SEISMIC VULNERABILITY ASSESSMENT OF PUBLIC RC FRAMED BUILDING

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ABSTRACT

The existing structures built in seismically vulnerable regions at different times need to be assessed in view of the changing codal provisions. The various buildings owned by Government of Nepal and located in different parts of the country are the subjects of seismic assessment. Of the many buildings, one of them selected for a detailed assessment in the study at Kathmandu the capital of Nepal which is situated in prone zone of seismic vulnerability. The building is categorized as frame structures, built in different time with different modes of design and supervision. The building is analyzed with a 3D model using ETAB 2018 software for all the possible actions including possible earthquakes. The capacities of different components of the buildings are compared with the response by shifting of components of the buildings and by variation of size of members so as to overcome seismic vulnerability. From the result of the study and observation of structural parameters of the building, it is noted that some of the members are subjected to stresses higher than their capacities making the building vulnerable. For analysis even building consisting shear wall and basement are not analyzed yet releasing partial fixity at bottom of footing which leads error for comparison of vulnerability of such buildings ; this article enhance to recover the errors in analysis.

KEYWORDS: *Seismic Vulnerability Index, Seismic Capacity, Seismic Performance.*

INTRODUCTION

Background

Nepal has been recognized as one of the highly seismically vulnerable region of the world. The seismic activity of the region is primarily due to the neo-tectonic activities and the geo-technical conditions. Earthquakes of smaller & moderate magnitude occur frequently and earthquakes of magnitude greater than 6 occur on average once every 80 years in the region. The last great earthquake of magnitude 8.4 occurred in 1934

In view of the seismicity of the region it is imperative that the structures designed and built shall withstand the ground motion due to possible earthquakes the history of construction of buildings with modern materials including concrete is relatively short. There has been an increasing trend in construction of many official building adopting the available new materials. Many of these buildings constructed in last decades may not have been designed or may not conform to the latest seismic code provisions. As the new knowledge and research in the area have implicated in more stringent provisions in the recent codes of practices, the structures existing are needed to be assessed for their performance during the possible earthquakes.

Earthquakes pose serious threat to life in many regions of the world. It poses engineering design problems in most civil engineering structures and the probability that a major earthquake will never affect any given structure is very low for locations near the boundary of major tectonic plates.

The construction of RC buildings only started after 1980; however, the mushrooming number of RC construction was started only after 1990. Even though the RC construction was started in early 1980s, engineered construction was only felt after enforcement of building codes in 2006 and almost 70 % of existing RC buildings are either owner-built construction constructed with the help of contractors following by-laws or constructed as per the mandatory rules of thumbs as suggested by Nepal Building Code. Smaller fraction of buildings is structurally analyzed, designed and constructed.

The seismic resistance of existing reinforced concrete structures may be inadequate due to weaknesses in the structural system and no ductile detailing. To mitigate the seismic and other natural hazards, existing inadequate or deteriorating structures should be rehabilitated. The evaluation of the seismic resistance of existing structures and their deficiencies is essential before an appropriate repair or upgrade.

A methodology to assess the seismic vulnerability of a building should consider its typology, the scale of the assessment, and resources available (economic and human). The methodology presented herein, based on post-earthquake damage observation and expert opinion, is thought to be a rapid screening approach to aid identifying more fragile and damage-prone buildings in the case of a strong earthquake.

Study Area

The Particular study area taken into consideration is located in Maitighar, Kathmandu,Nepal. The Site is located between 85.3230° E longitude and 27.6920°N latitude.

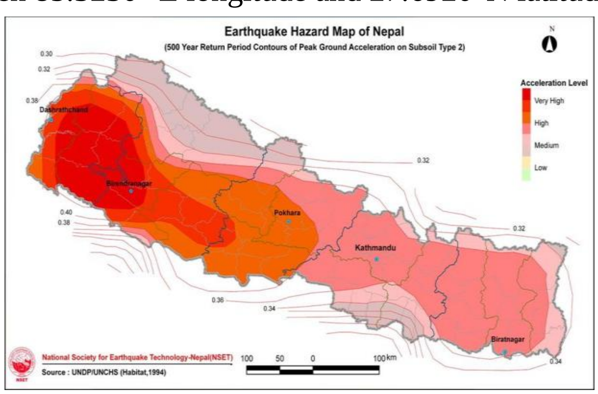


Figure 0-1: Earthquake Hazard Map of the study area

Figure 0-2: Existing Structure, Maitighar, Kathmandu

Need of the Study

Nepal lies in high seismic risk zone. In the Indian subcontinent seismological map, Nepal lies in seismic zone IV & V. the 1934 & 1988 earthquakes in Nepal showed the large scale of damage of the buildings Because of the distribution of the public buildings throughout the country, even may have to be converted into temporary shelter for homeless, medical clinics and other emergency functions following a disaster. However, these buildings are yet to be assessed for seismic vulnerability. A large number of those public buildings are assumed to be unsafe due to their improper seismic design & the lack of regular periodic maintenance. Majority of Public buildings are designed as per earlier codes, Due to the changes or amendments in codes because of the advances in knowledge on earthquake damage leads to the need of assessing the vulnerability of the public buildings.

Research Objectives

The principal objective of the study is to assess the capacity of the Public RC building and to use it to upgrade it and make functional for its purpose, if necessary, for expected performance according to the latest seismic and structural codes and implementing partial fixity in footing of shear walled building. The specific objectives of the study are as listed below:

To determine the seismic vulnerability of the proposed building

To purpose the deficiencies in the building specifically in the structural system and members, like column, beam and foundations

Comparative analysis result of building for story-drift, story-displacement, time period and base shear fluctuation under seismic loading

To work out for necessary strengthening and retrofitting measures:

Scope and Limitations of the study

The scope and limitations of the study are illustrated as follows:

Identification of the buildings representing the principal offices and sampling of the building for analysis.

Detailed analysis according to the prevalent codes, regularities and practices, Identification of weak members of the structure.

METHODOLOGY

Overview

Methodology for this research with the theory and the mathematical formulation of the study. The general outline of the methodology used is given by figure. II -1

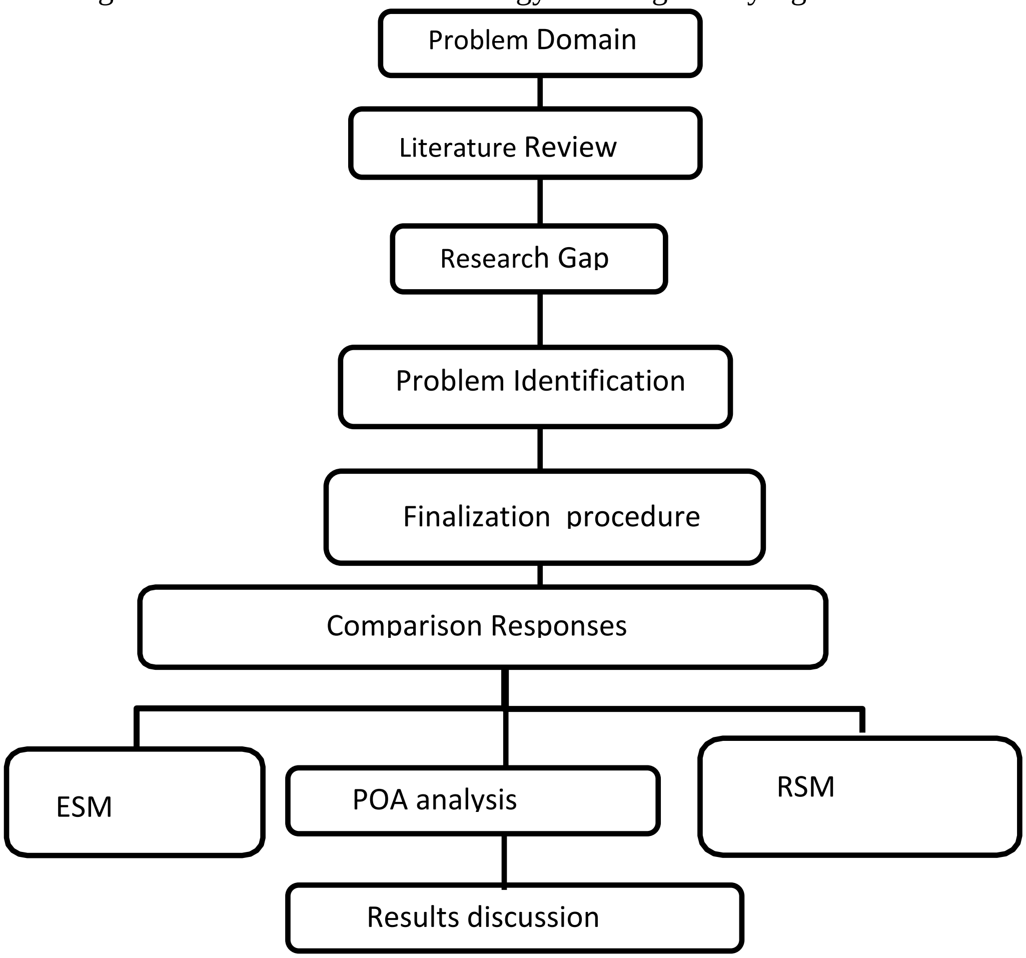


Figure II-1 : Flowchart of research methodolog

Seismic Analysis

Seismic force is an important force to be considered during the analysis of structures, especially for those located in seismic zones. During an earthquake, the ground motion caused due to the movement of tectonic plates underneath the surface also tends to move the structure along with it. But due to inertia, the structure tries to resist these motions. As a result, a shearing force (Base Shear) is imparted to the structure at the base and its acceleration as according to Newton's 2nd law of motion.

The force in the structure due to the dynamic ground motion can be analyzed by two methods.

Static method of analysis.

Dynamic method of analysis.

MODELLING AND ANALYSIS

General features of this model building are given.

TABLE III-1: GENERAL DESCRIPTION OF MODEL BUILDING

SN	Parameters	General Description
1	Type of building	Public building
2	Location	Zone II
3	Structure system	RCC frame structure
4	Plinth area	1441.28 m2
5	No. of story	Basement G+6
6	Floor to floor height	3.9 m
7	Types of Slabs	125 mm thick; Two-way Slab
8	Types of Beams	Rectangular main beam(300mm×500 mm)Secondary beam(230×400mm)
9	Types of Columns	Square(600×600) mm
10	Materials	Cement, Brick, Sand, Rebar etc.

TABLE III-2: RESPONSE SPECTRUM PARAMETERS

SN	Parameters	Input Value
1	Soil Type	B
2	Lower Period of the Flat Part of the Spectrum Ta	0.1
3	Upper Period of the Flat Part of the Spectrum Tc	0.7
4	Peak Spectral Acceleration Normalized by PGA α	2.5
5	Coefficient to control the descending branch of the Spectrum K	1.8

TABLE III-3: CHARACTERISTIC STRENGTH OF MATERIALS

SN	Parameters	General Description
1	Concrete	M20 for slab, M20 for beam, M20forcolumn Alteration will be done to upgrade using M30 in Columns and shear walls
2	Steel grade(fy)	Fe500
3	Methodof analysis	ETABS2018(Equivalent Static and Response Spectrum)

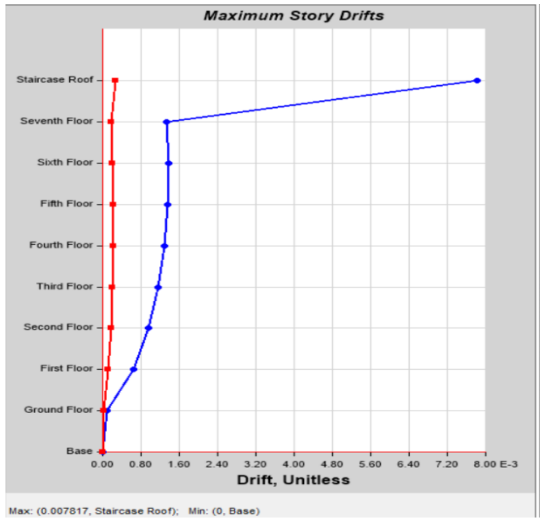
Loadings:

TABLE III-4: LOADS OCCURRING AT THE BUILDINGS IS IDEALIZED AND IS ACCORDING TO TABLE

SN	Parameters	General Description
1	Self-weight of Building	Program calculated
2	Floor finish	1.5 kN/m2
3	Live load	4 kN/m2
4	Partition wall load	1 kN/m2
5	Earthquake Load	As per NBC 105:2020code

Description of Model

Considering a building with B+G+ 6 storey which is in complex shape the analysis is performed using Etabs. Analysis is done using its architectural aesthetic plan with two stiff vertical shear wall and basement wall to optimize seismic vulnerability of the building. The model of the building and its Spectral Acceleration Vs Period is shown below in Figure III-1.



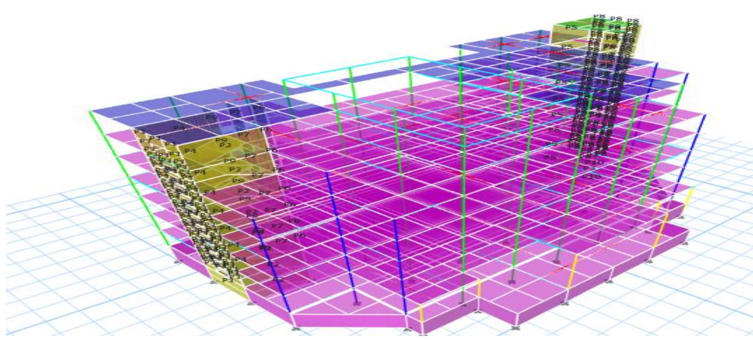


Figure III-1: Consider model for research

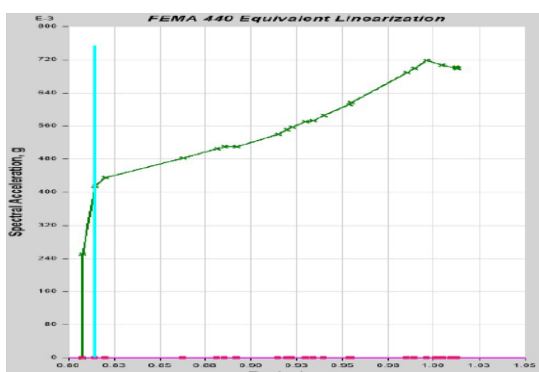


Figure III-2 Max storey displacement

Figure III-3 Max storey Drift

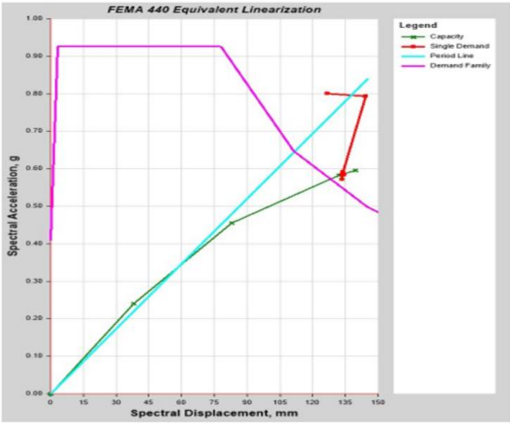


Figure III-4 Pushover curve of model with shear wall

Discussion on Research Gap

As we see many public RC buildings are just analyzed as one sample and same analysis is adopted in various places leading seismic vulnerability and mostly building with shear wall, basement wall are designed without concerning all effects of soil surcharge around buildings of various place. For this proper solution will be illustrated in this paper governing all structural parameters including pushover analysis

Results and Discussion

From this study, it is found that:

Building with shear wall seems more vulnerable without releasing partial fixity in footing.

As per building configuration and storey displacement we may note the max storey displacement in Y- dir is higher value than X-dir. So the building is more vulnerable in seismic response in Y dir. To minimize we may provide lateral shear wall along Y dir.

Storey Drift ratio obtained is higher value in Y- dir than X dir to generating more vulnerability in seismic response in Y dir

The member forces in Y- dir of the building are obtained as higher values than X- dir of building. And increasing reinforcements or section of members along y dir and making column section as rectangular type we may mitigate the seismic vulnerability of the building.

The auto- generation of member forces is also be seen affected by Beam column capacity ratio and diaphragm created by Shear walls in either side of X- direction of building. We may find appropriate location of shear wall so as to minimize seismic vulnerability of the building

CONCLUSION

Seismic vulnerably of complex building with basement and shear wall should be accounted by proper location of shear wall, opening, soft storey creation, beam column capacity.

By treating stiffness along Y dir of the building we may mitigate vulnerability in seismic response in Y- direction of building.

It will not be necessary the variation of column , beam size and rebar percentage if properly maintain diaphragm orientation and location within the building

Building with basement wall is seen to be optimized in various parameters considering soil interaction and springily footing laid in elastic foundation.

Several retrofitting technique will lead minimize vulnerability of building

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