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Effects of 2015 Gorkha Earthquake on Residential Buildings in Bhaktapur Municipality, Nepal

[1] Manoj Bakhunchhe Shrestha, [2] Tulshi Laxmi Suwal
[1] Engineer: Armed Police Force, Nepal (Technical Deputy Superintendent)
[2] President: Small Mammals Conservation and Research Foundation (SMCRF), Nepal

***Abstract:* -- The Barpak, Gorkha, Nepal earthquake of moment magnitude 7.8 which shook nearly 1 minute on 25th of April 2015 and its aftershock magnitude 7.3 shook for more than 30 seconds on 12th of May 2015 was catastrophic. Among the 14 severely affected districts, the historical district Bhaktapur was also affected because of compact ancient Newari settlements of improperly maintained much mud mortar buildings. This research was conducted to assess the situation and the impact of the catastrophic earthquake on the communities of study sites by numerous field visit, secondary data and PRA. There were 17,698 numbers of houses in Bhaktapur municipality in which 5,950 houses were completely damaged and 2,092 were partially damaged. Similarly, Earthquake killed 252 people and 397 were injured badly. In addition, 116 monuments were damaged where 67 were completely damaged and 49 suffered from partial damages including centuries-old buildings of UNESCO World Heritage Sites in Bhaktapur Durbar Square. Out of 865 houses, 53.33% buildings were of Adobe plus Mud joint typology whereas 8.68%, 14.43% and 23.55% were Adobe plus Brick in Cement, Brick in Cement and RC Frame buildings respectively. They were analyzed by using SPSS and R software. Based on different four damage characteristics; Adobe plus Mud mortar buildings were 28.65 times more damaged than RC Frame. Similarly, 12.5 times of Adobe plus Brick in Cement and 8.2 times of Brick in Cement were seen more damage than RC Frame typology. Therefore, people should construct new houses and retrofit of damaged buildings by the supervision of engineers to preserve historical and cultural iconic view. Strict implementation in a proactive way of building bylaws and building code is necessary by both house owners and concerned authority.**

***Index Terms*: - Buildings, Catastrophic, Earthquake, Heritage.**

I. INTRODUCTION

1.1. Background

Bhaktapur is the ancient Newari city which literally refers to "place of devotees" and also called as 'Khwopa' in local, Nepal Bhasa language. This city was the capital of Nepal from 12th to 15th century during the Malla Kingdom, the period when the present Bhaktapur city got its outline. Since its history dated back to numerous centuries, it is full of historical monuments which displays the Newari traditional art and architecture, pagoda styled temples full of wood and stone crafts alongside the residential buildings rich with traditional windows and other wood crafts thus it is enlisted in the World Heritage Site by UNESCO. Juju Dhau (special type of curd), Haku Patasi (newari black saree with red border), Pottery are the uniqueness of the place. It is an ancient city with preserved courtyards which attracts the tourist. Tourism is the main income sources of the Bhaktapur. In contrast to the preservation, the core area of the municipality is highly vulnerable to the earthquake and other disasters due to very congested unplanned, adobe, traditional type old buildings, narrow roads and unreinforced masonry and non-engineered type. Nepal is one of the most vulnerable countries to the impact of the disaster and ranked 11th in the earthquake-prone country in the world [1]. Three earthquakes greater than magnitude 6 have occurred within 250 km of the 2015 earthquake within the 100 years [2]. The aftershocks of Gorkha earthquake is still continuing and till 21 September, 2017 there were 487 numbers aftershocks greater than 4 local magnitude has occurred [3]. The earthquake, 2015 killed 8,773 people and fully damaged 2,638 government houses, 505,577 private houses, 392 public health facilities, 32,145 classrooms in Nepal [4].

1.2. Building Construction Practices

Unreinforced brick masonry buildings are found in most of the areas in Nepal. A typical older Newari house is composed of thick brick and mud/lime walls, wooden beams with planks to support mud floors, clay tile roofing, wooden stairs and columns which serve as the load bearing system. Newari houses suffered severe damage, particularly in Bhaktapur. Wood deterioration, poor bonding between the mud and brick, and construction of additional floors with heavy roofing might have contributed to the failures of these structures on the 2015

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earthquake [5].Unreinforced Masonry building construction is the predominant building type of traditional residential housing in the old Bhaktapur city. The majority of buildings were built without modern construction codes. In exceptional, many traditional buildings were modified in due time duration. Non–engineered modification such as, cement mortar masonry is built above mud mortar masonry, burnt brick masonry is built above sun-dried brick masonry, Reinforced Concrete (RC) or timber frame structure is built above masonry walls etc. These modifications cause irregularities in elevation, which adversely may limit the structural performance of horizontal actions. Unfortunately, many buildings consist of mixed floors system, i.e. timber joisted floor in lower few storeys, and concrete floors in few storeys above. Many houses have replaced their previous tile or metal roof with RC roof. In additional, non engineered modification carried out is even worst with corresponding to the seismic resistance requirement in Bhaktapur [6]. 26 municipalities are implementing National Building Code (NBC) where Lalitpur was the first that implemented NBC in 2002 in Nepal. However, Bhaktapur municipality has not started NBC implementation till 2014. Most of the indicators except number of fatalities and the fatality per 100 heavily damaged houses, Bhaktapur is much more damaged than two other municipalities of Kathmandu valley. One of the reasons of the damaged character is also related to the NBC implementation period [7]. More than 98 % of the buildings in Nepal are constructed by the owners following the advice of local craftsmen who have no any specific training on seismic safety and adequate information on safer building constructions. Most residential buildings, including urban areas do not receive any rational design for strength. Most municipalities have a system of building permits, but there is poor institutional and technical capacity within the local authorities for implementing strength-related provisions [8].

1.3. Earthquake Disaster in Nepal

The people of Nepal have been living with the vulnerability of earthquake from many generations. The Himalayan mountain range was formed by millions of years of earthquakes as the Indian and Eurasian tectonic plates have continued to push against one another at a relative rate of 40-50 mm per year. A large amount of that motion is driving the uplift of the Himalayan Mountains. The boundary region between these two plates has a history of large and great earthquakes, making it one of the most seismically hazardous regions in the world. Fig. 1 shows the locations of slip during Gorkha earthquake and its main aftershock ruptures [2].

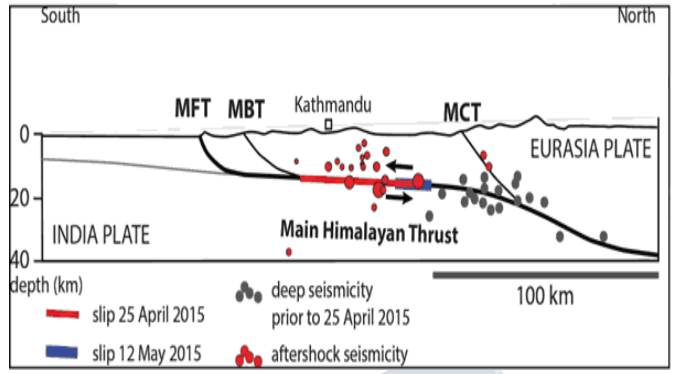

Fig. 1. Main and Aftershock Ruptures Locations

Nepal has a regular interval of occurrence of earthquakes along the major active faults in east-west alignment. Historical data and seismological studies have indicated that the entire region of Nepal is prone to earthquake and it lies in the active seismic zone V. Evidence shows that the seismic pattern geographically divided into three clusters of events that are western, central and eastern Nepal. It has also pointed out that Siwalik, lesser Himalaya and frontal part of the higher Himalaya are the most vulnerable zones. Historical data has shown that the country witnessed three major earthquakes in the 20th century, namely Bihar-Nepal 1934 earthquake, Bajhang 1980 earthquake and Udayapur 1988 earthquake [9]. A total of 92 active faults has been mapped throughout the country. In 1934 AD earthquake produced strong shaking in Kathmandu Valley, and destroyed 20 percent and damaged 40 percent of the valley's building stock [10]. Gorkha earthquake damaged lot of non engineered buildings in most part of municipality like as shown in Fig. 2. Damages along the longitudinal section of Koteshwor - Suryabinayak road section at Kausaltar (Fig. 3) was seen more and in some parts 600 mm uplift was also clearly visible at Kausaltar. Rescue operation, relief distribution and debris management was done effectively by security forces of Nepal in coordination with other countries (Fig. 4) after the earthquake.

Fig. 2. Collapsed RC Frame Buildings at Bhaktapur -17 due to aftershock on 12th May 2015

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Fig. 3. Damaged road at Kausaltar, Bhaktapur

Fig. 4. Rescue and Debris Management by Indian Army at Bhaktapur (Source: Nepal Army)

II. MATERIALS AND METHODS

2.1. Study Area
Bhaktapur Municipality covers 6.88 sq.km areas and located about 13 km from the capital city of Kathmandu. Among 17 wards, six wards: 1, 2, 9, 10, 16 and 17 (Fig. 5) were selected in which 16 and 17 were growing with new construction and remaining 4 wards were congested old habitat.

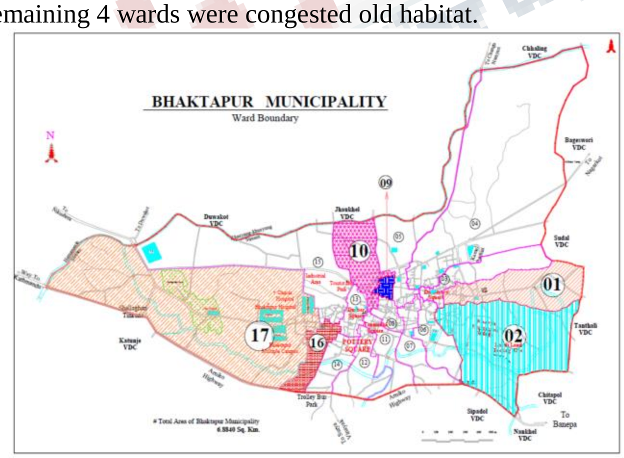

Fig. 5. Map of Study Area

2.2. Methods
2.2.1. Primary Data
Primary data were collected by Focused Group Discussion (FGD) and Key Informant Interviews (KII) with local residents and municipal staffs. Damages of buildings were closely observed instantly after 2-3 hours of earthquake and later on visited numerous times. For the convenience of the study purpose buildings were categorized as follows:

i) Adobe plus Mud Joint
The structures constructed with sun-dried or chimney made brick masonry and those which had purely mud mortar only were taken on this category. Generally, these types of structures were found in every ward of the municipality. This type of buildings in Bhaktapur municipality had generally 3 to 4 stories and somewhere up to 6 stories were seen. Clay tiles were mostly used for roofing and found the main wall thickness of 18 inches to 24 inches.

ii) Adobe plus Brick in Cement
The structures constructed with sun-dried or burnt brick masonry with mud mortar which were later on modified in the due duration of time in upper floors with burnt brick masonry with cement mortar were categorized on this type.

iii) Brick in Cement
The structures constructed with burnt brick masonry with cement mortar only as load bearing structure falls under this category.

iv) RC Frame
The structures constructed with frame structure consisting of concrete and reinforcement fall on this typology. Masonry partition and infill walls (brick, block or stone masonry) were other non-structural components. Infill walls were not tied to the frame and slab consist of reinforced concrete in these structures.

2.2.2. Secondary Data
Secondary data were collected in association with post-disaster Earthquake damage (Rapid Evaluation Safety Assessment) buildings data from Nepal Engineers' Association (NEA) for exploring the technical damages of different building types.

2.3. Data Analysis
The secondary data were classified, tabulated and managed with the help of the Microsoft-Excel and SPSS software then verified by R software. Damage evaluations were categorized under the following four conditions:

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Collapsed, partially collapsed or moved off its foundation
Plumb out of buildings or in any story
Damage to primary structural members, cracking of walls or other signs of distress present
Parapet, chimney or other falling hazard

All the above four conditions were further categorized under the following seen damage situations of buildings [11]:

a) Minor or None damage

Masonry buildings: Hair-line cracks in very few walls and fall of small plasters. RC buildings: Fine cracks in plaster, partitions and infill walls.

b) Moderate damage

Masonry buildings: Cracks in many wall, fall of fairly large pieces of plaster. RC buildings: Cracks in walls, columns, beams and fall of brittle cladding or plaster.

c) Severe damage

Masonry buildings: Extensive cracks and failures of most walls with roof tiles detach.

RC buildings: Large cracks in columns, beams, joints, walls and buckling of reinforced bars, collapse of few columns or upper floors.

III. RESULTS

3.1. Building Typology

The majority structures were of Adobe plus mud mortar joint type in almost all wards which were more vulnerable to earthquake. Non-engineered modification of Adobe type, i.e. Adobe plus Brick in Cement structures were also found relatively. Brick in cement typology were also found in a well manner, whereas earthquake resistant RC frame structures were seen lesser in aggregate (Figure 6).

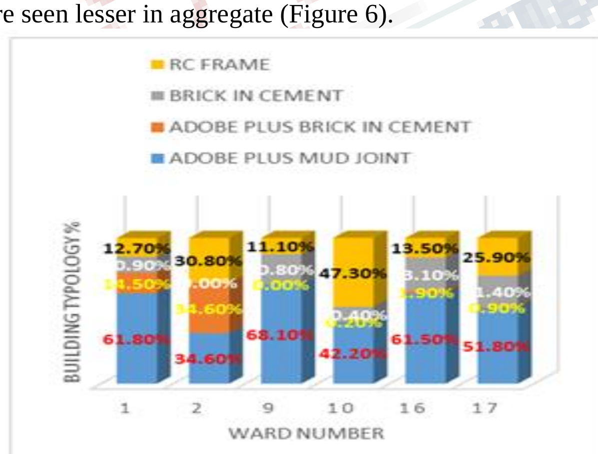

Fig. 6. Building typology in different wards

3.2. Damage evaluation

3.2.1. Collapsed, partially collapsed or moved off its foundation

Large numbers of buildings in Bhaktapur municipality were without RC frame structures which were very vulnerable to earthquakes. Severe and moderate damages to the structure of buildings order shows that Adobe plus mud joint is much higher than rest of all, then lower in order are Adobe plus brick in cement, Brick in cement and finally RC frame structure (Table 1). The result was obvious because of structural behavior according to seismicity.

Table 1

Collapsed, partially collapsed or moved off its foundation.

Building Typology	Minor/None (%)	Moderate (%)	Severe (%)	Total (%)
Adobe plus Mud Joint	50.4	27.4	22.3	100
Adobe plus Brick in Cement	75.0	15.0	10.0	100
Brick in Cement	86.8	7.9	5.3	100
RC Frame	96.5	1.9	1.6	100
Total	72.7	15.1	12.1	100

3.2.2. Plumb out of buildings or in any story

On this buildings plumb out category, severe and moderate damages to the structure of buildings order shows that Adobe plus mud joint (24.2%) is much higher than rest of all. Then lower in order are Adobe plus brick in cement, Brick in cement and finally RC frame (0.6%) structure as shown in Table 2. This result shows RC frame structure is far better than any other typology while mud joint structures obviously shows weak bonding characteristics.

Table 2

Plumb out of buildings or in any Story.

Building Typology	Minor/None (%)	Moderate (%)	Severe (%)	Total (%)
Adobe plus Mud Joint	43.6	32.2	24.2	100

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Adobe plus Brick in Cement	75.0	15.0	10.0	100
Brick in Cement	76.3	14.9	8.8	100
RC Frame	96.5	2.8	0.6	100
Total	68.1	18.7	13.2	100

3.2.3. Damage to primary structural members, cracking of walls or other signs of distress presents

Similarly, in case of damage to primary stuctural members as per analysis data on Table 3, severe damage to the wall or primary structural member was seen more in Adobe plus mud joint (51.3%) because of the non-resistant capacity of mud mortar buildings and less seen (1.9%) in RC Frame structure.

Table 3

Damage to primary structural member, cracking of walls or other signs of distress presents.

Building Typology	Minor/None (%)	Moderate (%)	Severe (%)	Total (%)
Adobe plus Mud Joint	27.4	21.3	51.3	100
Adobe plus Brick in Cement	50.0	30.0	20.0	100
Brick in Cement	63.2	21.9	14.9	100
RC Frame	88.4	9.7	1.9	100
Total	55.0	17.3	27.6	100

3.2.4. Parapet, chimney or other falling hazard

Severe damage to parapet, chimney or other falling hazard was seen more in Adobe plus mud joint 21.8% and less in RC frame structure 0.9% due to its good resisting behavior against earthquake (Table 4).

Table 4

Parapet, chimney or other falling hazard.

Building Typology	Minor/None (%)	Moderate (%)	Severe (%)	Total (%)
Adobe plus Mud Joint	58.1	20.1	21.8	100
Adobe plus Brick in Cement	75.0	10.0	15.0	100
Brick in Cement	84.2	7.0	8.8	100
RC Frame	93.4	5.7	0.9	100
Total	74.9	12.8	12.3	100

IV. DISCUSSION

4.1. Damages on Adobe plus Mud joint buildings

The overall result shows that building typology of Adobe plus Mud joint had exhibited more damage characteristics than the other building typology. Adobe plus Mud joint buildings have mud mortars which has weak bonding nature than other mortar. The seismic resilient capacity of this type of structures is low due to lack of integrity of structural components, the strengths of the wall and the lack of elements tying the structural component. The main reasons for damages in the study area were due to age of the buildings and non-engineered traditional building typology. Other reasons for huge destructions on Adobe plus Mud joint building typology were due to lack of joist, ties and latches in different parts of buildings, and also those buildings which had generally four to six stories (Fig. 7). For the Adobe plus Mud joint buildings, the increase in stories is proportional to the risk of damages due to the earthquake. Another reason was due to unsymmetrical nature of buildings for more damages. No proper maintenance and pre-retrofit of such buildings were done to minimize the losses due to the earthquake disaster. The face of buildings which were not in plumb and were easily visible with naked eyes could easily be spotted in the municipal areas before earthquake and still. It was also revealed that poor workmanship might be the one of the causes of damages. Some of such buildings foundation depths were found with just 1-2 feet which is inadequate to resist axial load as well as dynamic load during earthquake as revealed on the focused group discussion. The thicknesses of upper walls were comparatively found to be less than those of ground floors which were seen more damaged in the locality. Another reason for the cause of more damage, i.e. full open spaces in upper stories with no partition walls, only the boundary skin walls on the periphery. In addition, the topography of the locality also played the role to increase in the damages of the buildings in certain area like Sano Byasi and Golmadhi in comparison to other locality due to its sloppy terrain topography. The more damages were also because of the more dampness on that locality which made weaker the structure due to course in Adobe and Cemented Load bearings wall buildings. As from FGD in ward number 1, the damaged buildings by earthquake in 1934 were renovated and constructed only from above the foundation, which was also the main cause of more destruction. Some parts of ward number 16 also lies in sloppy area where the extensive damage can be witnessed. Despite the huge damage in mud mortar buildings the World Heritage Nyatapolan (five story roof) temple had experienced very less damage. Only some bricks were spilled out at the fifth floor. The low damage of the Naytapolan (Fig. 8) is mainly due to its flexibility behavior of timber, workmanship and of course the center of gravity (CG) of the structure also.

Fig. 7. Damages seen at Jellan, Bhaktapur.

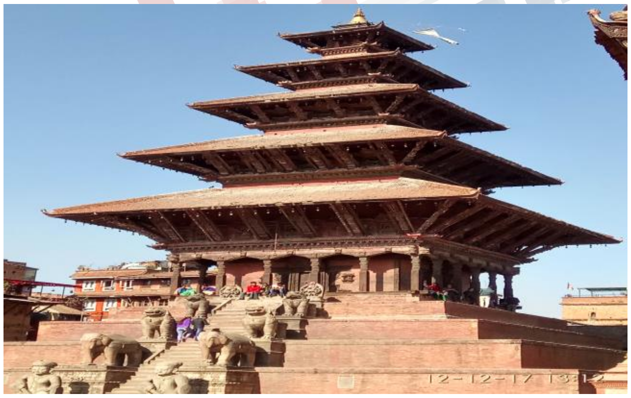

Fig. 8. Minor Damages in the World Heritage, Naytapolan.

4.2. Damages on Adobe plus Brick in cement buildings

Adobe plus Brick in cement does not behave uniformly on seismic activity because of partially behaving non-rigid on below part and behaving partial rigid behavior in upper parts treating as complex in nature. These types of non-engineered modification cause irregularities in elevation which adversely limits the structural performance to axial loadings and the maximum stresses are induced in ground floor having mud mortar and obviously, they cannot bear the stresses (Fig. 9). This type of construction generally done by the house owners when their income rises, later on, due in the course, even some house owner made rigid floors and roofs too.

Fig. 9. Hanging Non Engineered Modification house (Source: BM).

4.3. Damages on Brick in cement buildings

It was seen that the damage grade was seen lesser than that of Adobe plus Mud joint and Adobe plus Brick in cement (Fig. 10). Most of this typology had rigid floor with rigid roof. And with no doubt, these buildings bonding capacity which uses burnt brick is much higher than mud mortar. The burnt brick strength is obliviously much more than Adobe sun-dried bricks. Mostly those buildings have also RC beams which intact the whole structure in different levels. The structural performances were also not purely adequate on this typology. In the study area, these typologies were not old in age as compared to mud mortar buildings.

Fig. 10. Damaged Brick in Cement building.

4.4. Damages on RC Frame structure buildings

RC Frame structure buildings are the modern new advanced technology in the construction field. Structural analysis was done on this type of buildings by professional engineers considering earthquake building codes and other structural detailing in depth. In the municipality, in the recent years, the newly constructed buildings adopted this typology. Thus, the RC Frame structure buildings in the municipal area were seen fewer damages due to the strict implementation of building bylaws which were regulated from 2003 in compiled form and was amended in subsequent years. Set back, Floor Area Ratio (FAR), the heights of the buildings were strictly regulated and if tolerated demolition were also done by the municipality. Stepwise building permits process like in the first stage field observation by ward overseer was done, then municipality overseer/engineer verified it, then after permission was granted to build for up to ground floor. In second stage field verification was done by field inspectors and municipality overseers then if ground floor was completed correctly as per drawings and permit will be issued for the construction of upper floors. Finally, the completion of the building was given by field verification again. There were two ward inspectors who had a duty of regular visiting of any construction in that ward and if any irregularities were seen in construction from initial starting phase to the completion phase, the owner was warned and notified by official letter to correct the irregularities. Building code was fully implemented from August 17th 2014 prior to 8 months of the catastrophic earthquake that shook Nepal in 2015. House owner had used horizontal bands such as sill bands, lintel bands, and roof bands on infill walls on their efforts to build earthquake resistant buildings. They had also constructed the lower tie beams for earthquake safety. So, in spite of non implementation of building codes by municipality till August 17th, 2014, most of the new house owner had constructed earthquake safety provisions which results in lesser percentage of damages in RC frame than other structures. Fig. 2 and Fig. 11shows the sever damages on RC frame structures mainly due to non-engineered design and lack of technical supervision and monitoring during construction phase.

Fig. 11. RC frame 2nd floor collasped at Jagati, Bhaktapur.

V. CONCLUSION AND SUGGESTIONS

Damages degree in all categories shows Adobe plus Mud joint buildings were found much more than another typology. Second in damage order Adobe plus Brick in Cement, then in third Brick in cement and finally, RC Frame structure as per the research carried out. Bhaktapur is the old historical and cultural city so it cannot be purely modernized replacing the old buildings with new modern technology and retrofitting. Thus demolition and maintenance of the old building in the name of modernization will not be appropriate and suitable. Therefore, the followings are our suggestions:

- The outlook of the buildings in core area should be preserved traditionally even if RC frame structure building construction is done.
- Old buildings with minor damaged should be well retrofit and should be properly supervised by the engineers.
- The house owner should consult with engineers while designing and regularly be monitored during construction.
- Building bylaws and building code should be strictly implemented. The municipality should do regular monitoring and supervision of the construction.

- The municipality has to organize the training program regularly to engineers, masons, and other stakeholders to alert about bylaws, code and the building permit process.

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REFERENCES

- UNDP, (2011). Comprehensive Disaster Risk Management Plan. Kathmandu, Nepal: United Nations Development Programme.
- USGS, (2015). The M7.8 Nepal Earthquake, 2015 – A Small Push to Mt. Everest. United States Geological Survey(USGS): https://earthquake.usgs.gov/research/everyone/nepal2015/ [Accessed on Nov 28, 2016].
- http://www.seismonepal.gov.np/index.php?listId=161 [Accessed on Dec 12, 2017].
- MOHA, (2015). Nepal Disaster Report 2015. Kathmandu, Nepal: Ministry of Home Affairs (MOHA). Available at: http://drrportal.gov.np/uploads/document/329.pdf [Accessed on Nov 25, 2017].
- Shakya, U., Blaisdell, M. and Fleischman, R. (2016). Challenges and Possible Solutions for Building Back Better in Nepal. In: Khwopa Engineering College and Khwopa College of Engineering, International Conference on Earthquake Engineering and Post Disaster Reconstruction Planning. Bhaktapur, Nepal, 24 – 26 April, 2016.
- Shakya, M., Duwal, S. and Kawan, K. (2016). Rapid Visual Damage Assessment of Masonry Buildings after 2015 Gorkha Earthquake: A Case Study of Bhaktapur Municipality. In: Khwopa Engineering College and Khwopa College of Engineering, International Conference on Earthquake Engineering and Post Disaster Reconstruction Planning. Bhaktapur, Nepal, 24 – 26 April, 2016.
- Ando, S. (2016). National Building Code and Damage Analysis of the 2015 Nepal Earthquake. In: Khwopa Engineering College and Khwopa College of Engineering, International Conference on Earthquake Engineering and Post Disaster Reconstruction Planning. Bhaktapur, Nepal, 24 – 26 April, 2016.
- Dixit, A. M. (2004). Promoting safer building construction in Nepal, 13th World Conference on Earthquake Engineering (WCEE). Canada, 1- 6 August, 2004.
- MOHA, (2016). Risk Profile of Nepal 2015. Kathmandu, Nepal: Ministry of Home Affairs (MOHA). Available at: http://drrportal.gov.np/risk-profile-of-nepal [Accessed on Dec 12, 2017].
- NSET, (1999). Kathmandu Valley's Earthquake Scenario. Kathmandu, Nepal: National Society for Earthquake Technology (NSET).
- NSET, (2009). Seismic Vulnerability Evaluation Guideline for Private and Public Buildings (Part ll: Post-Disaster Damage Assessment): National Society for Earthquake Technology (NSET).
- Shrestha, M. B., Tamang, K. K., Suwal, T. L. and Mishra. A. (2017). Perception Regarding Security Forces Involvement in Post Gorkha Earthquake Scenario 2015, Nepal: International Journal of Emerging Technologies and Innovative Research, ISSN:2349-5162, Vol.4, Issue 10, page no. pp23-31, October-2017, Available at: www.jetir.org & http://www.jetir.org/JETIR1710003

AUTHORS BIOGRAPHIES

Manoj Bakhunchhe Shrestha: He is the Gold Medalist of Master's Degree in Construction Management from Nepal Engineering College (2016), Pokhara University. He has completed Diploma in Electrical Engineering (1996) and Bachelor in Civil Engineering (2000), from Pulchowk Campus, Tribhuvan University. He has experience as a lecturer in Khowpa Engineering College, Bhaktapur. Currently, he is Deputy Superintendent (Technical) in the Armed Police Force, Nepal.

Tulshi Laxmi Suwal: She is an ecologist and at currently working as a President in Small Mammals Conservation and Research Foundation (SMCRF), Nepal. She has completed her Master degree in Zoology (Ecology and Environment) from Tribhuvan University. She is the energetic and enthusiastic researcher, working closely with community and conducting awareness program. Similarly, she has more than 10 years of teaching experiences.