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Seismic vulnerability of existing buildings in ward no- 3 of nagar palika parishad Ramnagar, Uttarakhand, India

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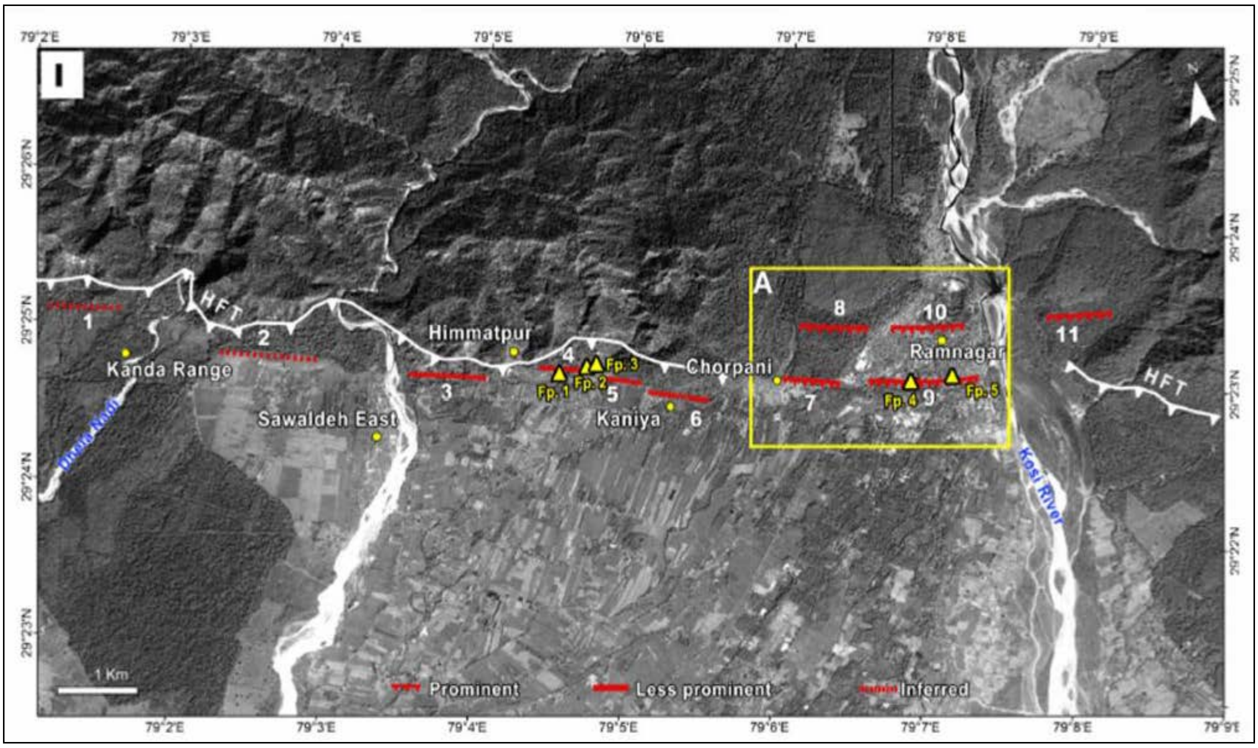
Abstract
Uttarakhand has witness major earthquakes in the past history. The vulnerability of the region to earthquakes is characterized by the fact that during the last century, the region had experienced 11 earthquakes of magnitude greater than 6.0 on the Richter scale. Growing urban centres in the region is a major concern as most of these constructions are inadequate to resist earthquake force. The magnitude of damage to buildings and resultant loss of life are largely attributed to structural vulnerability and non engineered construction practice.
The current paper made an attempt to examine seismic vulnerability of Ramnagar Urban centre considering building age and maintenance. To fulfil the purpose on site seismic vulnerability assessment through Rapid Screening Process (RSP) modify version of FEMA, RVS (Rapid Visual Screening) methodology for primary data collection. For calculation the damage modified FEMA scoring and EMS 98 is used. The result show a close relation between building age and seismic vulnerability score. Based on the final score ward no 3 scored the highest in vulnerability of Grade 5. Out of total 55.5 percentage of the building are observed to fall in category 5 damage. The study highlight the poor maintenance and building age are the main reason enhancing vulnerability of the surveyed building.

Keywords: Uttarakahnd, himalaya, rapid screening process (RSP), seismic vulnerability, building age

Introduction
Indian sub continent is prone to multi hazards. North Indian plate continues subduction beneath the Eurasian plate results collision of these continental plates (Dewey, 1989) [4]. The tectonic movement result in upliftment, deformation and accumulating strain energy, Constant movement of plates, deform rocks during stress result generation of large of strain energy (Bilham R.G, 2001) [3].
The Indian landmass after its fragmentation from Gondwanaland is moving beneath Eurasian plate at the rate of 37–40 mm/ year. This motion can generate earthquake greater than M~8.0. Distinct geological structure is responsible for inhomogeneity in Himalayan seismicity and responsible for number of seismic gaps in Himalayan seismic belt (Kumar, 2019) [5]. According to seismic zoning map, 59 percentage of Indian continents is prone to high to moderate earthquakes. The existence of Main Central Thrust (MCT), Main Boundary Fault (MBT) result in zonal compacting in the area resulting into timely earthquakes. Indian Himalayan region is seismically active and have witness four earthquakes in past 200 years, 1897 Western Assam, 1905 Kangara (Ambraseys, 2000) [1], 1934 Bihar–Nepal (Bilham R, 1995) [2] and 1950 Eastern Assam, central Himalayan region earthquake of 1803 Garhwal region (Rautela, 2015) [9] (Thakur, 2006) [13]. The seismicity of Himalayas can be classified into four zones as: 1) Kashmir-Himachal Himalayas; 2) India West Nepal Himalayas; 3) Nepal-Sikkim Himalayas; and 4) Northeast India- Burma Himalayas.
Growing urbanisation in Himalayan region a reason to concern. Morphology bring change in land use pattern. The study area is located in Himalayan Foothill region making it a gateway to the Garhwal and Kumoan region. The region has gain and losses in each category between the year 1990 and 2010. In case of a single such future great event in the Himalayan region, quantitatively estimated potential losses of 150,000 human lives and more than 300,000 will be injured and ~3,000 settlements will be affected. This estimated human loss shows if such event occur around the Kathmandu the loss will be 21–42 thousands and number of injured may cross 45–86 thousands (Paudyal H., 2012) [6, 7].
Structure vulnerability result in seismic risk of the built environment. Thus assessing vulnerability of building become important, assist in taking mitigation measurement an dris reduction exercise. Rapid urban growth have concentration to high population and unplanned built environment posing threat to both infrastructure and population. Non engineered building practise, lack of hazard awareness and risk associated give much region to assess the vulnerability of building in seismic active zone.

Study area
The study area i.e, Ramnagar town extends between 29°20′13″N and 29°24′42″N latitudes and 79°04′15″E and 79°08′22″E longitudes in district Nainital of Uttarakhand state. Ramanagr is under Nagar Palika Parishad. The town is located in foothill of Himalayas (locally called as Bhabhar). The town drained by *Kosi* river.It is a ninth–order non-graciel river and has a catchment area (about 738 km2) cover about 45% area of the Kumaon Himalaya mountain region (Pradeep, 2017) [8].
Its foothill region encompasses an area of 64.82km2. The

average elevation lies between 303m above mean sea level which varies between 271 m in south and 419 m at extreme north The foot hill zone have a total population of 54787 according to the 2011 census of India. The town population density is 22546 person per km2. The town is gateway to western Kumaon and Garhwal region of state. Being located in foothill region of Himalayas Ramnagar town falls under seismic zone IV. Himalayan Frontal Thrust (HFT) separating Siwalik from Bhabhar zone (Shefali, 2009) [11]. HFT pass through Ramnagar also characterised with Traverse faults in the region. Figure 1: map showing passing fault line in Ramangar town



Source: Jayangoandaperumal, R, Thakur, V.C, V. Joevivek, V, Rao P.S Gupta, AK (2018)

Fig 1

The study region have 15 wards out of which 06 wards are surveyed. Surveyed ward were categorised using statistica software to categories 15 wards into 6 major groups followed by surveying single ward from each group. Ramnagr is a tourist destination providing employment options attracting large population to migrate from near by mountains. The 2001 census gives a population of 46205 and in census of 2011 the population increase to 54787. A Sharpe rise of 18.57 percentage can be witness, therefore rise in unplanned non seismic resistant built up area. the seismicity of the region is associated with northward drifting of Indian plate and interaction with Eurasian landmass. Research articles show 85 % of total earthquake of Himalayan region are within top 40 km whereas 10 percentage show focal depth ranging from 40 to 70 km depth (Paudyal H, 2012) [6, 7]. According to seismic zoning map of India Ramnagar town is located in Zone IV. This stands for a high seismic hazard, where maximum damage during an earthquake may be up to MSK Intensity VIII.

Methodology

India have withstand many devastating earthquake during recent time and it has demonstrated the need to assess the seismic vulnerability capable to predict the consequences. The chief contributor to the damage and injuries to people are manmade engineered and no engineered buildings. Vulnerability Atlas of India state 11 million people houses in seismic zone V, 50 million for seismic zone IV, an estimate figure of 80 million buildings units in India are seismic vulnerable. The greatest challenge will not only be rehabilitation of these building units but also to reduce human loss and property damage. Also to evolve an accepted methodology in Indian context to quantify structural vulnerability of existing building structure. A modification of FEMA RVS is done by Agarwal Kr. shailesh and Chauhan Ajay in Indian context (Shailesh Kr. Agarwal & Chourasia). It propose an approach to estimate seismic vulnerability of existing building structure in Indian context. The quantitate approach take into account demand capacity while qualitative approach estimates structural score based on national and international sate of art procedure, Rapid Screening Procedure (RSP). Rapid screening process identify structural vulnerable of building without getting into detail analysis. RSP methodology starts with identifying Primary Structural lateral load resisting system and material of building. the method generate a Structural Score "S" consist of series of "score" and modifiers based on building attributes that can be identify during survey. The Structural Score'' S'' is associated with building sustaining life-threatening damage should a earthquake occurs in the region. A low S suggest building is vulnerable and need further detail study, where as a high score suggest building is probably safe. The expression is:

S (structural score) = BSH (Basic Structural Hazard) + PMFs (Performance Modification Factors)

This BSH reflects the estimated likelihood of a typical building of that category sustaining major damage given its seismic environment. ATC-21-1988 and ATC-21-1-1988, presents BSH for various building types applicable to state of California. These scores have been suitably modified in Indian context, based upon 1997 Jabalpur earthquake damage survey data. These values have been determined so that the seismically good building has a high value, and a potentially weak/hazardous building has a low value.

The BSH scores estimated for Type-A, Type-B, and Type-C are 2.0, 2.5 and 3.0 respectively.

In order to arrive at final structural score 'S' for the building under review, a series of ''Performance Modification Factors (PMFs) are subtracted from BSH''. The score have been suitably modified in Indian context, and categorised Indian structures as (i) TYPE A reinforced concrete (RCC) with unreinforced masonry infill walls (ii) TYPE B unreinforced masonry building (URM) and (iii) TYPE C Building made of GI sheets, thatch and other light material (Sinha, 2004) [12], assigned BSH score of 3.0, 2.5 and 2.0. PMF.

These PMFs factors include such as high rise, quality of construction, vertical & plan irregularities in the structural system, soft storey, pounding, cladding, soil/ground condition and ambience that can negatively affect a building's seismic performance or adequacy. These PMFs (Table-1) were assigned values based on judgment such that when subtracted to BSH, the resulting modified score would approximate the possibility of major damage.

Table 1: Performance Factors (PMF) score

Parameters	Specification/ Boundary	Modification Factor
Number of Stories	< 2	0
	2 to 5	-0.15
	> 5	-0.5
Minimum gap between adjacent building	< 100 mm per storey	-0.2
	Otherwise	0
Building site located	Hill top	-0.2
	High slope of hill	-0.15
	Mild slope	-0.1
	plain	0
Building location	Isolated	0
	Internal	-0.1
	End	-0.15
	Corner	-0.2
Soil Type	Rock/Had soil	0
	Medium soil	-0.1
	Soft soil	0.25
	Reclaimed/Filled soil	0.2
	Partially filled soil	0.15
	Loose sand	0.3
Roofing Material	RCC Slab	-0.15
	Tiles	-0.25
	Gi Sheets	0
	Asbestos sheet	-0.1
	Wooden building	-0.25
Parapet	Secured	0
	Not secured	-0.2
Re – entrant corner	≤15%	0
	> 15%	-0.25
Regularity/irregularity in elevation	Regular	0
	L – shaped	-0.3
	T – shaped	
	shaped	
Soft storey exist	Yes	-0.3
	No	0
Heavy mass at top	Yes	-0.25
	No	0
Construction Type	Engineered	0
	Non -Engineered	-0.2
Building Construction Quality	High	0
	Medium	-0.1
	low	-0.2
Building condition/ maintenance	Excellent	0
	Good	0
	Damaged	-0.1
	Distressed	-0.2
Overhang length, balcony (in m)	< 1.5	0
	> 1.5	-0.2
Plan Irregularity	Symmetric	0
	Asymmetric	-0.25

Source: *Grisih Chandra Joshi, Shailesh Ghildiyal, Piyoosh Rautela 2019* [9]

Damage Grade

In an event of earthquake the damage to structures has been categorised under different grades depending on the seismic strength of the building. For assessing vulnerability of the building units scores assigned to various surveyed constituents of the building units (BSH and PMF) are integrated and vulnerability of the structures is classified into five caotegories based on final Structural Score (S); < 0.80 = Grade 5, 0.81–1.60 = Grade 4, 1.61–1.80 = Grade 3, 1.81–2.00
= Grade 2 and > 2.00 = Grade 1 (Shailesh Kr. Agarwal & Chourasia)

The damageability of structure have been recommended by European Macroseismic Scale (EMS-98) are used as: Grade 1 for Negligible to slight damage (No structural damage, slight non-structural damage), Grade 2 for Moderate damage (Slight structural damage, moderate non-structural damage), Grade 3 for Substantial to heavy damage (moderate structural damage, heavy non-structural damage), Grade 4 for Very heavy damage (heavy structural damage, very heavy non-structural damage) and Grade 5 for Destruction (very heavy structural damage).

Finding and discussion

Different building sustain different level of damage depending on their inherent characteristics. The dominating class is Type B unreinforced masonry building (URM). Out of total 81 surveyed building 50 (61.7 percentage) and Type A reinforced concrete (RCC) 31 (38.3) type of buildings are found. It has been observed that the surveyed ward scored highest damage grade 5, maximum building are either damaged or in distressed condition, the result found that 45 building are in very high damage (55.5 percentage), High 33(40.7percentage), medium 2 percentage) and low 1 (1.23 percentage) of damage grade. Therefore, it can be understand that these building will suffer serious damage in an seismic event. The structure age is a factor to consider vital in visual screening process, it has been found in the ward that building has a wide variation from oldest to newest The result show 40 (49.3 percentage) of the building stock to be 40 years of age, 20 (24.7percentage) to be 20 years old followed by 9 (11.11 percentage) being 60 year of age and 12 (14.8 percentage) of building stock to be above 80 years. Age of building and its maintenance go along each other, it was observed that most, age Detroit building and lack of maintenance result in structure deteriorated condition, its performance in an seismic event.

Building height, its number of stories and plan dimension determine building fundamental natural period. In Ramnagar town, out of total 25 (30.8 percentage) are single story, 53 (65.4 percentage) are double story and 3 (3.7 percentage) are three stories.

Conclusion

Uttarakhand state location in Himalayas has introduced it with history of seismic events. Recent earthquake events like Uttarkashi (1991) and Chamoli (1999) has caused damage. The major cause of such damage was the poor non engineered building in the region. The vulnerability of Ramnagar ward no 3 to earthquake is very high to high. The increasing population concentration is also an area to concern. The ward also has a high population concentration. The region high concentration for residential building and increasing population, deteriorating building can lead to higher damage and casualties in a night seismic event. Most of the building are non – engineered and awareness among the masses is lacking regarding safe earthquake building practise. Non compliance to building by laws only add to the vulnerability of the region. It is important to be prepare for future earthquake based on the result of the region. Present study shows the earthquake damage scenario, an anticipated critical image of the disaster.

It is recommended to further detail assessment of buildings and retrofitting of damaged building should be operated. Massive awareness programme and strict by laws be made mandatory.

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