ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization, Volume 2, Special Issue 1, December 2013

Proceedings of International Conference on Energy and Environment-2013 (ICEE 2013)

On 12th to 14th December Organized by

Department of Civil Engineering and Mechanical Engineering of Rajiv Gandhi Institute of Technology, Kottayam, Kerala, India

DEVELOPMENT OF URBAN SEISMIC RISK ASSESSMENT SYSTEM

Lenin Babu S, P. Sabu

Assistant Professor, Vidya Academy of science and Technology Technical campus Kilimanoor, Trivandrum, Kerala-695602, India

Assistant Professor, College of Engineering Trivandrum, Thiruvananthapuram, Kerala, India

ABSTRACT: Earthquake prediction and mitigation is a very difficult process although we know the probable regions and expected magnitude. But after the development of earthquake engineering there are several methods to reduce the risk of earthquake impact. Large amount of data is required for proper earthquake risk analysis. Data collections through field survey are tedious and costly. Risk analysis using outdated existing information also affects the accuracy of results. But after the development of remote sensing and GIS it is now possible to overcome the difficulties in evaluating the seismic risk of any area with great accuracy. In this study an urban seismic risk assessment system is developed which is very useful for urban planners and disaster management wings because they can use it for estimating probable loss of life and buildings. It is also helpful to develop an earthquake warning system. Study area chosen for this work is part of Sasthamangalam ward of Thiruvananthapuram Corporation.

1. INTRODUCTION

Earthquake is one of the most destructive natural hazards. It cannot be predicted accurately although we know the probable region. Hence it leads to huge amount of loss to human and property. A seismic risk assessment study helps to reduce the impact of earthquakes and is also helpful to formulate disaster management plans for local authorities.

In this study a web based urban seismic disaster management system is developed on a GIS platform based on the location and plan of buildings, materials of construction, type of structure, height of buildings, and day and night time population that will help the seismic risk assessment disaster management plans of the study area.

2. STUDY AREA

The study area chosen for this study is Sasthamangalam ward of Thiruvananthapuram Corporation. Sasthamangalam ward is located between latitudes 8°50′20″N and 8°51′70″, longitudes 76°58‟30″E and 76°58‟12″.″ It is a popular residential area in Tivandrum city and is one of the wards having high population density. Hence preparation of urban seismic risk assessment system of this area is important and is useful for future disaster management processes. As the building inventory data, and population data of individual buildings required for analysis was not available with the authorities field study was carried out to collect these information. Since collecting information of entire Sasthamangalam ward is a tedious process a buffer of 500 meter diameter from Sasthamangalam junction is drawn and buildings within this buffer are selected for analysis. About 500 buildings were identified from high resolution satellite image of this selected study area.

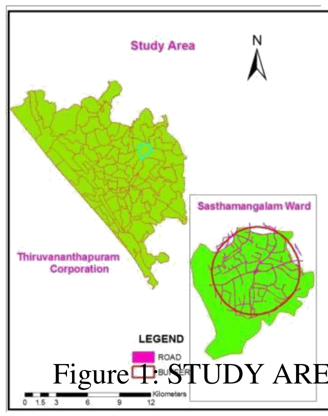


Figure 1: STUDY AREA

3. DATA USED

The data used for this study are administrative boundary of study area, building inventory data, population data, road map, satellite images etc. Administrative boundary of Sasthamangalam ward is collected from Regional town planning office. The building inventory data contains information about different attributes of buildings such as building use, number of storey, age of building and structure of building. Population data contains information about number of members in the house, population during day and night time. Building inventory data and population data is collected by field survey. Road maps of the study area are necessary to make base map. Road map of Thiruvananthapuram Corporation is collected from corporation office. Then road map of study area is subset from the entire road map of Thiruvananthapuram Corporation. A satellite image of study area is also necessary for base map preparation. Google image from Geoeye satellite is used for base map preparation.

4. METHODOLOGY

Urban seismic risk assessment system is an user interface (UI) which helps to identify the damage ratio of buildings for different intensities of earthquake and vulnerability of buildings during low and high frequencies of earthquakes. Development of this UI consist of several steps such as base map generation, data base generation and interface designing. Base map generation and data base generation was done in Arc GIS and interface designing was done using Geoserver which is open source software.

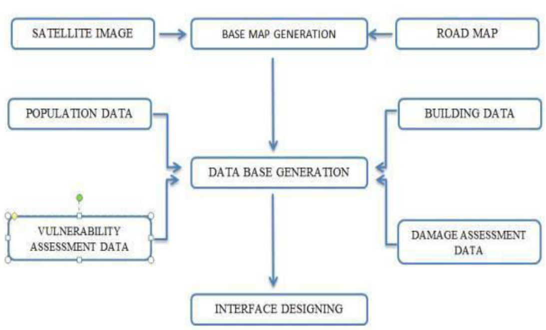


Figure 2: FLOW CHART OF METHODOLOGY

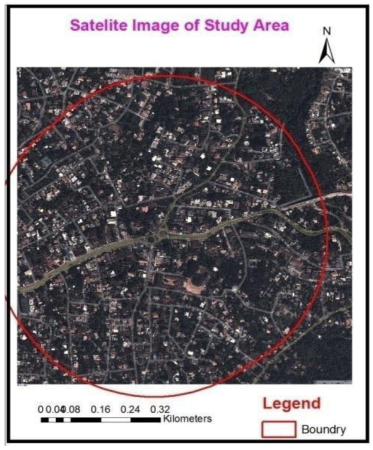


Figure 3: SATELLITE IMAGE OF STUDY AREA

Figure 3 shows the satellite image of the study area after preprocessing. From the preprocessed image buildings of study area is digitized in Arc Map.

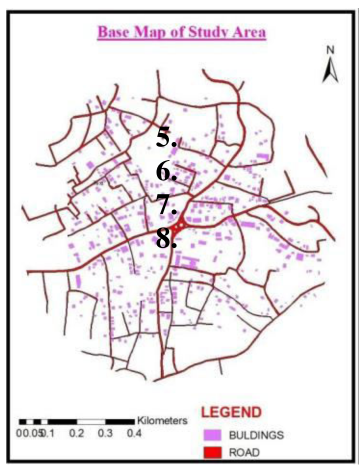


Figure 4: BASE MAP

5.BASE MAP GENERATION

A base map displays the fundamental data set such as buildings, roads, railway network, rivers, slum boundaries, schools, other landmarks etc that is used to render sector data more meaningful. In order to prepare building inventory data base, base map should contain buildings [1]. In this study first the satellite image obtained is georeferenced using control points.

6. DATA BASE GENERATION

A database is an organized collection of data. The data is typically organized to model relevant aspects of reality [1]. In this project building inventory data, population data, building vulnerability assessment data and damage assessment data is used to create Data base. Building inventory data contains the information such as Building name, Number of storeys, Age of building, and Buildingstructure. Population data contains information such as Population during daytime about 8 am to 6 pm and Population during night time about 6pm to 8 am. Vulnerability assessment data contains vulnerability class of buildings during low and high frequency earthquakes. Damage assessment data contains damage value of buildings during different intensities of earthquakes.

7. BUILDING VULNERABILITY ESTIMATION

Weight estimation for different building parameters, vulnerability index estimation and vulnerable class identification etc. are the main steps involved in this study to find out seismic vulnerability of buildings. Weight for each building parameter is estimated by AHP. Then vulnerability index for different combinations of building parameters are estimated by certain query operations in Arc map. According to the vulnerability index obtained, buildings are grouped under four vulnerable classes and vulnerability maps were prepared for high and low frequency earthquakes.

TABLE 1. DECISION MATRIX AND WEIGHT OBTAINED FOR BUILDING PARAMETERS

Building parameter	**Decision Matrix**				**Weight obtained**	
Building materials						
	Mud	Mixed	Bricks	Concrete		
Mud	1	5	7	7	Mud	0.625
Mixed	0.2	1	5	5	Mixed	0.2656
Bricks	0.1429	0.2	1	1	Bricks	0.0544
Concrete	0.1429	0.2	1	1	Concrete blocks	0.0544
Building Type						
	Framed	Load bearing				
Framed	1	0.125			Framed	0.125
Load bearing	8	1			Load bearing	0.875
Number of storeys						
1.High frequency earthquakes						
	Single	Double	3 to 5 storey	Multi storey		
Single	1	3	5	7	Single	0.5066
Double	0.3333	1	4	6	Double	0.3062
3 to 5 storey	0.2	0.25	1	6	3 to 5 storey	0.1432
Multi storey	0.1429	0.1667	0.1667	1	Multi storey	0.0434
1.Low frequency earthquakes						
	Single	Double	3 to 5 storey	Multi storey		
Single	1	0.3333	0.1667	0.125	Single	0.0437
Double	3	1	0.25	0.1429	Double	0.0835
3 to 5 storey	6	4	1	0.1667	3 to 5 storey	0.2218
Multi storey	8	7	6	1	Multi storey	0.661

Table 2 shows the Decision matrices and weights obtained for various building parameters

8. BUILDING DAMAGE ASSESSMENT

During an earthquake the damage occurred in buildings varies according to the materials used and type of structure. For example at a particular level of seismic intensity the damage occurred for mud buildings are different from that of concrete blocks. Hence in this work a damage matrix is used to estimate the building damage at different intensities of earthquake.

TABLE 2. DAMAGE MATRIX (source: IS 1893)

Intensity of earthquake	**Mud**	**Brick**	**Concrete blocks**	**R.C buildings**
V	Grade 1	-	-	-
VI	Grade 2	Grade 1	Grade 1	-
VII	Grade 3	Grade 2	Grade 2	Grade 1
VIII	Grade 4	Grade 3	Grade 3	Grade 2
IX	Grade 5	Grade 4	Grade 4	Grade 3
X	Grade 5	Grade 5	Grade 5	Grade 4
XI	Grade 5	Grade 5	Grade 5	Grade 5
XII	Grade 5	Grade 5	Grade 5	Grade 5

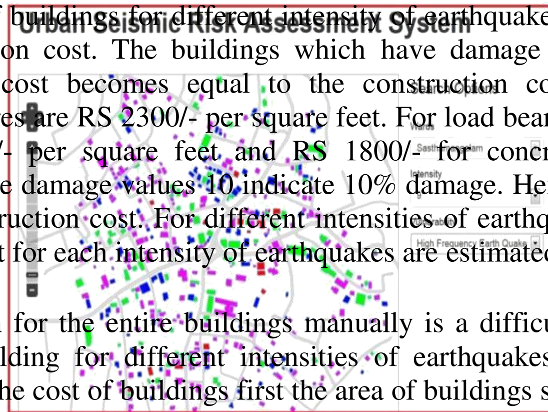
Table 2 shows the damage matrix for different types of buildings. By comparing the damage matrix along with different studies damage ratio for each intensity is identified.

TABLE 3. DAMAGE RATIO

Intensity	Mud	Brick	Concrete blocks	R.c buildings
V	10	-	-	-
VI	40	10	10	-
VII	60	40	40	10
VIII	80	60	60	40
IX	100	80	80	60
X	100	100	100	80
XI	100	100	100	100
XII	100	100	100	100

Table 3 shows damage ratio for different materials for different intensities of earthquakes. According to field survey the buildings in study area is constructed by materials such as concrete blocks, bricks, mud and mixed materials. After obtaining the damage ratio for different intensity of earthquakes it is assigned to the data base for further process.

The costs of damage of buildings for different intensity of earthquakes are found out based on the present building construction cost. The buildings which have damage value 100 indicate total collapse. Hence the damage cost becomes equal to the construction cost. The current rate of construction for framed structures are RS 2300/- per square feet. For load bearing structures with brick, construction cost is RS 2000/- per square feet and RS 1800/- for concrete blocks load bearing structures. Buildings which have damage values 10 indicate 10% damage. Hence the cost of damage is equal to the 10% of total construction cost. For different intensities of earthquakes the damage loss is different, hence the damage cost for each intensity of earthquakes are estimated.



Damage cost estimation for the entire buildings manually is a difficult process. But using Arc Map damage cost of each building for different intensities of earthquakes can be done easily and accurately. In order to estimate the cost of buildings first the area of buildings should be estimated. In Arc Map using the base map prepared, the area of each building can be estimated easily. For that a new field is added to the attribute table such as „area of buildings" then using „calculate geometry" option the area of buildings included in the base map is estimated.

After estimating the area of buildings total construction cost of each buildings are estimated. For that another one field is added to the attribute table such as „total construction cost" then using field calculator total construction cost is estimated by forming different equations. For example in the case of framed structures construction is estimated using the equation

$$\text{Total construction cost} = \text{Area x } 2300 \qquad (1)$$

Where 2300 is the construction cost for framed structures per square feet. Similarly the construction cost for different buildings are estimated.

After estimating the construction cost of each building, the damage cost of buildings for different intensities of earthquakes are estimated. For example in order to find the damage cost of buildings at intensity 5, first a new field is added to the attribute table such as

„Damage cost at intensity 5". At intensity 5 some of the buildings have 10%damage and most of the buildings have no damage. The buildings which have 10% damage is selected and using field calculator the damage cost is estimated by forming an equation

Damage cost at intensity 5 = Total construction cost x 0.10 (2)

Similarly the damage cost of buildings for different intensities of earthquakes is estimated using Arc Map and added to the data base for further processes.

9.INTERFACE DESIGN

Geoserver is used to create the interface of the Urban seismic risk assessment system. GeoServer is an open source software server written in Java that allows users to share and edit geospatial data. It publishes data from any major spatial data source using open standards.

Figure 5: URBAN SEISMIC RISK ASSESSMENT SYSTEM

In this project the data base created in Arc GIS is converted to Shape files, then it is loaded to the spatial data base of Postgrey SQL. Data stored in Postgrey SQL is in binary form. Geoserver convert this binary data to user friendly forms.

Figure 6: URBAN SEISMIC RISK ASSESSMENT SYSTEM WITH BUILDING MAP

Figure 5 shows the index page of Urban Seismic Risk Assessment System. User can enter into the interface by clicking the ENTER tab.

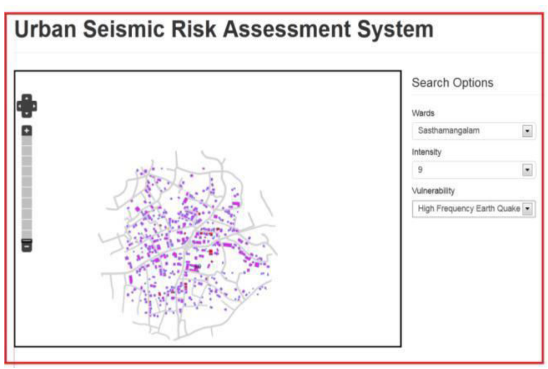


Figure 7: URBAN SEISMIC RISK ASSESSMENT SYSTEM FOR SEISMIC VULNERABILITY

Figure 6 shows the Urban seismic risk assessment system of study area. In this interface user can select his area of interest from the wards icon. Then he can check the damage value of buildings for different seismic intensities and building vulnerability at low or high frequency earthquakes. If the user selects intensity then a base map containing buildings with corresponding damage values will display.

If the user requires seismic vulnerability information about buildings then it will obtain by selecting particular frequency of earthquake from vulnerability tab. Figure 7 shows seismic vulnerability of study area for high frequency earthquake.

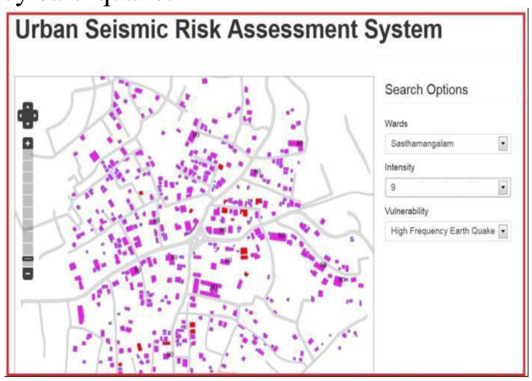


Figure 8: URBAN SEISMIC RISK ASSESSMENT SYSTEM FOR SEISMIC INTENSITY

If the user requires damage value of buildings during particular earthquake intensity then it will obtain by selecting the required intensity of earthquake from the intensity tab. Figure 8 shows the building map with damage value for intensity 9.

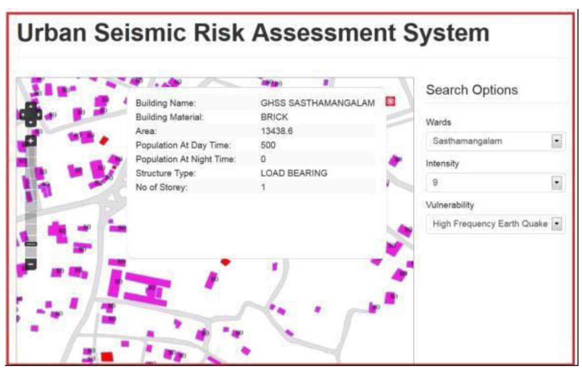


Figure 9: URBAN SEISMIC RISK ASSESSMENT SYSTEM WITH BUILDING DETAILS

Some additional information about buildings is also obtained from this system. For that user should select the building which information is needed. Then a small window will appear with different information such as building name, building material, area of building, day time and night time population, structure type and number of stories. Figure 9 shows the risk assessment system with building details.

10.CONCLUSION

An urban seismic risk assessment system is developed in this study to check the damage value of buildings during different intensities of earthquakes and seismic vulnerability class of buildings during low and high frequency earthquakes. This system is very useful for urban planners and disaster management wings because they can use it for estimating probable loss of life and buildings. It is also helpful to develop an earthquake warning system.

REFERENCES

[1] "Guidelines for GIS mapping, MIS development and integration of GIS with MIS", report on subcommittee 1 on Rajiv Awas yojana

[2] Jose badal and Alwaro Gonzalez (2005), "Preliminary quantitative assessment of earthquake casualities and damages", Natural Hazards 34, pp.353-374.

[3] Jovel and Roberto (1989), "Natural Disasters and Their Economic and Social Impact", Economic Commission for Latin America and the Caribbean Review, No. 38.

[4] Mahdi Hashemi and Ali Asgar (2011), "A GIS based earthquake assessment and settlement methodology"‟ Soil Dynamics and Earthquake Engineering 31. pp.1607-1617.

[5] Sandeep Maithani (2007), "Urban seismic risk assessment in Dehradun city using remote sensing and geoinformation Techniques",Project.

[6] Sharmili Parthasarathy and Vaishali Rajendra Kumar (2011), " Remote sensing and GIS based seismic sub-zonation in north-western Tamilnadu", Disaster, Risk and Vulnerablity Conference 2011.