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Earthquake loss estimation by using Radius tool: A case study of Gangtok municipal ward, East Sikkim

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Abstract
Radius (Risk Assessment Tools for Diagnosis of Urban Areas against Seismic Disasters) is a tool, which has been extensively used for risk assessment by different groups or agencies or researchers. Radius tool is developed in United States by Geo-Hazard International (GHI). The United Nations, International Decade for Natural Disaster Reduction (IDNDR) in 1997 funded the Radius project, a spreadsheet-based earthquake loss estimation tool.

Gangtok Municipal Corporation has recognized the need for enhancing the activities in earthquake risk reduction, but they lack the expertise and resources required. The municipality does not have the required spatial information to investigate the existing trend of urbanization, population growth rate, and the resulting level of building and vulnerability.

The main aim of this paper is to implement Radius tool to assess the possible impact of upcoming seismic events and to evaluate earthquake risk scenarios for possible damage and systematic inventory of the elements at risk and their relative value and vulnerability assessment of Gangtok town.

Keywords: Radius, Earthquake, risk reduction, loss estimation, Gangtok, Urbanization, population growth, building vulnerability, Seismic events, Vulnerability assessment

1. Introduction

The rapid growth of population and haphazardly construction of houses, buildings and increasing numbers of urban population particularly developing countries including India needs primary concern to assessment of buildings before occurrence of any major disastrous events like earthquake. The alarming growth rate of population and rapid construction of multi-stores buildings in past last decades in small and big towns of India may pose serious threat of vulnerability for further earthquake.

In the recent year's rapid growth of population and haphazardly construction of public buildings in sensitive zone led to more susceptibility for earthquakes. Hazard is the probability of occurrences of a potentially damaging phenomenon within a specified period of time and within a given area (Smith, 2001) [11].

It is necessary to design and construct earthquake resistant dwellings in the seismic prone zones. The principles of a seismic design should be kept in mind in this regard. The important earthquake resistant features which are recommended in the latest BIS codes (IS 13828:1993) should be followed (Bhagwan and Sreenath, 1996) [2].

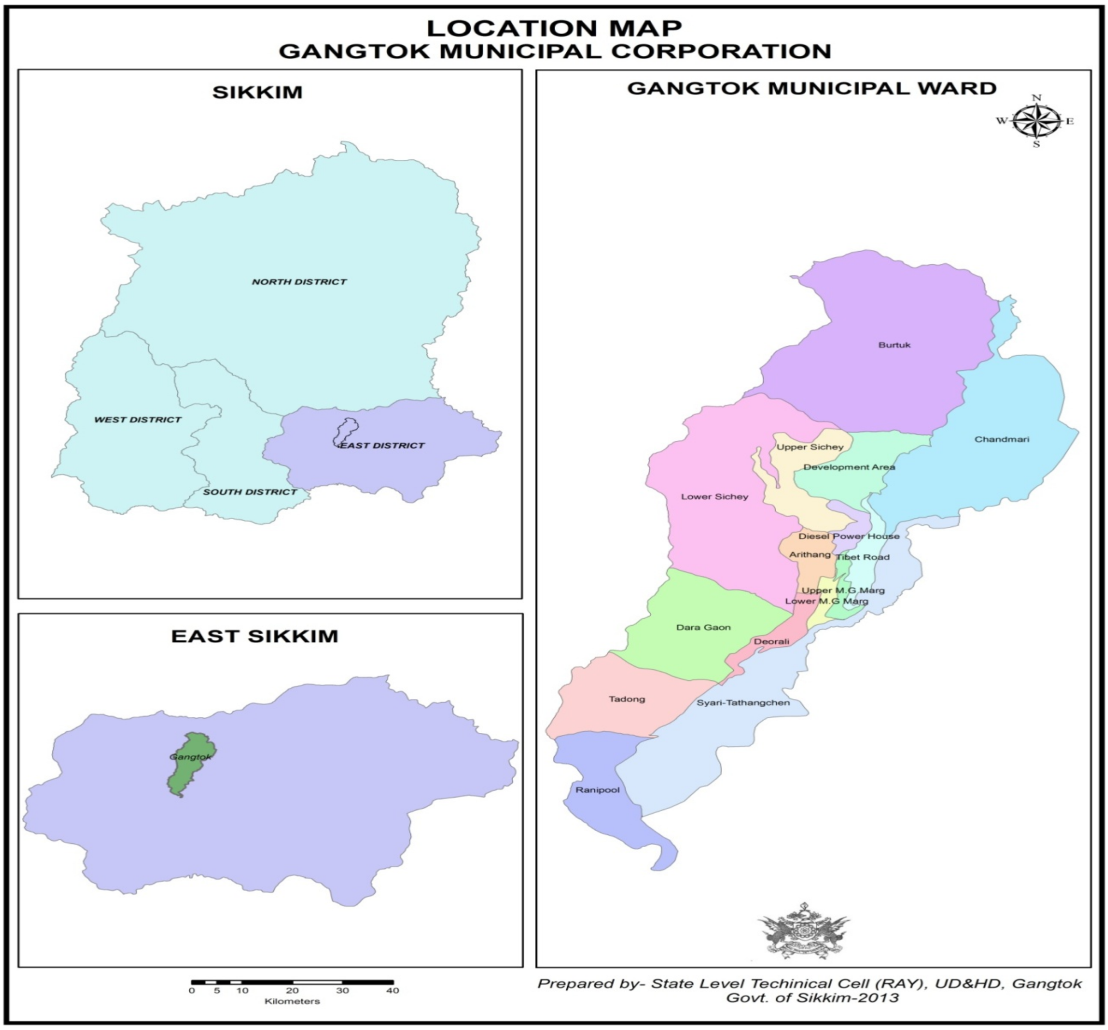
The city has been expanding in a very improper manner having huge encroachment, haphazardly constructions of multi-stories public buildings, incapable land-man-material ratio, lack of proper infrastructure facilities, unplanned urban development etc. Moreover, the earthquake risk in the area makes the problem much more acute for the urban governing body. According to previous studies the probability of human casualties, death and damage of buildings and urban infrastructures during the large earthquakes seems to be very high (JICA, 2002).

Therefore, a planned seismic vulnerability assessment of building structures is required and it will be more justified to evaluate earthquake risk scenarios for possible damage and systematic inventory of the elements at risk and their relative value and vulnerability assessment of Gangtok town.

2. Study Area

Gangtok Municipal Wards come under the Gangtok Town, located in the East District of Sikkim, India, on the lap of Mt. Kanchenjunga (world third highest peak) in a mountainous region as a beautiful Himalayan capital. The precise meaning of the name *Gangtok* is unclear, though the most popular meaning is "hill top" (Banerjee Parag, 2007) [1].

There are 15 wards notified by the Gangtok Municipal Corporation after it come to effective on 2011. The total population of Gangtok town is 105196, according to the census of India 2011. The total numbers of buildings is estimated as 26641 by UD & HD, Govt. of Sikkim in 2011.



Source: (Source: UD&HD, Gangtok, Govt. of Sikkim, 2013)

Fig 1: Map of Gangtok Municipal Corporation

3. Objective of the Study

The main objective of the study is to assess seismic vulnerability of the existing building stock in the wards of Gangtok town. The other objectives of the study is summarise in the following heads:

- To estimate the building damage under different probable earthquakes scenario and the resulting expected human casualties of Gangtok Town.
- To identify the parameters (seismic data, building inventory classification and damage curves) required for ERA (Earthquake Risk Assessment) for building structures in Gangtok.
- To raise the awareness of seismic risk among public, administrators and the decision makers as well as local institutional to sustain the earthquake risk mitigation plan for Gangtok Town.

4. Sources of Data

- The present study is based on primary as well as secondary data. To collection of primary sources of data, researcher directly engage in the field survey through observation, questionnaires, opinionaires, personal interviews and group interviews and supportive photographs has been taken. To collection of secondary sources of data, researcher did extensive review of books, volumes, journals, magazines, articles, newspapers and electronic sources.

5. Hypothesis

“″It is possible to develop and implement the methodology for seismic vulnerability assessment for building structures in Gangtok town for earthquakes”.

6. Literature Review

Normally houses are built to withstand vertical load only and as a result they collapse when subjected to horizontal stresses produced by earthquake waves. The main requirements for preventing the collapse are a lateral load carrying system of enough residual capacity to safely resist lateral forces, a monolithic roof with sufficient in-place rigidity and a strong and durable vertical load carrying system (Shukla, 1998).

I Pal, *et al*., (2008) [8] study Earthquake hazard zonation of Sikkim Himalaya using a GIS platform for assessment of Natural Hazard with giving focus over the recent year’s rapid growth of population, over exploitation of land and natural resources have resulted in deterioration of the overall environment of the Sikkim hill resultant the prone for earthquake.

Gangtok town is possibly one of the town of India having most vulnerable to potential threat and damage of earthquake. In order to estimate seismic vulnerability of existing building stocks on a wide spread area, it is imperative to make several assumptions for selection of building samples, analysis and determine the damage levels. (FEMA, 1997) [4].

7. Method and Methodology

Method for study is based on observation and analytical in nature. To assess seismic vulnerability of the existing building stock in the wards of Gangtok town, Purposive Sampling method is adopted i.e. (5% of total existing buildings from each 15 wards).

Methodology Radius (Risk Assessment Tools for Diagnosis of Urban Areas against Seismic Disasters) Tool based on input-output methods is use to assess the vulnerability of buildings and demographic features.

The user needs to input the following information:

- Shape of target region by meshes
- Total population and distribution
- Total buildings, building types and their distribution
- Ground condition (soil type)
- Total numbers of lifeline facilities
- Choice of scenario earthquake and its parameters
- The programme then validates the input data and performs analysis.

Output from the analysis includes:

- Seismic (ground shaking) intensity, such as PGA and MMI Intensity
- Building damage
- Lifeline damage
- Casualties, such as number of deaths and injuries.

8. Radius data analysis (Procedure)

Table 1: Radius Program Menu

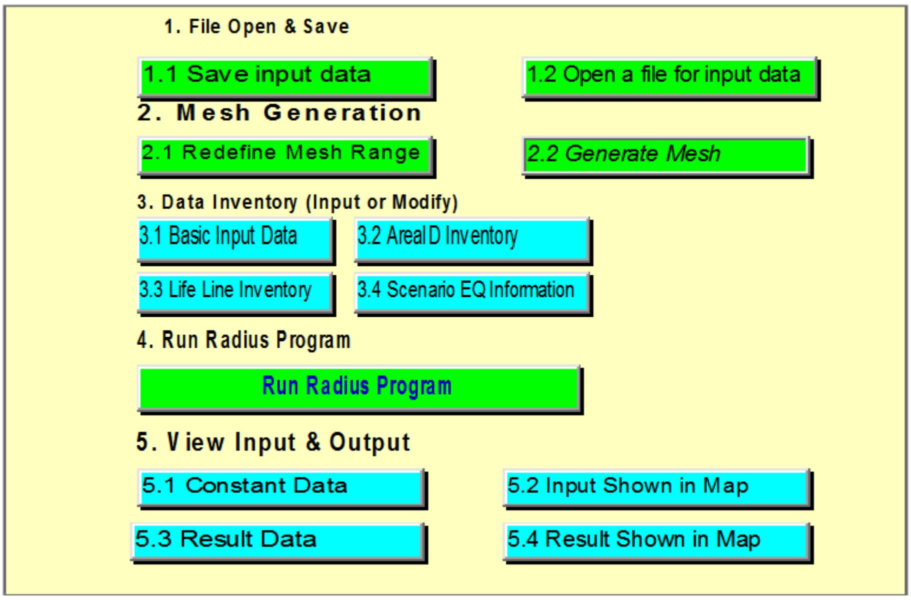


Table 2: Basic Input Data

Mesh ID	Area ID	Area Name	Mesh Weight	Local Soil Type
1	1	Burtuk	4	2
2	2	Lower Sichey	3	2
3	3	Upper Sichey	3	2
4	4	Chanmari	4	3
5	5	Development Area	3	3
6	6	Disel Power House	1	2
7	7	Arithang	3	3
8	8	Lower M.G. Marg	1	1
9	9	Upper M.G. Marg	1	1
10	10	Tibet Road	1	1
11	11	Deorali	1	1
12	12	Daragoan	3	2
13	13	Tadong	3	1
14	14	Ranipool	1	0
15	15	Syari Tathenchen	4	3

MMI formula: log (PGA*980) =0.30*MMI+0.014 or
MMI=1/0.3*(Log10 (PGA*980)-0.014)

Table 3: Inventory by Area

Area ID	Area Name	RES1 (%)	RES2 (%)	RES3 (%)	RES4 (%)	EDU1 (%)	EDU2 (%)	MED1 (%)	MED2 (%)	COM (%)	IND (%)	Sum (%)
1	Burtuk	10.00	25.00	18.00	20.00	8.00	5.00	2.00	0.00	10.00	2.00	100.00
2	L. Sichey	5.00	27.00	16.00	20.00	10.00	3.00	2.00	0.00	12.00	5.00	100.00
3	U. Sichey	8.00	25.00	15.00	20.00	8.00	2.00	2.00	2.00	14.00	4.00	100.00
4	Chanmari	12.00	30.00	16.00	20.00	6.00	3.00	2.00	0.00	10.00	1.00	100.00
5	D. Area	5.00	29.00	18.00	21.00	5.00	5.00	2.00	0.00	10.00	5.00	100.00
6	Dph	4.00	26.00	20.00	23.00	4.00	5.00	2.00	3.00	11.00	2.00	100.00
7	Arithang	8.00	32.00	14.00	20.00	6.00	7.00	2.00	0.00	8.00	3.00	100.00
8	Lmg	3.00	27.00	13.00	25.00	2.00	3.00	2.00	0.00	20.00	5.00	100.00
9	Umg	2.00	26.00	14.00	30.00	1.00	2.00	2.00	0.00	18.00	5.00	100.00
10	T, Road	3.00	30.00	19.00	22.00	2.00	3.00	2.00	0.00	17.00	2.00	100.00
11	Deorali	5.00	26.00	14.00	20.00	8.00	5.00	2.00	0.00	15.00	5.00	100.00
12	Daragoan	5.00	28.00	17.00	21.00	8.00	5.00	2.00	0.00	12.00	2.00	100.00
13	Tadong	7.00	25.00	11.00	21.00	10.00	8.00	2.00	0.00	11.00	5.00	100.00
14	Ranipool	12.00	28.00	12.00	20.00	8.00	5.00	2.00	0.00	8.00	5.00	100.00
15	Syari T.Chen	14.00	29.00	15.00	18.00	8.00	5.00	2.00	0.00	7.00	2.00	100.00

Table 4: Casualty M3 (Trapped by Collapsed Structures) Coefficient

MMI	RES1	RES2	RES3	RES4	EDU1	EDU2	MED1	MED2	COM	IND
5	0.03	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.02	0.02
6	0.05	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
7	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
8	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
9	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
10	0.70	0.70	0.70	0.60	0.70	0.60	0.70	0.60	0.60	0.60
11	0.80	0.80	0.80	0.60	0.80	0.60	0.80	0.60	0.60	0.60
12	0.90	0.90	0.90	0.60	0.90	0.60	0.90	0.60	0.60	0.60
	Masonry	Masonry	Masonry	RC	Masonry	RC	Masonry	RC	RC	RC

Table 5: Casualty M4d (Death) Coefficient

MMI	RES1	RES2	RES3	RES4	EDU1	EDU2	MED1	MED2	COM	IND
5	0.200	0.125	0.075	0.050	0.125	0.050	0.125	0.050	0.075	0.075
6	0.200	0.125	0.075	0.050	0.125	0.050	0.125	0.050	0.075	0.075
7	0.200	0.125	0.075	0.050	0.125	0.050	0.125	0.050	0.075	0.075
8	0.200	0.125	0.075	0.050	0.125	0.050	0.125	0.050	0.075	0.075
9	0.200	0.125	0.075	0.050	0.125	0.050	0.125	0.050	0.075	0.075
10	0.200	0.125	0.075	0.050	0.125	0.050	0.125	0.050	0.075	0.075
11	0.200	0.125	0.075	0.050	0.125	0.050	0.125	0.050	0.075	0.075
12	0.200	0.125	0.075	0.050	0.125	0.050	0.125	0.050	0.075	0.075
	Masonry	Masonry	Masonry	RC	Masonry	RC	Masonry	RC	RC	RC

9. Result and Discussion

Under this tool activity, Table no. 1 is related with procedure how to operate Radius programme menu and mesh area generation. It is simple computer system, where we have to put input system, firstly we have file open and save option. It was further divided into option of save input data and opens a file for input data. Secondly, it comes mesh generation, in which we have option of redefine mesh range and generate mesh. Third, we have option of data inventory, in which we can put basic input data, area ID inventory, and life line inventory and scenario earthquake information. Fourth option is related to run the Radius program. Now fifth and last option of this procedure is to view input and output data, in which we have four options i.e. to see constant data, input map, result data and result map.

15 meshes area has been generation for comparing and counting of serial wise 15 wards of Gangtok Town. Input is based on: 1) mention city‘s name Gangtok, 2) total night population is 105196 and 3) total building count is 26641, as well as mesh spacing is equal 1 km Radius of each ward.

In table 2, next step is to put basic input data, in which four horizontal rows and 15 vertical rows show the irrespective of Mesh ID, Area ID, Area Name, Mesh Weight and Local Soil Types of 15 wards of Gangtok Town.

Under table 3, division of inventory by area is necessary, in which each column discuss about the building use types.

Building has classified as residential 1, residential 2, residential 3, residential 4, education 1, education 2, medical 1, medical 2, commercial and industry depend open size, composition and purpose of use. Life line inventory like roads, bridges, tunnels, electricity, water, reservoir and gasoline distance from the city, length and total numbers is require to incorporate to get the damage result. Next step is to compare present earthquake scenario with historical earthquake parameters. Mesh weight was mention on the base of code, description and rate. Soil types have to be identified by code, description and amplification factor. Next step is to compare with the attenuation equations proposed by different authors. The intensity of Earthquake is measure in MMI formula: log (PGA*980)=0.30*MMI+0.014 or MMI=1/0.3*(log10 (PGA*980)-0.014).

Table 4 provide the result of casualty M3 (trapped by collapse structure) coefficient relation with MMI and building use types. Table 13 reflects the casualty M4 (Death) coefficient relation with MMI and building use types. Table 14 depicts the primary damage curve data in percentage in relation to MMI and building use types. Now the damage result of life line inventory will obtained after the comparison of MMI with life line damage curve data. Day and night differences habitat parameter brings different result. Soil colours distribution map colours the value range of mesh data and character shows area ID. Mesh weight distribution map is shown in different colours, mesh range and from low to very high mesh weight. Mesh weight distribution map in colour shows value range of mesh data and character shows value area ID. Co-relate with mesh weight summary ward-wise with mess weight, description and prescribe rate is necessary to get damage result of population and building stocks.

10. Findings and Conclusions

The findings of this study is that, the classification and structure of buildings, soil types, life line inventory, habitat parameters, occupancy of building by population in day and night play significance role for the estimation of loss during earthquake. This study proves that, Radius is an appropriate tool to assess the building damage estimation.

From the result of Radius tool loss estimation, it is concluded that the Upper M G Marg, Lower M G Marg, Diesel Power House and Arithang Ward building stocks is much vulnerable due to over crowd and high multi-storeyed building may take huge damage probability in near future earthquake. Deorali, syari-Tathenchen, Chanmari, Daragoan, Tadong, Lower Sichey and Upper Sichey is also comes under high risk zones due to haphazardly construction of buildings and numbers of encroachment of residents. The other wards are comes under less damage estimation, but alarming growth of population and increasing numbers of building constructions in these localities also possibilities for increase in damage estimation in future.

11. References

1. Bannerjee Parag. Next weekend you can be at. Gangtok. The Telegraph Retrieved, 2007, 2008.
2. Bhagwan NG, Sreenath HG. A seismic vulnerability reduction strategy for low rise building construction. International Conference on Disaster & Mitigation, Madras, 1996; 1(A3):11-16.
3. City Development Plan-Gangtok City. Jawaharlal Nehru National Urban Renewal Mission, Ministry of Urban Development, Government of India. Retrieved, 2011.
4. FEMA. NEHRP Guidelines for the Seismic Rehabilitation of the Buildings, A pre-standard Federal Emergency, 1997.
5. City Development Plan-Gangtok City. Jawaharlal Nehru National Urban Renewal Mission, Ministry of Urban Development, Government of India. Archived from the original Section 2: Introduction to the State and Its Capital. On Retrieved, 2008.
6. Housing planning and development, Gangtok, Master of Planning (Housing), Department of Housing School of Planning and Architecture, New Delhi, 2011, 7
7. Housing planning and development, Gangtok, Master of Planning (Housing), Department of Housing School of Planning and Architecture, New Delhi, 2011, 10-11.
8. Pal I, Shukla SK, Pal DK, Raj A. Earthquake hazard zonation of Sikkim Himalaya using a GIS platform, natural hazard, 2008.
9. NIDM. Disaster Management in India - A status Report. In: N.I.o.D. Management (Editor). Government of India, Ministry of Home Affairs, Delhi, 2004.
10. Shukla AK. Scaling and zoning of earthquakes. In: BMTPC (Editor), Mitigation Measures and Preparedness for earthquakes. Building Material and Technology Promotion Council, New Delhi, 2008, 16.
11. Smith K. Environmental Hazards: Assessing Risk and Reducing Disaster, London, 2001.
12. SFCPoA (Slum Free City Plan of Action), Rajiv Awas Yojana, Ministry of Housing and Urban Poverty Allevation, 2012.
13. UDHD. City Development Plan. Urban Development and Housing Department, Gangtok, 2013.
14. Census of India, 2011.
15. Damage and restoration on Mexico earthquake; Japan Society of Civil Engineers, 1985, 1986.
16. Earthquakes and volcanic eruptions; Swiss Re, 1992.
17. Earthquake Damages: The Mother of Earthquake Engineering; Hakuno Motohiko, Kajima Institute Publishing, 1992.
18. Memories for 100 years; TVBS, 1999.
19. Message from San Francisco; OYO Corporation, 1991.