*IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*
*e-ISSN: 2278-1684, p-ISSN: 2320-334X*
*PP 14-19*
*www.iosrjournals.org*

# SEISMIC EVALUATION OF HIGH RISE REGULAR AND IRREGULAR STRUCTURE USING PUSHOVER ANALYSIS

Govind M[1], Kiran K. Shetty[2], K. Anil Hegde[3]
[1]*(M. Tech Final Year (Structures), Department of civil engineering, M.I.T Manipal, INDIA)*
[2]*(Associate Professor (senior scale), Department of civil engineering,M.I.T Manipal, INDIA)*
[3]*(Senior Structural consultant, Vimal Anil Structural Consultants, Mangalore, INDIA)*

***ABSTRACT:***The behaviour of the building duringearthquakesdependscritically on its overallshape, size and geometry. Buildings with simple geometry in plan have performedwell, during thepast strongearthquakes. But buildings with H shape in plan, have sustainedsignificant damages. So the proposedprojectattempts to evaluate the effect of plan irregularityon the response of the structure. In the present study,the behaviour of G+20 storied R.C frame buildings (Rectangular and H shape in plan, having same plan area) subjected to earthquake,located in seismic zone III isdiscussedbrieflyusing ETABS software. Gravity loads and laterals loads as per IS 1893-2002 are applied on the structure and it is designed using IS 456. Displacement control pushover analysis is carried out.

***Keywords:***Same plan area; Irregular structure; Pushover analysis; Seismic assessment

## 1. INTRODUCTION

### 1.1 General

In recent years, a large number of high-rise buildings have been constructed throughout India. Some of these buildings were irregular and do not follow traditional structural design concepts. From the past experience, it has been shown that structural irregularities could directly or indirectly cause the collapse or severe damage to these structures under strong earthquakes. A thorough investigation of their performance under seismic loads is thus necessary to verify the safety of these irregular buildings [1].Irregular buildings constitute a large portion of the modern urban infrastructure.Buildings are the complex system and multiple items have to be considered at the moment of designing them. Hence at the planning stage itself, architects and structural engineers must work together to ensure that the unfavourable features are avoided and good building configuration is chosen. Earthquake resistant engineering emphasis the inconvenience of using irregular plans, instead recommending the use of simple shapes. The effects that cause seismic action in irregular structures were observed in many recent earthquakes [2]. Since inelastic behaviour is intended in most structuressubjected to infrequent earthquake loading, the use of nonlinearanalysis is essential to capture behaviour of structures underseismic effects. Due to its simplicity, the structural engineeringprofession has been using the nonlinear static procedure(NSP) or pushover analysis, described in FEMA-356 [3] andATC-40 [4]. It is widely accepted that, when pushover analysisis used carefully, it provides useful information that cannot beobtained by linear static or dynamic analysis procedures [5].In this paper, the results of pushover analysis of reinforced concrete frames designed according to the IS1893:2002 has been presented.

### 1.2 Pushover Methodology

Pushover analysis is a static, nonlinear procedure in which the magnitude of the lateral force is increased, maintaining the predefined distribution pattern along the heights of the building. With the increase in the magnitude of the loads, weak links and failure modes of the building are found. Pushover analysis can determine the behaviour of a building, including the ultimate load and the maximum inelastic deflection. Local nonlinear effects are modelled and the structure is pushed until a collapse mechanism gets developed. At each step, the base shear and the roof displacement can be plotted to generate the pushover curve. It gives anidea of the maximum base shear that the structure was capable of resisting at the time of the earthquake.

### 1.3 Nonlinear Static Pushover Analysis

The model frame used in the static nonlinear pushover analysis is based on the procedures of the material, defining force – deformation criteria for the hinges used in the pushover analysis. Fig.1 describes the typical force-deformation relation proposed by those documents. Five points labelled A, B, C, D and E are used to define the force deflection behaviour of the hinge and these points labelled A to B – Elastic state, B to IO-below immediate occupancy, IO to LS – between immediate occupancy and life safety, LS to CP- between life safety to collapse prevention, CP to C – between collapse prevention and ultimate capacity, C to D- between C and residual strength, D to E- between D and collapse >E – collapse.

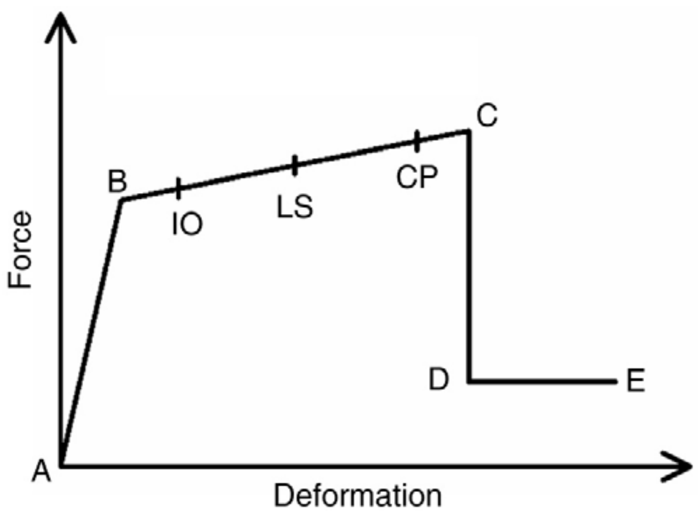


Figure 1: Force-Deformation for Pushover Analysis

### 1.4 Purpose of pushover analysis

The pushover is expected to provide information on many response characteristics that cannot be obtained from an elastic static or dynamic analysis. The following are the examples of such response characteristics.

- Estimates of inter story drifts and its distribution along the height.
- Determination of force demands on brittle members, such as axial force demands on columns, moment demands on beam-column connections.
- The capacity of the structure as represented by the base shear versus roof- displacement graph
- Maximum rotation and ductility of critical members
- Determination of deformation demands for ductile members.
- Identification of location of weak points in the structure (or potential failure modes)
- Consequences of strength deterioration of individual members on the behaviour of structural system.
- Identification of strength discontinuities in plan or elevation that will lead to changes in dynamic characteristics in the inelastic range.
- Verification of the completeness and adequacy of load path.
- To assess the structural performance of existing or retrofitted buildings.

### 1.5Research Significance

In the present study, RCC frame model is developed using ETABS software and pushover analysis is done on the Rectangular and H shape model with same plan area and same column size. The result obtained from the analysis is observed and compared with each other.

## 2 BUILDING PLAN AND DIMENSION DETAILS

The Following are the specification of G+20 commercial building,resting on Soil type II and located in seismic zone III.The complete detail of the structure including modelling concepts and a brief summary of the building is presented below:

Table 1: Details and dimensions of building

| | |
|---|---|
| Type of structure | Ordinary moment resisting RC frame |
| Grade of concrete | M 40 ($f_{ck}$= 40 N/mm$^2$ ) |
| Grade of reinforcing steel | Fe 415 ($f_{y}$ = 415 N/mm$^2$) |
| Plan area | 960 m$^2$ |
| Number of stories | G + 20 |
| Floor height | 3.5m |
| Column size: | 230 × 1500 mm |
| | 300 × 1500 mm |
| | 230 × 1800 mm |
| | 300 × 1800 mm |
| Beam size | 230 × 600 mm |
| Slab thickness | 130 mm |
| Wall thickness | 230mm |
| Density of concrete | 25 N/mm$^3$ |
| Live Load on Floors | 3 KN/m$^2$ |
| Density of wall | 20 N/mm$^3$ |
| Diaphragm | semi rigid diaphragm |
| Plan irregularity: | H shape |

a) Model- 2: In this model rectangular plan is considered (Fig.2).
b) Model-1: In this model plan irregularity is considered (Fig.3), (planarea is kept same as model 2). In order to stabilize the structure additional four columns of 300×1500mm size are included.

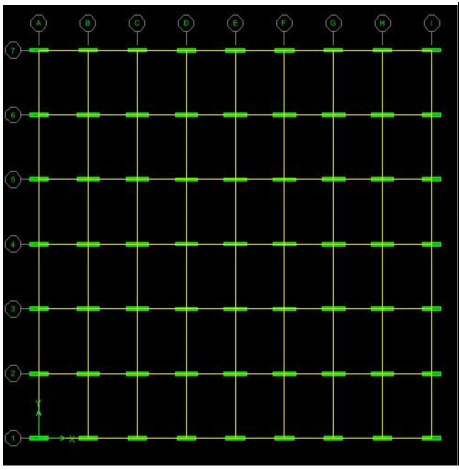

Figure2: Typical plan view of H shape

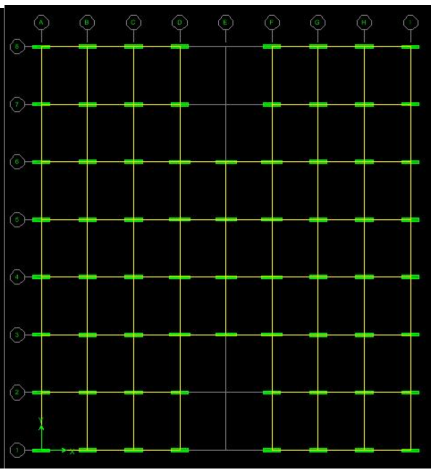

Figure 3: Typical plan view of rectangular shape

# 3 RESULTS AND DISCUSSION

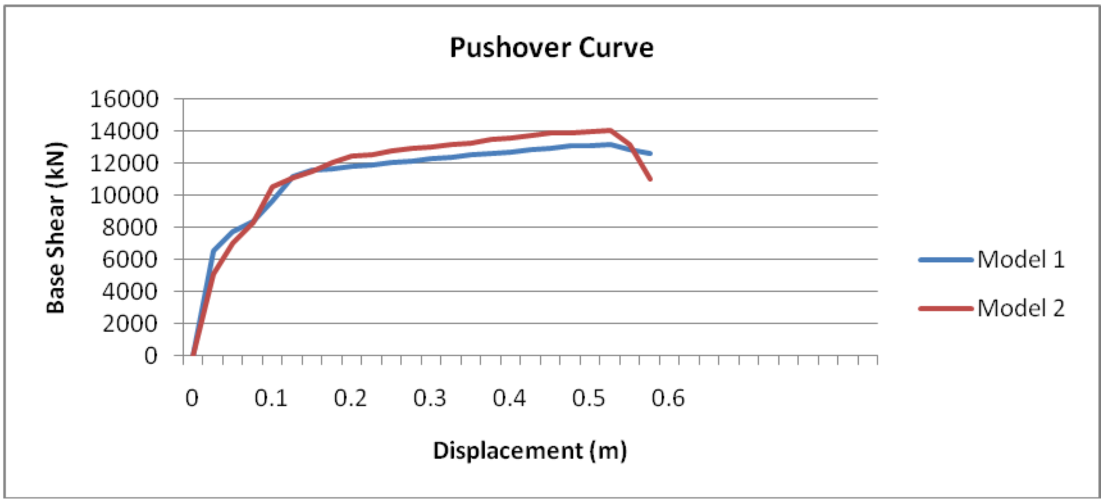


Figure 4: Post elastic behaviour of bare frame for Pushover Load – EQX

The resulting pushover curve for the G+20 building is shown in Fig 4. The curve is initially linear but starts to deviate from linearity as the beams and columns undergo inelastic actions. When the building is pushed into the inelastic range, the curve become linear again but with a smaller slope. The curve could be approximated by a bilinear relationship. In the present case for static pushover load EQX, Model 2 shows 6.55% more base shear than Model 1.

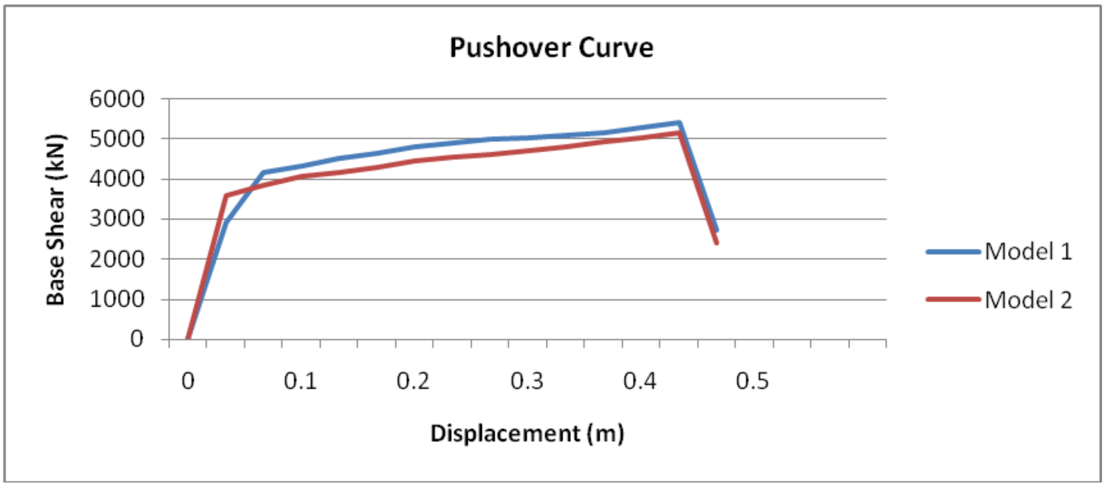


Figure 5: Post elastic behaviour of bare frame for Pushover Load - EQY

In Fig 5 static pushover load EQY, Model-1 shows 4.8% more base shear than Model-2.This is because the number of columns are increased in y direction in order to stabilize the structure, when the plan is modified to irregular. The curve is initially linear but starts to deviate from linearity as the beams and columns undergo inelastic actions.

### 3.1 Capacity and Demand Spectrum of Bare Frame for $C_a$=0.22 and $C_v$ =0.32 (Equivalent value for Type II soil and Zone III)

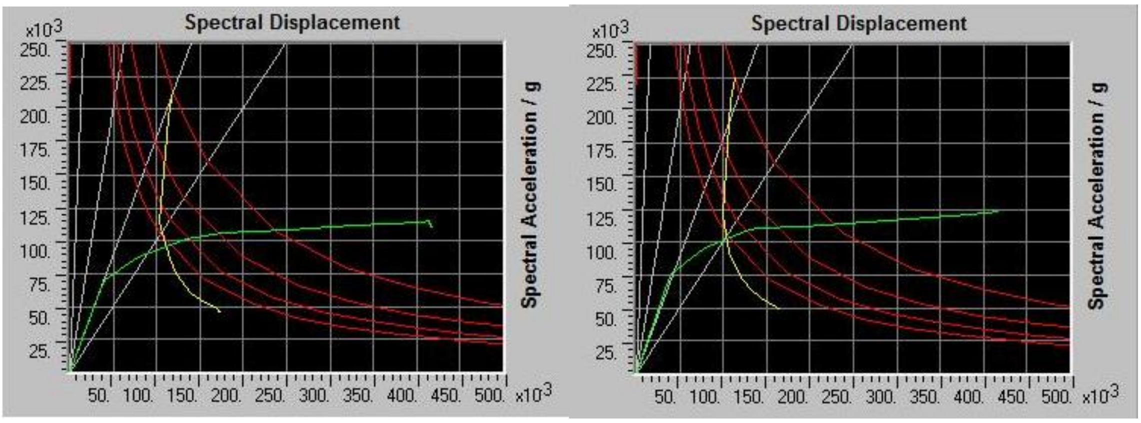


Figure6: Capacity and demand Spectrum of Model-1 and Model-2, Pushover Load- EQX

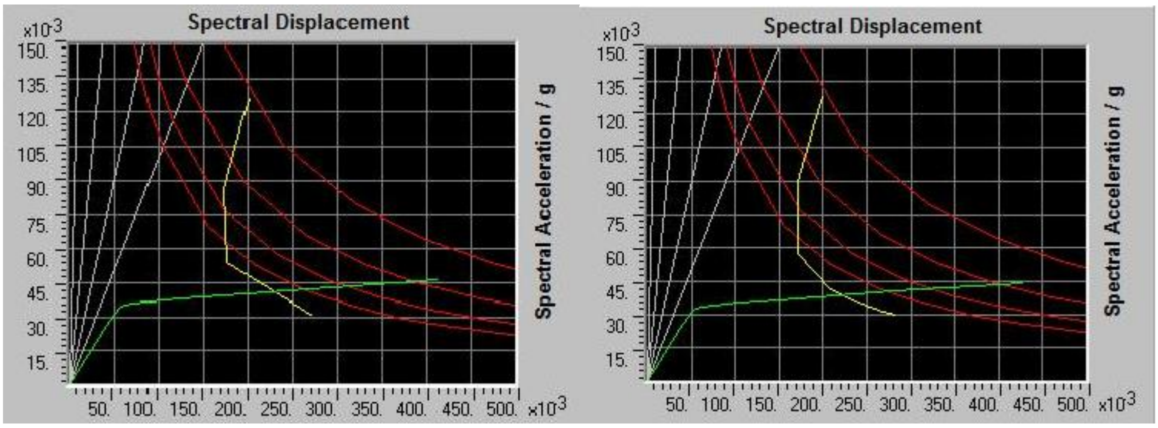


Figure 7: Capacity and demand Spectrum of Model-1 and Model-2, Pushover Load- EQY

From the Fig.6 it is observed that the demand curve tend to intersect the capacity curve in the building performance level of Life Safety Level, which means asubstantial damage as occurred to the structure, thus it maylose a significant amount of its original stiffness. However, a substantial margin remains for additional lateral deformation before collapse would occur.

From the Fig.7 it is also observed that the demand curve tend to intersect the capacity curve in the building performance level of immediate occupancy. Where damage is relatively limited, the structure retains a significant portion of its original stiffness and most if not all of its strength.

Table 2: Performance Point of bare frame obtained from Capacity Spectrum Method

| Type of Pushover Load | Type of RC Frame | Performance Point ($V_{BP}$, $\delta_{roof}$) |
|---|---|---|
| Static- EQX | Model - 1 | (10507.17, 0.137 ) |
| | Model - 2 | (11207.14, 0.128) |
| Static-EQY | Model - 1 | (4752.18, 0.232) |
| | Model - 2 | (4588.56, 0.247) |

## 4 CONCLUSIONS

The performance of reinforced concrete frames was investigated using the pushover Analysis. These are the conclusions drawn from the analyses:

1. The pushover analysis is a relatively simple way to explore the non-linear behaviour of Buildings.
2. The plan configurations of structure have significant impact on the seismic response of structure, in terms of displacement and Base shear.
3. When earthquake load is applied in X direction, it is found that rectangular plan structure can resist more base shear than irregular plan structure.
4. When earthquake load is applied in Y direction, it is found that irregular plan structure can resist more base shear than rectangular plan structure.This is because the number of column are increased in y direction in order to stabilize the structure, when the plan is modified to irregular
5. Capacity and Demand spectra shows the performance of the structure under the earthquake loads.

## REFERENCES

[1] M.Mouzzoun, O.Moustachi, A.Taleb2, S.Jalal,” *Seismic performance assessment of reinforced concrete buildings using pushover analysis*” *ISSN: 2278-1684 Volume 5, Issue 1 (Jan. - Feb. 2013), PP 44-49*

[2] Pankaj Agrawal and Manish Shrikhande, “*Earthquake Resistant Design of Structures*”, PHI Learning Private Limited, May 2010, pp. 234-238.

[3] Applied Technology Council, ATC-40. Seismic evaluation and retrofit of concrete Buildings, California, 1996; Vols. 1 and 2.

[4] Federal Emergency Federal Agency, FEMA-356.Prestandard and Commentary for Seismic Rehabilitation of Buildings. Washington DC, 2000

[5] Mehmet Inel, HayriBaytanOzmen, M. Inel, H.B. Ozmen / Engineering Structures,”*Effects of Plastic Hinge Properties in Nonlinear Analysis of Reinforced Concrete Buildings*”, pp. 1494–1502, 2006.