

Evaluation of RC Frame Building under Seismic Loading and Base Isolation

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Abstract— Earthquake causes major loss of life and at the same time they also cause huge economic impact in the regions affected. If we look at the recent earthquake that has occurred in and around the world, one can easily highlight the structural inadequacy to withstand seismic forces. Therefore there is an urgent need for assessment of existing buildings which do not fulfil seismic requirement and suffer severe damage under seismic ground motion and also the new structures to be constructed. The aim of evaluating and assessing such buildings is to make them more seismic resistant with the help of techniques like seismic retrofitting and base isolation. This paper presents nonlinear static analysis technique for performance evaluation of 4-storey reinforced concrete residential building subjected to earthquake loading. The performance of the reinforced concrete building is evaluated in terms of maximum base shear, maximum displacement, performance point and sequence of plastic hinge formation. The building considered for analysis is an existing RC residential building located in Mysore designed only for gravity loads as per IS code. The seismic resistance of the building is determined by performing response spectrum analysis and static nonlinear analysis for uniform loading. The building is found that it has more capacity than demand and permissible displacement in Mysore zone hence it does not collapse. Further the push over analysis is carried out for different types of soils and zones and the performance of the building is studied. Base isolation technique is also adopted for 4 storey building. Comparison of results like base shear, time period have been made between the buildings with isolation and without isolation.

Key words: RC Frame, Seismic Loading

I. INTRODUCTION

“One nation, many worlds” is a term that aptly describes the varied diversity present in India. India is also a country that has witnessed some of the greatest earthquakes that has occurred over the last century. In fact, 50 percent area of the country lies in earthquake prone zones. We all know that the entire Himalayan belt as well as the north eastern part which includes states like Assam, Meghalaya, Sikkim etc. are susceptible to frequent earthquakes of magnitude more than 8.0 which is as evidenced by the recent earthquakes that struck Nepal causing heavy loss to human life as well as economic loss. Hence there is a strong requirement to develop structures that are more earthquake resistant.

After the 2001 Bhuj earthquake special steps/attention was taken to assess the seismic vulnerability of the existing building. Also, a lot of efforts were made and researches were carried out to account for the safety of structures under seismic loading. The seismic building design code (IS 1893, part1) in India was revised in 2002 and suitable amendments were made in this regard. The

magnitude of the design seismic forces has been considerably enhanced in general and the seismic zone of some region has also been upgraded.

The present study focuses on the performance evaluation of the residential reinforced concrete 4 story building located in Mysore and the parameters such as base shear capacity, performance point, formation of hinges and maximum displacement are studied. Further, seismic performance of the building with different zones is studied. Comparison of forces for equivalent static analysis, response spectrum analysis and pushover analysis is made. Also base isolation technique is used to evaluate the performance of the 4 story building using Bhuj earthquake records. Evaluation is done using software ETABS.

II. METHODOLOGY

In this present study an attempt is made to evaluate seismic performance of reinforced concrete residential buildings. Earthquake capacity and demand parameters are evaluated by carrying out pushover analysis as per guidelines of ATC-40(1996) and FEMA document (2002).analysis is carried out using ETABS software for residential buildings. The pushover analysis is typically of displacement control type and default hinge properties are assigned as per the definition of ATC-40. The result of the pushover analysis used for the comparison include capacity curves, characteristics such as base shear, displacement, capacity and the performance point and status of hinge formation .

A. Modelling using Etabs

1) General

One of the major objectives of this work is to study the nonlinear behavior of the structure. For this, a residential building to be constructed in Mysore is considered. The plan and elevation of the building is unsymmetrical. This chapter gives an overall idea about the 3dimensional modelling aspects of reinforced concrete structure which is used for both linear and nonlinear analysis.

2) Plan of Residential Building

The plan of the residential building is shown in the Fig. 5.1. The building is of 4 story and 7 story and it is unsymmetrical in plan in both x and y direction.

- Nature of the project: Residential building
- Location: MYSORE

This report outlines the member evaluation of G+3 and G+6 story reinforced concrete residential building construction in Mysore as per IS456-2000.The building is constructed based on architectural and structural requirements for gravity load case only. The structural system of residential building is a reinforced concrete frame with one-way and two-way slab and beam floor system.

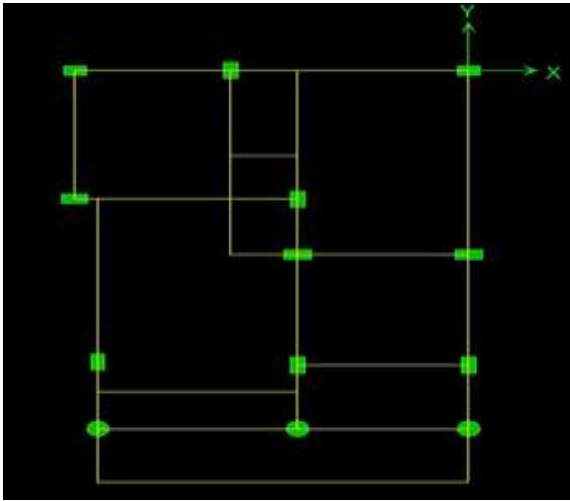


Fig. 1: Plan of residential building

B. Building Structural Member Information

ELEMENT	SIZES
COLUMN	R230x380,R230x460, C380d
BEAM	R230X300,R230X380
SLAB	150mm thickness
WALL	230 mm thickness

Table 1(a): Building Element Information

ELEMENT	MATERIAL		
	Concrete Grade	Longitudinal Rebar	Confinement Rebar
COLUMN	M25	Fe500	Fe415
BEAM	M25	Fe500	Fe415
SLAB	M25	Fe500	Fe415
WALL	M25	Fe500	Fe415

Table 1: Building Element Information

Live load	2KN/m ² on slabs and 1.5 KN/m ² on terrace.
Super imposed dead load	1.5KN/m ²
Wind load	Not designed for wind load
Earthquake load	As per IS-1893(part-1)-2002
Depth of foundation below ground	1.5 m
Type of soil	Type2, medium soil as per IS: 1893
Story height	3.00 m for all stories
Wall thickness	230 mm

Table 2: Design Data

Following base shear are obtained for the residential building by Equivalent static analysis, Response Spectrum Analysis and Pushover Analysis.

EQX: 191.17 KN
 EQY: 191.17 KN
 RSX: 37.54 KN
 RSY: 42.02 KN
 PUSH X: 401.43 KN
 PUSH Y: 418.07 KN

III. RESULTS AND DISCUSSION

The nonlinear static analysis and base isolation results for a residential building are as follows

A. Results of Pushover Analysis

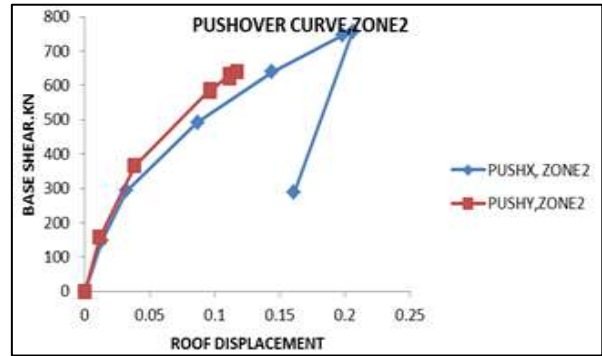


Fig. 2: Pushover curve for Building in X and Y direction

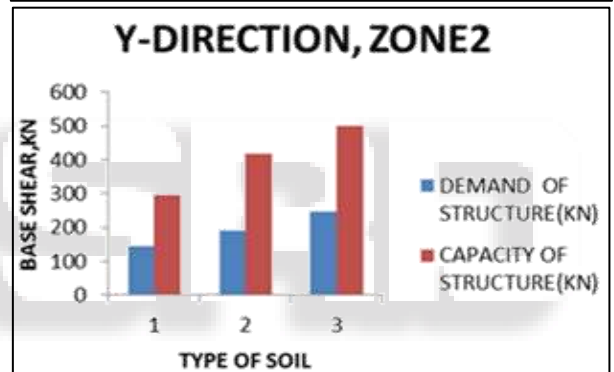
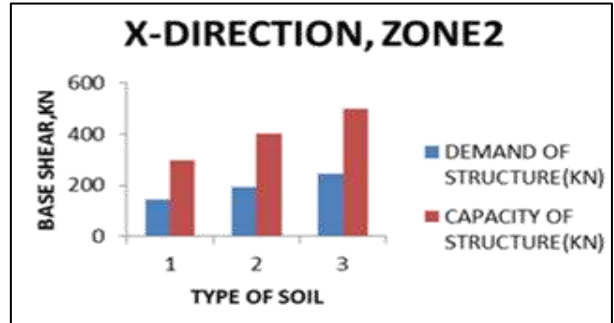
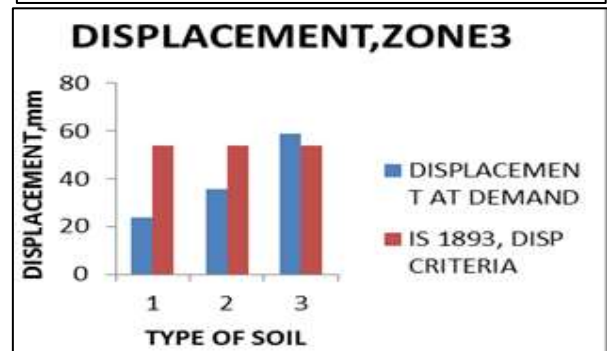
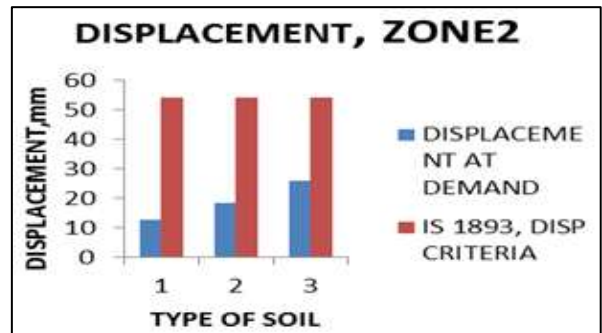


Fig. 3: Comparison between demand & capacity in zone 2 for different soil condition in X & Y directions.



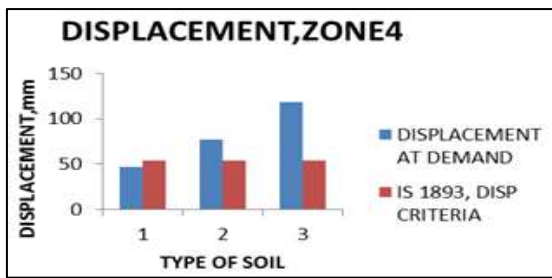


Fig. 4: Comparison of displacement at demand of structure with IS:1893-2002 in different Zones

B. Base Isolation Results

The results are drawn for Base Isolation and Non-Isolation techniques and are compared as shown below

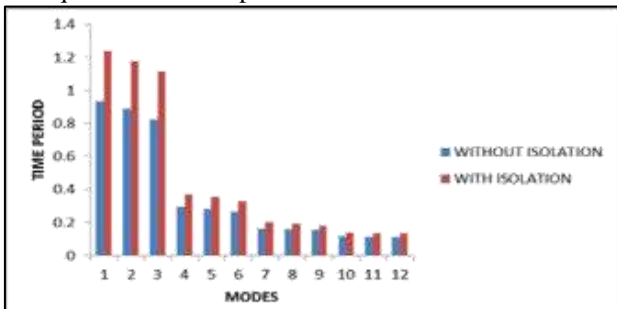


Fig. 5: Graphical representation of time period with respect to modes

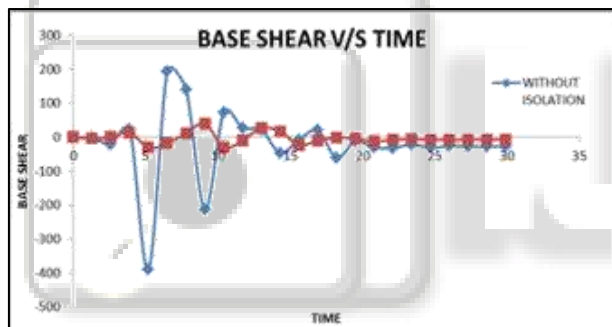


Fig. 6: Graphical representation of base shear with respect to time

IV. CONCLUSION AND SCOPE FOR FUTURE STUDY

Following conclusion are made by performing pushover analysis of a residential building and also base isolation

- The residential building in zone II is safe as the capacity of building is more than the demand and hence the building does not collapse.
- The displacement of the building is less than the allowable displacement as specified in IS 1893:2002.
- The earthquake capacity of an analysed RC building in zone II is more than the demand of the building.
- Zone III and zone IV are crucial for the residential building since the capacity of the building is less than the demand of the building.
- Pushover analysis studied for the residential building to know the performance of building in different zones and soil conditions. It is found that the capacity of building is less than the demand for the soft soil in zone III and one IV.

- During the non-linear static analysis of the residential building, it is observed that the seismic demand of the structural element increases with the change in the seismic zone and soil type.
- Approximately 30% increase in the base shear is observed from hard soil to medium soil and from medium to soft soil.
- Base isolated structures experience much higher time period compared to fixed base structures.
- Base isolated structures experience lower base shear from the seismic forces.

A. Scope for Future Work

- This work can be extended by the addition of bracing effect on the structure under both pushover analysis and time history analysis.
- This work can be extended for performing pushover analysis and time history analysis with considering infill walls.
- The seismic performance study of base isolated RC frame structure could be made using time history analysis for other earthquake data.
- Different types of bracings can be used to study their efficiency.

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