Library Progress International *Print version ISSN 0970 1052*
Vol.44 No.3, Jul-Dec 2024: P.6509-6517 *Online version ISSN 2320 317X*

Original Article *Available online at www.bpasjournals.com*

Pushover Analysis of Low and Medium Rise RCC FramesWith and Without Bracings for Regular & Irregular Buildings

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How to cite this article: M. Uday Bhaskar, Ipsitha Bose Roy Choudhury, A. Madhusudhan (2024) Pushover Analysis of Low and Medium Rise RCC Frames With and Without Bracings for Regular & Irregular Buildings. *Library Progress International,* 44(3), 6509-6517.

ABSTRACT
Recent earthquakes have caused severe damage to many concrete structures, so there is need for evaluating the seismic adequacy of structure. Steel Bracings was one of the most effective methods for RC frame building to improve the stiffness of the structure. This study is aimed at evaluating and comparing the response of G+5 and G+15 storey RC structures. The methodologies are applied to a regular and irregular plans (L, T and PLUS shaped plan) with and without considering the steel bracings. In the present study, we observe that base shear increases with the increases in mass and number of story of the building. L-Shaped irregular building plan shows a better performance compared to all other models.

Keywords
Pushover Analysis, Irregular Building Plan, Steel Bracings, ETABS 9.

1. General

Earthquake is a natural phenomenon, which is generated in earth's crust. Duration of earthquake is usually short, lasting from few seconds to more than a minute. But thousands of people lose their lives due to earthquakes in different parts of the world. Along with the growth of Indian population there is an increase in demand for infrastructure facilities. In urban areas, the demand for land is increasing day by day. Due to these reasons construction of high rise structures is taken up. This type of development brings challenges to work against additional lateral loads due to wind and earthquake. About 60% of the land area of our country is susceptible to damaging levels of seismic hazard. We can't avoid future earthquakes, but safe building construction practices can certainly reduce the extent of damage and loss. To evaluate the performance of framed building under future expected earthquakes, a linear and non-linear static pushover analysis has been conducted in our project.

A. Seismology

Earthquakes results from the sudden movement of tectonic plates in the earth's crust. Earthquakes takes place at fault lines and the energy is released in the form of waves that causes ground motion.

These waves arrive at a various instants of time, having various amplitudes and carry various levels of energy. Magnitude is measure of size of an earthquake, which was obtained by recording the data of Motions on seismograms.

B. Effect of earthquake for irregular buildings

Now a day's most of the buildings are irregular in both plan and vertical configurations. Irregularities in plan may imply significant eccentricity between the building mass and stiffness centers giving rise to damaging coupled lateral/torsion response. The damage in the irregular buildings is more compare to regular buildings. . The irregular structures need a more careful structural analysis to reach a suitable behaviour during devastating earthquake. In irregular buildings the impact of dissimilar lateral load patterns are observed in non linear static analysis.

C. Steel Bracings

Steel bracing is highly capable of resisting the horizontal forces in a Reinforced Concrete building frame

structure and it is less expensive method. Many researchers have investigateda variety of techniques such as infilling walls, base isolation, shear wall, jacketing, adding walls to existing columns and adding steel bracing technique to develop the strength or ductility of existing buildings. Bare frame buildings need bracings to resist seismic effect. Hence in this project steel bracings are incorporated as infill for both regular and irregular plan buildings.

2. Methodology

A. Linear static analysis or equivalent staticAnalysis

Equivalent static method of analysis is a linear static manner in which the response of building is a linearly elastic approach. According to Indian code IS: 1893-2002 (part -1) the analysis is carried out. Design horizontal seismic coefficient depends on the zone factor, importance factor of structure and response reduction factor of the lateral load resisting elements and the fundamental period of the structure.

B. Pushover analysis

Pushover analysis is a simplified, static non- linear procedure the lateral loads is increased to maintain a pre-defined distribution pattern alongthe height of the building until a collapse mechanism develops. The performance based approach requires a lateral load verses deformation analysis. The pushover analysis is amethod to observe the successive damage states of a building.

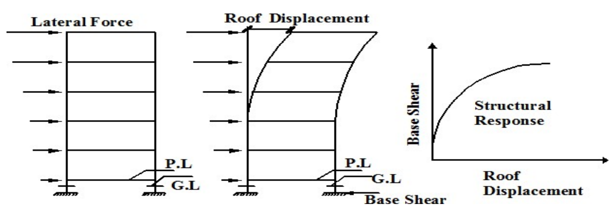


Fig a: Base shear vs displacement

C. Pushover Curve

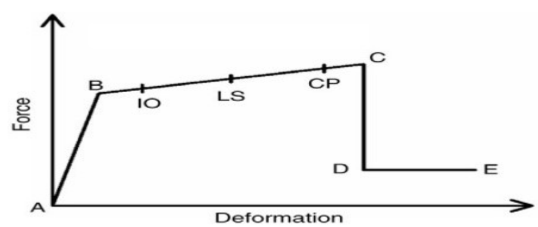


Fig b: load deformation curve

The above fig.b, shows about the differentstages of load deformation curve
A to B indicates Elastic state
B to IO indicates below immediate occupancy
IO to LS indicates between immediateoccupancy and life safety
LS to CP indicates between life safety tocollapse prevention
CP to C indicates between ultimate capacity andcollapse prevention
C to D indicates between C and residual strengthD to E indicates between D and collapse

3. Modelling And Analysis

A. Building description

The entire analysis has done for all the 3D models using ETABS. The different Types of buildings considered for the present study are
Model-1: Regular plan building modeled for 6 and 16 stories bare frame.
Model-2: **L**-Shaped irregular plan building for 6and 16 stories bare frame.
Model-3: **T**-Shaped irregular plan building for 6and 16 stories bare frame.

Model-4: **PLUS**-Shaped irregular plan building for 6 and 16 stories bare frame.
Model-5: Regular plan building modeled for 6 and 16 stories using steel bracings in outer periphery.
Model-6: **L**-Shaped irregular plan building for 6and 16 stories using steel bracings in outer periphery.
Model-7: **T**-Shaped irregular plan building for 6and 16 stories using steel bracings in outer periphery.
Model-8: **PLUS**-Shaped irregular plan building for 6 and 16 stories using steel bracings in outer periphery.
The structure analyzed are 6 and 16 stories of regular and irregular plan, four bays along X- direction and four bays along Y-direction for Moment-resisting frame of reinforced concrete
.The details of the models are given belowNo of stories = G + 5 and G + 15.
No of bays along X-direction = 4No of bays along Y-direction = 4Storey height = 3.5 m
Bay width along X-direction = 6, 7, 12, 5 m fromleft to right.
Bay width along Y-direction = 8, 7, 11, 10 m from Bottom to top

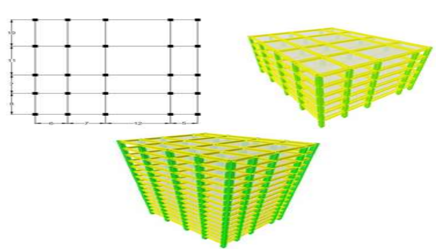
B. G+5 Building description

- Type of Structure : RC momentresisting frame.
- Seismic Zone : IV.
- Seismic Zone factor : 0.24
- Type of soil : Soft soil.
- Importance factor : 1.5.
- Response reduction factor : 5.
- Plan of the Building: 30 m x 36 m.
- Live load : 4 KN/m^2 at floor.
  : 1.5 KN/m^2 on terrace.
- Floor Finish : 2 KN/m^2.
- Beam Size : 800 x 800mm.
- Column Size : 900 x 900mm.
- Slab Thickness : 150 mm.
- Type of Bracing used : concentric X Bracing
- Grade of steel used for bracing : ISHB-300

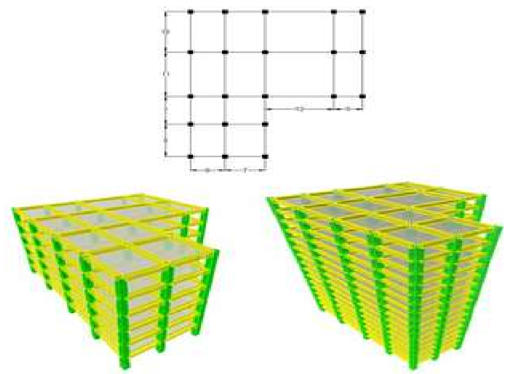
C. G+15 Building description

- Type of Structure : RC momentresisting frame.
- Seismic Zone : IV.
- Seismic Zone factor : 0.24
- Type of soil : Soft soil.
- Importance factor : 1.5.
- Response reduction factor : 5.
- Plan of the Building : 30 m x 36 m.
- Live load : 4 KN/m^2 at floor.
  : 1.5 KN/m^2 on terrace.
- Floor Finish : 2 KN/m^2.
- Beam Size : 600 x 1000mm.
- Column Size : 1200 x 1200mm.
- Slab Thickness : 150 mm.
- Type of Bracing used : concentric X Bracing
- Grade of steel used for bracing: ISHB-450.

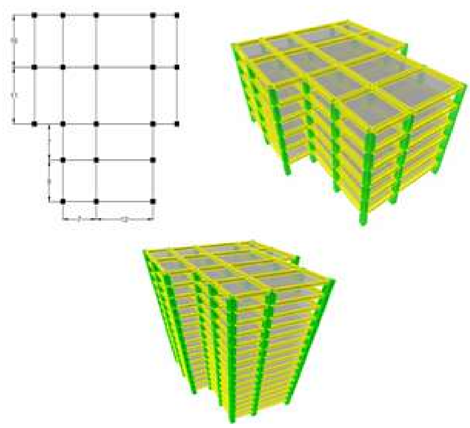
D. Regular and irregular building plans forG+5 building



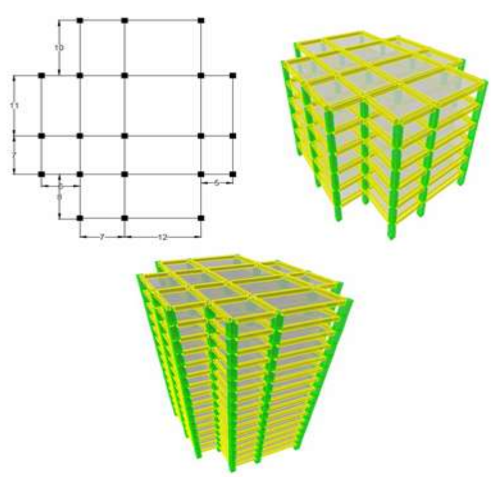
Model-1: Regular plan building modeled for 6and 16 stories bare frame.



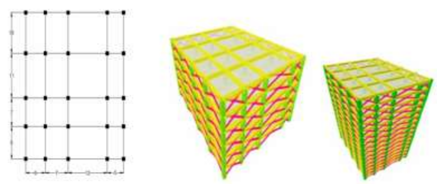
Model-2: **L**-Shaped irregular plan building for 6storey frame



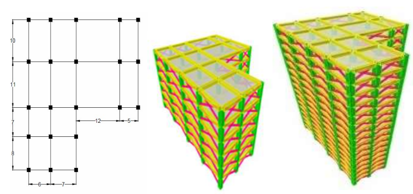
Model-3: **T**-Shaped irregular plan building for 6storey bare frame.



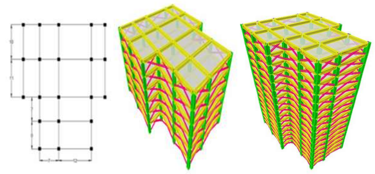
Model-4: **PLUS**-Shaped irregular plan buildingfor 6 storey bare frame.



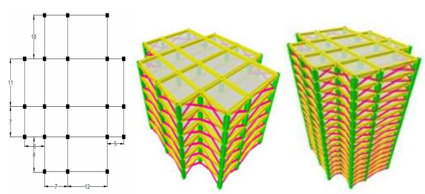
Model-5: Regular plan building modeled for 6 and 16 stories using steel bracings in outer periphery.



Model-6**: L**-Shaped irregular plan building for 6and 16 stories using steel bracings in outer periphery.



Model-7: **T**-Shaped irregular plan building for 6and 16 stories using steel bracings in outer periphery.



Model-8: **PLUS**-Shaped irregular plan building for 6 and 16 stories using steel bracings in outer periphery.

4. Results and Discussion

This dissertation work is carried out to compare the dynamic characteristics of G+5 and G+15 storied Buildings with and without steel Bracings for 4 different models, namely rectangle shaped, L-Shaped, T-Shaped, Plus–shaped. From Equivalent static force method base shear, displacements, storey drift are obtained for zone- 4 and soil condition is soft soil type-3 as per IS 1893-2002 (part-1). From nonlinear static analysis base shear, displacement results are obtained considering performance point fordifferent models.

A. Equivalent Static Analysis Results

Time Period: The values of time period for allthe models are shown in Table 1

Table 1: Time Period Values for G+5 andG+15 Building

Models	Time period (Sec)		
	(X) Direction	(Y) Direction	Torsion
Model-1	0.7244	0.7834	0.6485
Model-2	0.7059	0.7772	0.6368
Model-3	0.7577	0.8041	0.6827
Model-4	0.7482	0.7969	0.6892
Model-5	0.507	0.525	0.3701
Model-6	0.4698	0.4916	0.3682
Model-7	0.504	0.5073	0.387
Model-8	0.5027	0.5074	0.3876

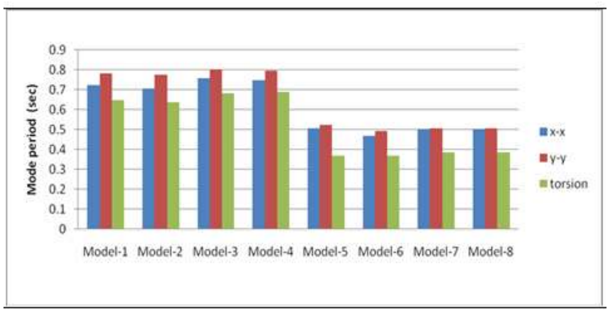


Fig 1: Time Period Vs. No of Modes fordifferent Models

From the above Figure 1, it is observed that the time period for infilled frame structure is lesser compared to bare frame models, because stiffness being provide for infilled frame structures

B. Base shear for G+5 and G+15 Building

Table 2: Base shear for G+5 and G+15 Buildin

Models	Base Shear (kN) G+5
Model-1	7419.95
Model-2	5741
Model-3	6214.40
Model-4	6157.81
Model-5	8255.33
Model-6	6406.23
Model-7	6927.60
Model-8	6865.28

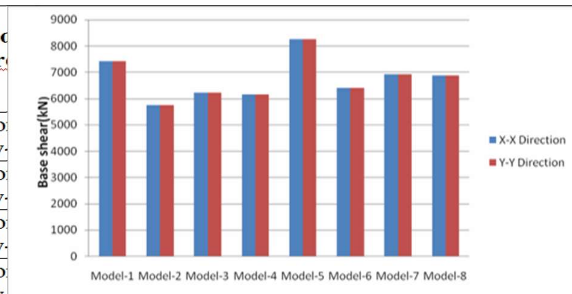
Models	Base Shear (kN) G+15
Model-1	9763.97
Model-2	7900.22
Model-3	8504.28
Model-4	8432.50
Model-5	17184.21
Model-6	13435.28
Model-7	14443.23
Model-8	14323.46

Fig 2 : Comparison of Base Shear for G+5and G+15 Building

From the above Figure 2, for base frame models, model-1 has maximum base shear compared to other models.Model-2 decreases by 19%, Model- 3 decreases by 13% and model-4 decreases by 14%. For infilled frame structures, model-5 has maximum base shear compared to other models.Model-6 is decreases by 22%, model-7 isdecreases by 16% and Model-8 is decreases by 17%.

C. Storey displacement for G+5 Building and G+15 Building

Table 3: Storey displacement for G+5Building



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Storey-2	6.1	5.9	6.9	6.4	3.5	3.1	3.5	3.4
Storey-1	2.2	2.2	2.5	2.3	1.4	1.2	1.4	1.3

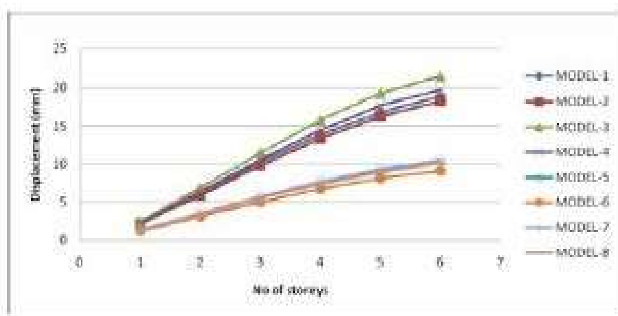


Fig 3: Storey Displacement for G+5Building

From figure 3, it is observed that infill frame structures have lesser displacement compare to the bare frame models in X Direction

D. Pushover analysis for G+5 and G+15building

Table 4: Pushover analysis for G+5 and G+15building

Type of models	G+5 BUILDING		G+15 BUILDING	
	Base shear at Performance point(kN)	Displacement (mm)	Base shear at Performance point(kN)	Displacement (mm)
Model-1	17033.805	86	20554.801	207
Model-2	12745.061	86	16904.452	206
Model-3	14092.046	92	18112.965	217
Model-4	14004.260	88	17814.693	220
Model-5	37755.350	73	50794.875	166
Model-6	32167.997	70	37787.291	144
Model-7	32222.110	77	43085.234	166
Model-8	30633.968	67	42487.357	168

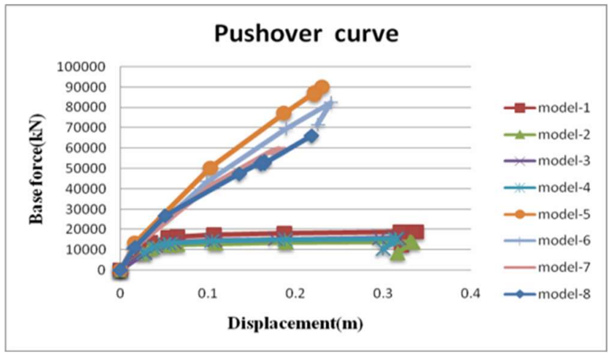
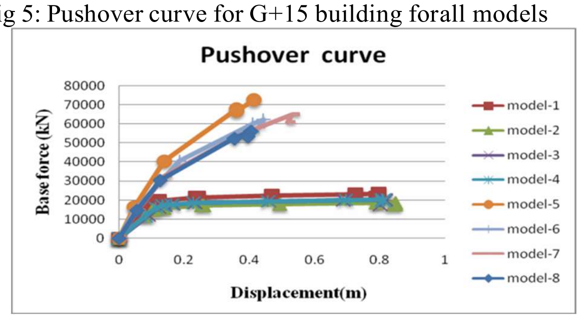


Fig 4: Pushover curve for G+5 building for allModels

From figure 4, it is observed that, For bare framestructures, there is decrease in base shear at performance point for Model-2, Model-3 and Model-4 by 25.20%, 17.20% and 17.80% respectively when compared to Model-1 in Push over analysis due to deduction of elements in that models (Model-6 to Model-8). For infill frame structures, there is an increase in displacement at performance point for Model-5, Model-6 and Model-7 by 4.2% and 13% respectively when compared to Model-8
in Push over analysis due to stiffness participation factor.

Fig 5: Pushover curve for G+15 building forall models



From figure 5, it is observed that for bare frame structures, there is decrease in base shear at performance point for Model-2, Model-3 and Model-4 by 20.90%, 12.50% and 12.95% respectively when 5 compared to model-1 in Push over analysis. For bare frame structures, there is an increase in displacement at performance point for model-2, model-3 and model-4 by 1%, 3.7% and 1% respectively whencompared to model-1 in Push over analysis due to stiffness participation factor.

5. Conclusions

1. Base shear increases with the increases in mass and number of story of the building.
2. Base shear obtained from pushover analysis is much higher than the base shear obtained from equivalent static analysis for all models.
3. L–shaped irregular building plan shows a better performance compared to all other models(i.e. Model-1 to model-5 and model-7 to model- 8).
4. It is observed that steel bracings models in both pushover analysis and linear static analysis has more performance compared to Bareframe models.
5. Steel braced building models shows lesser displacement compares to bare frame buildings.

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