic vulnerability was seen in W1 building type with 8303 buildings. Minimum number of damaged buildings was observed in complete damage probability scenario with 1256 buildings where C3M building type has the highest building damaged. The study showed the safest building was represented by C3L building types; the reason may be better seismic resistivity due to lower building height and building material (reinforced concrete cement (RCC) structure). Low raised RCC structure represented better seismic resistivity as compared to the higher structures or even the lighter wooden frame structure which are older in structure. In order to minimise the seismic vulnerability, retrofitting and better construction policies are recommended.

References

1. Kayal J.R., Arefiev S.S., Barua S., Hazarika D., Gogoi N. Kumar A., Chowdhury S.N. and Kalita S. (2006). Shillong Plateau earthquakes in Northeast India region: complex tectonic model. *Curr. Sci.*, 91(1), 109-114.
2. Cees J. Van Westen, Enrique Castellanos and Sekhar L. Kuriakose (2008). Spatial data for landslide susceptibility, hazard, and vulnerability assessment: An overview. *Eng. Geol.*, 102, 112-131.
3. Rashed T. and Weeks J. (2003). Assessing vulnerability to earthquake hazards through spatial multicriteria analysis of urban areas. *Int. J. Geogr. Inf. Sci.*, 17(6), 547-576.
4. Mohan K., Joshi A. and Patel R.C. (2008). The assessment of seismic hazard in two seismically active regions in Himalayas using deterministic approach. *J. Ind. Geophys. Un.*, 12(3), 97-107.
5. Calvi G.M., Pinho R., Magenes G., Bommer J.J., Restrepo-Vélez L.F. and Crowley H. (2006). Development of seismic vulnerability assessment methodologies over the past 30 years. *ISET J. Eart. Tech.*, 43(3), 75-104.
6. Bhandari R.K. (2013). Challenges of the Devastating Indian Landslides. *Cur. Sci.*, 105(5), 563-564.
7. Ahmed M.M., Jahan I. and Alam M.J. (2014). Earthquake vulnerability assessment of existing buildings in Cox-Bazar using field survey and GIS. *Int. J. Eng. Res. Tech.,* 3(8), 1147-1156.
8. FEMA (2003). Multi-hazard Loss estimation methodology, Earthquake Model. *HAZUS MR4 Technical Manual,* 1-712.
9. Ebert A. and Kerle N. (2008). Urban social vulnerability assessment using object oriented analysis of remote sensing and GIS data. A case study for Tegucigalpa, Honduras. *The Int. Arch. Photogramm., Remote Sens. and Spat. Info. Sci.*, 36(7), 1307-1312.
10. Das S., Gupta I.D. and Gupta V.K. (2006). A probabilistic seismic hazard analysis of Northeast India. *Eart. Spect.*, 22(1), 1-27.