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Seismic vulnerability of Chamoli ward of Chamoli Gopeshwar Township in Uttarakhand, India using Radius

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Abstract

The Chamoli earthquake of magnitude 6.8 on Richter Scale struck midnight on March 29, 1999. This marks a significant event in the recent seismic activities of the Himalayas. The study area comes under active MCT region.

The severity of the earthquake is evaluated from the extent of damage caused to man-made structures like houses, buildings, bridges, dams, roads, etc. and the loss of life and property. However it is most important to study the structural aspect of the buildings in the urban landscape since it's not the earthquake but the collapse of buildings that kills the people during seismic events.

In the present study, the RADIUS methodology is used to analyse the vulnerability aspect of Chamoli municipal ward that comes under Chamoli Gopeshwar township. The buildings were surveyed, structural data as well as demographic data is acquired to analyse the vulnerability of population in case of any significant seismic event in the future. The different vulnerability classes are determined and classified to show effect of any major seismic event, and how the infrastructure and structures will succumb to it.

The results we got from the study shows a high vulnerability of building structure in the area, and can lead to high damage and casualties in case of seismic event higher or equal to the past event.

Keywords: Aerobic exercise, fasting glucose, post prandial glucose.

Introduction

Study Area

Chamoli is one of the wards of Chamoli Gopeshwar townships. However being located other side of Alaknanda it is geographically somewhat dissimilar to Gopeshwar settlement that lies in southern slopes above it. It is located on the banks of river Alaknanada with the average elevation of 990m above sea level.

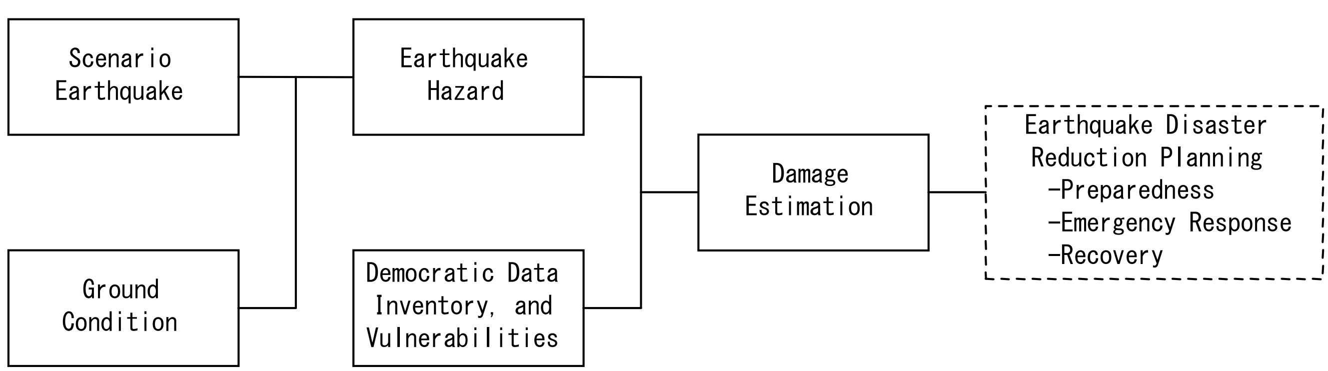
It extends from 30° 24.516'N to 30° 24.012'N and 79° 19.677'E to 79° 21.666'E

Data and Methodology Used

Methodology Adopted

This report is mainly on the lines of methodology that is adopted by RADIUS, which is pointed in the following lines:

- Optimization of the time and resources necessary to prepare damage estimates and realistic risk management plans
- Production of sound damage estimates that identify only the main, not all, factors that contribute to the earthquake risk of a city
- Best possible use of already existing information, as well as of the local scientists' expertise and their familiarity with the region
- Incorporation of representatives of the various sectors of the society throughout the project
- Set up of the conditions that will allow the immediate start of the implementation of the prepared risk management plans



Other than that, the help of GIS is taken as a tool to better identify, analyze and interpret the area information.

Secondary Data and Software Used
Google Earth Satellite Image
The Google Earth image gives a good spatial resolution to assess the building details in the area. The effective and precise interpretation was done as buildings are easily identified comparing with the ground truth.
The digital image used for the present study covers the area of Chamoli ward with some adjacent areas.

Fig 1: Google Image with Chamoli Ward Boundary

Ward Map
The study area covers the Chamoli Ward of Chamoli Gopeshwar township (30° 24.516'N to 30° 24.012'N and 79° 19.677'E to 79° 21.666'E) covering an area of 0.69 sq km with population around 5000.

Software used
- Global Mapper 10
- Surfer 8
- MS Word and Excel

Creation of Vector Layers
Vector layers are created in Surfer 8 for buildings of different vulnerability classes and the hazard zones of different vulnerability type. The projection system used is Geographic (Lattitude/Longitude) and datum used as Everest 1956. The ward boundary as well as the buildings is digitized as polygon feature.
The wards layer (polygon) is digitized with the help of the ward map with scale; Ward Map shows important points and road intersections. Identification of these landmarks on the satellite image has paved way for delineating the ward boundaries.
The building layer (polygon) is digitized simultaneously with the data entry with the help of Google satellite image.
Before that the map was georeferenced using Global Mapper 10.

Ground Data Collection and Data Input
A detailed seismic analysis of buildings is the best way to analyze an area, however it is time consuming but for my small area I can afford to do that. This gave the precise data observing each of the structure and collecting the other data relating to demographic characteristics and detailed information about the buildings.
The following primary data were collected during the survey work:
- Name of the house owner
- Construction time of the building
- Material used for the construction of building
- Number of stories (height of the building)
- Roof type
- Persons living in the particular building
- Number of major repairs of the building, if any
- Depth of foundation
- Working population in the building

These informations helped in providing the health of the buildings and also the demographic information of the area which is not available anywhere as secondary data.
Some of the information collected is utilized in mapping and other major information was input in the RADIUS program for further analysis and interpretation of data.

Zoning of the Area
Usually damage estimation is carried out by subdividing the area in question. That is why earthquake damage estimation is often called seismic microzoning. The RADIUS Tool introduces a simplified method to evaluate ground conditions. Subdivision of the area in question into mesh units or irregular shapes using GIS (Geographical Information System) is done. The zoning of area is done through the meshes created in the RADIUS program. The area is mainly divided into east and west zone on the simple basis of direction in the RADIUS program.
However for a better representation of data the area is further divided into hazard zones on the basis of population density and building types in the area.

Seismic Intensity
The calculation earthquake hazard is done through various techniques. Seismic intensity scale and PGA (Peak Ground Acceleration) are popular measures.
The seismic intensity scale is the most familiar index to indicate the strength of ground shaking and/or how an area will be affected by an earthquake. Several types of intensity scales exist

and different types are used throughout the world. The most commonly used scale is the MMI (Modified Mercalli Intensity) scale and is used in this Tool. PGA (Peak Ground Acceleration) is also used for the convenience of engineers since this parameter is used in the design or analyses of structures. Velocity or displacement parameters are used for specific purposes, but are not used in this Tool. These parameters present only the maximum values of the ground shaking time history, but there are other precise parameters that can be used to indicate the intensity of shaking depending on frequency, such as Fourier Spectrum and Response Spectrum. If precise data for the seismic source and ground conditions are available, precise parameters can be estimated.

Here we have calculated the PGA using Joyner & Boore (1981) formula. PGA is converted to MMI using the empirical formula of Trifunac & Brady (1975). These formula are popularly used worldwide.

Joyner & Boore (1981) formula

PGA=10^(0.249*M-Log(D)-0.00255*D-1.02,
D=(E^2+7.3^2)^0.5

Trifunac & Brady (1975) formula for MMI calculation

MMI=log(PGA*980)=0.30*MMI+0.014 or,
MMI=1/0.3*(log10(PGA*980)-0.014)
PGA unit is G.

Data Analysis

The data analysis is done through RADIUS program with the input of the data collected. But before directly going into the analysis it should be better to see first that how this program works?

How the Program Works

The following data was entered to get the analysis:

- Shape of Nainital Club ward through meshes.
- Total population in the ward and their distribution.
- Total building, building types and their distribution.
- Ground condition (soil type).
- Total number of lifeline facilities. (fig.)
- Choice of scenario earthquakes and its parameters. (fig.)

The program 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. (fig.)
- Summary tables and thematic maps showing the result

Overview of Earthquake Damage

Earthquake damage can affect many fields that are correlated to each other. The most universal and basic damages are building damage and human casualties. In order to reduce earthquake damage, a first step by an earthquake prone city should be to understand what would happen if a significant earthquake were to strike the city. As a second step, effective earthquake risk management activities and measures that would aid in damage reduction, and that are based on the findings of the first step, should be identified. Assessing the magnitude of potential damage should not be thought of as the final goal of the damage estimation process, but rather as the beginning of the earthquake disaster management planning

Outline of Damage Estimation

To begin, a scenario earthquake for the area should be decided on. Reoccurrence of a past damaging earthquake or active fault earthquake is commonly assumed. The epicenter, magnitude, occurrence time (day or night) should also be determined. Usually, ground shaking intensity or PGA (peak ground acceleration) at the site generally becomes greater as the magnitude becomes larger or the distance from the site to the epicenter becomes smaller. Ground shaking is also greatly influenced by the ground conditions of the site. Thus, Earthquake Hazard will be estimated from the parameters of the scenario earthquake and ground conditions. Damage will be estimated from hazard and the existing structures in the area and depends on not only the number of structures but also types of the buildings or lifeline facilities, using vulnerability functions derived for each type of structure. Vulnerability functions reflect the relationship between seismic intensity and the degree of damage to the structure. Casualties such as deaths and injuries are also estimated if the population distribution is known. Thus, the total amount and distribution of damage can be estimated if the chosen scenario earthquake were to occur.

In this study the past earthquakes of Chamoli (March, 1999) and Nepal (April, 2015) are chosen, assuming such earthquake to take place in the study area. The epicenter is taken about 7 kms from the study area that was the actual epicenter during Chamoli earthquake of March, 1999.

Earthquake Vulnerability of Buildings

A large scale earthquake can affect a wide area in many different aspects. In such an earthquake, for example, the area near the epicenter will be shaken severely and some slopes may fail. The direct disaster of the ground shaking caused by earthquakes is called Earthquake Hazard. Earthquake Hazard can inflict damage on a wide variety of structures. The damage to buildings is the most obvious and important damage.

Estimated Building Damage

Building damage caused by earthquakes contributes to disasters and causes casualties and fires. Earthquake damage to buildings is greatly influenced by the types of buildings. There are various ways to classify buildings, namely by materials, construction type, building age, story or height and usage, etc. It is desirable to adopt the classification based on the factors that closely correlates to observed past damages. However, since detailed building information is not available in many cases, a general classification is often used.

The estimated building damage for a hypothetical earthquake in Chamoli Ward is calculated through RADIUS program. Here two hypothetical earthquakes are considered taking examples from past in the nearby areas. The first earthquake is supposed to be intensity of Chamoli Earthquake that was of magnitude 6.8 on Richter Scale. It struck on the midnight of March 30, 1999 in which about 100 people lost their life and about 5 lakh people were affected in the districts of Chamoli, Rudraprayag and Pauri. The second is supposed to be intensity of recent Nepal earthquake which rocked the whole Nepal, and parts of India and China with the magnitude of 7.9 on Richter scale. In this event more than 9000 people lost their lives and about 23,000 are severely injured.

If such earthquakes again strike the region, what will happen? That's the major question. With the collection of primary data regarding building types along with other information like soil type and then putting these data in RADIUS program, we got an estimation of the building type in the Chamoli ward.

There are certain parameters for the building type in the program testing the vulnerability of the buildings. They are:

- **Res1:** Informal construction mainly slums, row housing etc made from unfired bricks, mud mortar, loosely tied walls and roofs. This formed about 30.5% of the total area.
- **Res2:** URM-RC composite construction sub standard construction, not complying with the local code provisions. Height up to 3 stories URM is Un-Reinforced Masonary and RC is Reinforced Concrete Building. Such buildings were quite common and found as about 62% of the total area.
- **Res3:** URM-RC composite construction old deteriorated construction, not complying with the latest code provision. Height- 4 to 6 stories. Such building types are absent in the area.
- **Res 4:** Engineered RC construction, newly constructed multi storied buildings, for residential and commercial purposes. Such building types are absent in the area.
- **Edu 1:** School building up to 2 stories usually percentage should be very small. This covers about 7.5% of the total area.
- **Edu 2:** School greater than 2 stories. Such building types are absent in the area.
- **Med 1:** Low to medium rise hospitals. No hospital in the research area.
- **Med 2:** High rise hospitals. No hospitals in the research area.
- **Com:** Shopping centres. No major shopping centres in the area.
- **Ind:** Industrial facility both low and high risks. No such industrial facility.

For the ease of study we divided the buildings into two classses. The buildings are divided according to the time of construction for pre and post earthquake of March 1999 in the area. In total 48 buildings of the ward are surveyed on random stratified sampling basis in the area. For the study area buildings we find out that out of 48 buildings, 17 buildings will be completely destroyed with the earthquake of same intensity as of Chamoli, with mean damage ratio (MDR) being 35.7.

On the other hand, taking the magnitude of earthquake equaling that of Nepal Earthquake of 7.9, we find out the damage to the buildings to be 47.1 MDR. The total damage count is 23 buildings out of 48.

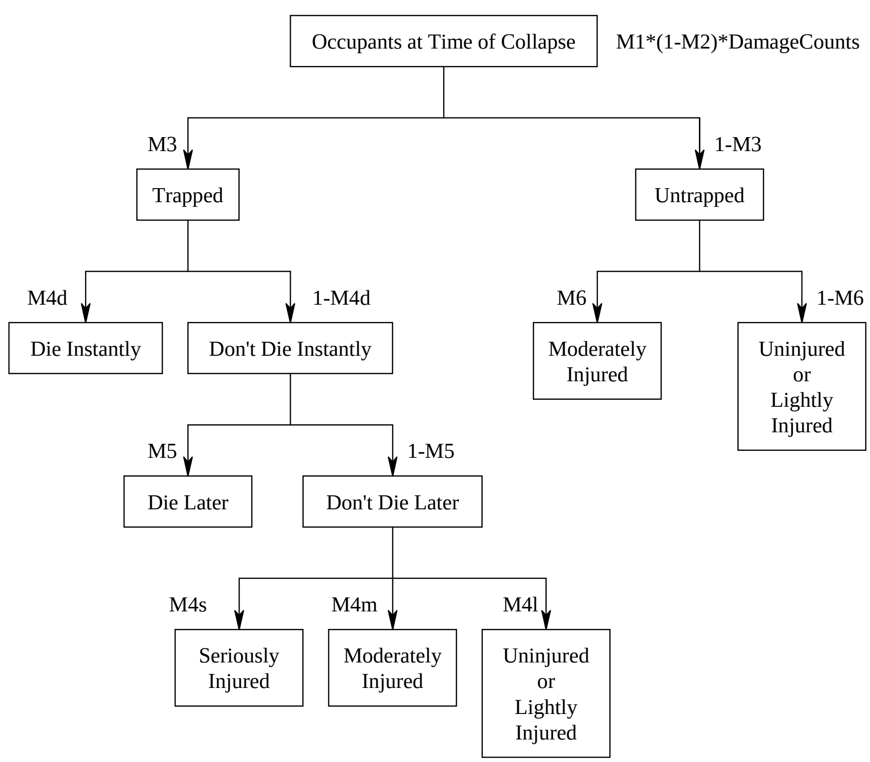
This is a very shocking result with a significant amount of buildings surrendering to the earthquake on both occasions. As there is a saying about earthquake, it is not the earthquake that kills people; it is the buildings that kill people. The reason for such a result is that the most of buildings in the area are sub standard not complying with the local code provisions. Also there is no such major repairing done for the older buildings which are in good numbers in the area.

Estimated Casualties

Casualties caused by earthquakes are main "damages" and their reduction is targeted in disaster planning and preparedness. Building collapse is a main cause of casualties during earthquakes. Therefore, information on the number of people inside buildings when the earthquake occurs is necessary for casualty estimations. Moreover, day and night populations are different.

The estimation of casualties is determined by putting the value of casualty coefficient into the data entered for the area. The value given to the different building types are shown in the tables

The fate of casualty with the collapse of building is shown in the diagram below:



The earthquake of the magnitude equaling Chamoli, would give the following results for our research area:

- For the total population 6% deaths are estimated. Out of 5000 people in the ward 316 are estimated to lose their life.
- Out of total population % are estimated to be injured, i.e. 45 of 316 population.
- The more damage is estimated on the western part with 665 injured and 166 deaths. Whereas in the eastern part the injured are estimated to be 607 with 150 deaths.
- Now, let's see the impact of earthquake equaling that of Nepal:
- For the total population 2.5% deaths are estimated. Out of 336 people in the area about 8 are estimated to lose their life.
- Out of total population 13.3% are estimated to be injured, i.e. 45 of 316 population.

This gives the clear idea that how disastrous it can be for the life of people. This data only implies to the casualties due to the damage to buildings, but the earthquake possibly can also cause landslide in this vulnerable unstable zone. So, the casualties could be lot higher in that scenario.

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