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To study of seismic analysis and design for different plan configuration in structural behavior of multi story RC framed building

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***Abstract*- Reinforced concrete multi storey buildings are subjected to most dangerous earthquakes. It was found that main reason for failure of RC building is irregularity in its plan dimension and its lateral force resisting system. This project aims at studying of the seismic analysis and design on structural behaviour of multi-storey building (G+20) for different plan configurations like rectangular and C- shape using ETABS computer program. A detailed parametric study is carried out to investigate the effect of various parameters on the building structure by linear static and response spectrum analysis for medium soil at zone III. Finally the results are observed to study the effect of structural displacements, drifts, story shear, overturning moment and stiffness. Comparison of the results of static and response spectrum analysis of different structure is done.**

***Index Terms*- Static and response spectrum analysis, Structure Design, ETABS, Multi Story Building & Different Plan.**

I. INTRODUCTION

As the our country is the fastest growing country across the globe and need of shelter with higher land cost in major cities like Mumbai, Delhi, Hyderabad, Vijayawada and Vishakhapatnam where further horizontal expansion is not much possible due to space shortage, we are left with the solution of vertical expansion. High rise buildings are the best suited solution for this problem. Many high rise commercial, residential and communication towers around the world have been constructed using reinforced concrete structural frames.

The most recent findings of building damage or failures caused by seismic events have resulted in extensive changes in the areas of seismic designs and detailing.

The earthquake forces are principally internal forces resulting from the distortion produced by the inertial resistance of the structure to earthquake motions. Building codes base their provisions on the historic performance of buildings and their deficiencies and have developed provisions around life-safety concerns by focusing their attention to prevent collapse under the most intense earthquake expected at a site during the life of a structure.

1.1 CHARACTERISTICS OF BUILDINGS

There are four aspects of buildings that architects and design engineers work with to create the earthquake-resistant design of a building, namely seismic structural configuration, lateral stiffness, lateral strength and ductility, in addition to other aspects like form, aesthetics, functionality and comfort of building. Lateral stiffness, lateral strength and ductility of buildings can be ensured by strictly following most seismic design codes. But, good seismic structural configuration can be ensured by following coherent architectural features that result in good structural behaviour.

1.2 OBJECTIVES OF THE STUDY

Structural analysis is a complex phenomenon which involves local damage to structures during earthquake. It is necessary to study of the linear static and response spectrum analysis of 20-story building for different plan configurations like rectangular and C- shape using ETABS computer program.

The principal objectives of the study are as follows:

a. Overall building movements.
b. Story drifts & other internal deformations.
c. to determine the base shear, overturning moment and stiffness of the building under seismic loading.

II. LITERATURE REVIEW

Structural analysis means determination of the general shape and all the specific dimensions of a particular structure so experimental studies has been conducted to investigate the buildings located in that it will perform the function for which it is created and will safely withstand the influences which will act on it throughout its useful life.

Ismail Sab, Prof .S.M. Hashmi, generated 3D analytical model of twelve storeyed buildings for different buildings Models and analyses using structural analysis tool ETABS. To study the effect of infill, ground soft, bare frame and models with ground soft having concrete core wall and shear walls and concrete bracings at different positions during earthquake; seismic analysis using both linear static, linear dynamic (response spectrum method) has been performed. The analytical model of the building includes all important components that influence the mass, strength, stiffness and deformability of the structure.

III. SEISMIC ANALYSIS PROCEDURE

Various methods of differing complexity have been developed for the seismic analysis of structures. The two main techniques currently used for this analysis are:

- Equivalent Static Analysis.
- Linear dynamic (Response spectrum) Analysis

3.1 Equivalent Static Analysis

Linear static analysis or equivalent static analysis can only be used for regular structure with limited height. The most design codes represent the earthquake-induced inertia forces as the net effect of such random shaking in the form of design *equivalent static* lateral force.The Seismic analysis of most of the structures are still carried out on the basis of lateral (horizontal) force assumed to be equivalent to the action (dynamic) loading. This force is called as the *Seismic Design Base Shear VB* and remains the primary quantity involved in *force-based* earthquake-resistant design of buildings. Base shear which is the total horizontal force on the structure is calculated on the basis of structure mass and fundamental period of vibration and corresponding mode shape. The base shear is distributed along the height of structures in terms of lateral forces according to code formula.

3.2 Response Spectrum Analysis

The main purpose of linear dynamic analysis is to evaluate the time variation of stresses and deformations in structures caused by arbitrary dynamic loads. The response spectrum technique is really a simplified special case of modal analysis. The modes of vibration are determined in period and shape in the usual way and the maximum response magnitudes corresponding to each mode are found by reference to a response spectrum.

IV. ANALYSIS AND DESIGN

This analysis mainly deals with the study of a rectangular, and C shaped plan using ETABS.

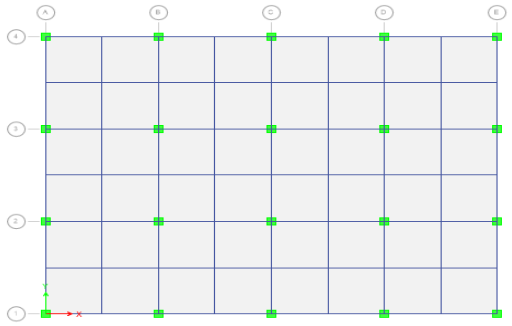


Fig 4.1 Plan Layout of Twenty Storeys Rectangular Shape Building with Brick Infill Walls

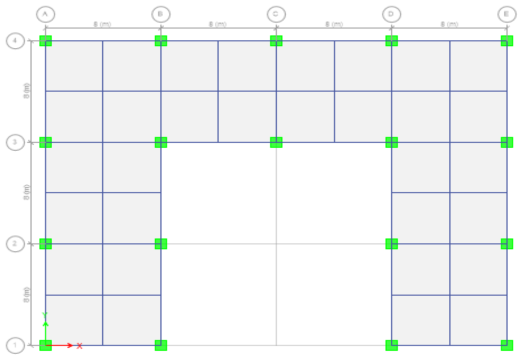


Fig 4.2 Plan Layout of Twenty Storey C- shape Building with Brick Infill Walls

4.1 Building Geometry

Plan dimension	:	32 mX24 m
X-direction grid spacing	:	8m
Y-direction grid spacing	:	8m
Ground floor	:	4 m
Floor to floor height	:	3.0 m
No of stories	:	G+19
Total height of the building	:	61m
Support condition	:	fixed

4.2 Material property

Grade of concrete	= M25
Grade of steel	= Fe415
Young's modulus of (M25) concrete, E	= 25×10^6 kN/m²
Density of Reinforced Concrete	= 25.00 kN/m³
Density of Reinforced Brick Masonry	= 20.00 kN/m³

4.3 Member property

Beam size	= 300 x 600 mm
Secondary beam size	= 300 x 450 mm
Column size for 1-6 storeys	= 800 x 800 mm
Column size for 7-14 storeys	= 600 x 600 mm
Column size for 15-20 storeys	= 400 x 400 mm
Beam clear cover	= 25 mm
Column clear cover	= 40 mm
Thickness of brick wall	= 230 mm
Thickness of R.C.C shear wall	= 300 mm
Height of parapet wall	= 0.90m
Thickness of parapet wall	= 115mm
Thickness of slab	= 150 mm

4.4 LOADING

Loads acting on the structure are dead load (DL), Live load and Earthquake load (EL).

4.4.1 Dead Loads and live load

a. Dead load:

Wall load, Parapet load and floor load (IS 875(Part1))

Wall load = (unit weight of brick masonry X wall thickness X wall height)

= 20 KN/ m^3 X 0.230m X 3m

= 13.8 kN/m (acting on the beam)

Wall load = (unit weight of brick masonry X parapet wall thickness X wall height)

= 20 KN/ m^{3}X 0.115m X 0.90m

=2.07 kN/m (acting on the top beam)

b. Floor finishes as uniform area load on slabs= 1.5 kN/m^2

c. Live load on all floors = 3.0 kN/m^2

4.4.2 Earthquake Loads

Earthquake loads have been defined and assigned as lateral loads for load pattern EQX and EQ Y on the building as per IS 1893:2002(part1).

Zone factor, Z = 0.16 (zone-III)
Importance factor, I = 1.0
Response reduction factor, R = 5.0 (SMRF)
Type of soil = Type II (Medium soil)
Spectral Acceleration Coefficient, S_a /g [IS 6.4.5]

= 1.36/T

= 0.34

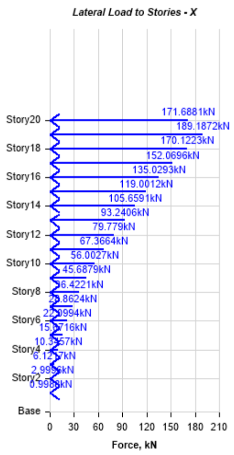
Design seismic base shear,

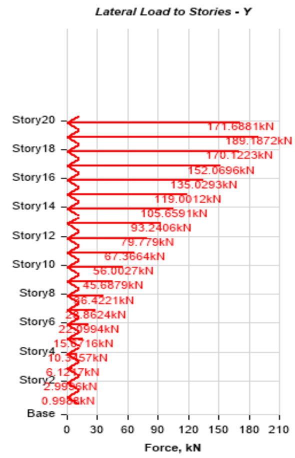
$$V_b = A_h W$$

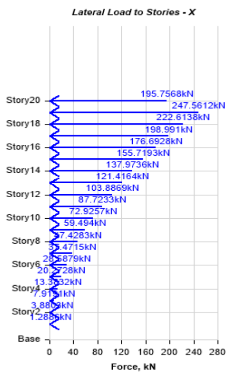
Design horizontal Seismic Coefficient, $A_h = \frac{Z}{2} x \frac{I}{R} x \frac{Sa}{g}$

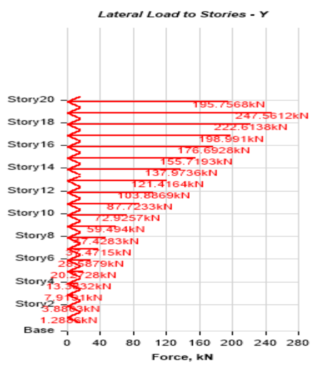
Seismic weight of 20 storey building,
In X-Direction, W = 356798.9881 KN
In Y-Direction, W = 277271.1137 KN
Design seismic base shear for 20 storey building,
In X-Direction, V_b = 1940.9865 KN
In Y-Direction, V_b = 1508.3549 KN

Applied Story Forces









4.5 LOAD COMBINATIONS

According to IS 1893(Part 1): 2002 for limit state design of reinforced concrete structures; the following load combinations have been defined as static analysis

1.5(DL+FF)
1.5(DL+LL+FF)
1.2(DL+LL+FF +EQX)
1.2(DL+LL+FF -EQX)
1.2(DL+LL+FF +EQY)
1.2(DL+LL+FF -EQY)
1.5(DL+FF +EQX)
1.5(DL+FF -EQX)
1.5(DL+FF +EQY)
1.5(DL+FF -EQY)
0.9DL+0.9FF+1.5EQX
0.9DL+0.9FF -1.5EQX
0.9DL+0.9FF +1.5EQY
0.9DL+0.9FF -1.5EQY

V. RESULTS AND DISCUSSION

5.1 Displacement

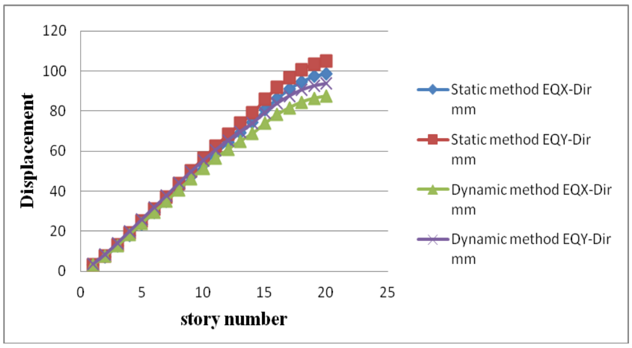


Fig 5.1 Graphical Representation of Displacement value in Rectangular shape building

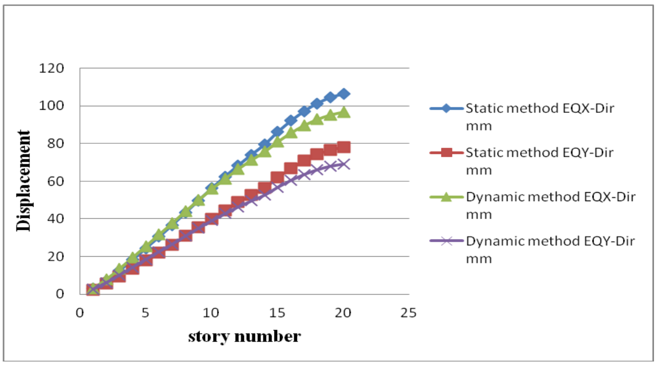
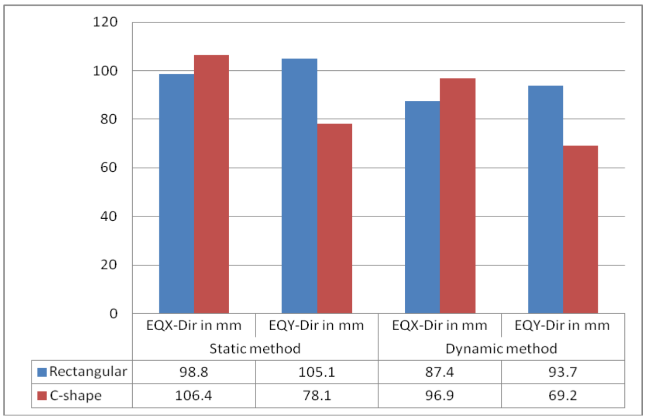


Fig 5.2 Graphical Representation of Displacement value in C shape building

From the above results it have been seen that the maximum storey displacements for 20th storey. Displacement in rectangular shape building is less than C shape building.



	EQX-Dir in mm	EQY-Dir in mm	EQX-Dir in mm	EQY-Dir in mm
	Static method		Dynamic method	
Rectangular	98.8	105.1	87.4	93.7
C-shape	106.4	78.1	96.9	69.2

Fig 5.3 Graphical Representation of Displacement value in Top Story

5.2 **Storey Drift**

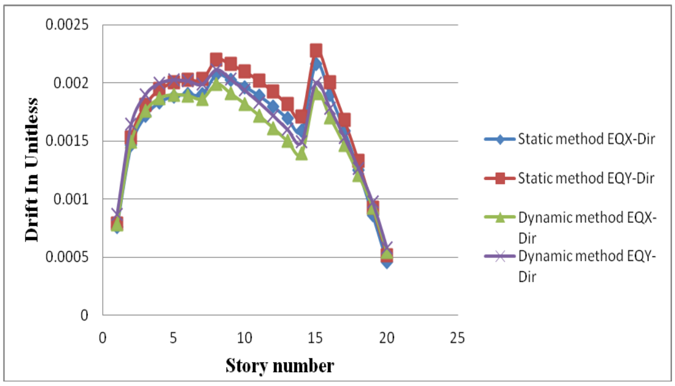


Fig 5.4 Graphical Representation of drift values in Rectangular shape building

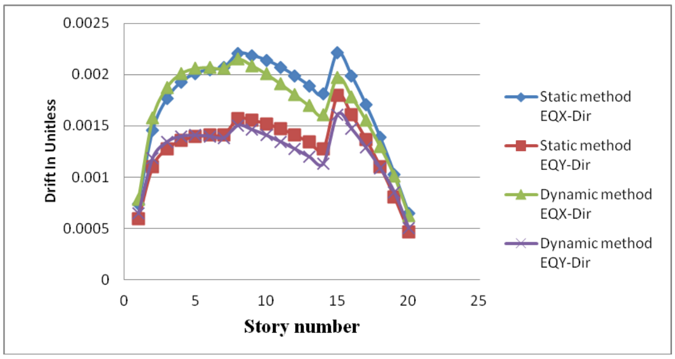
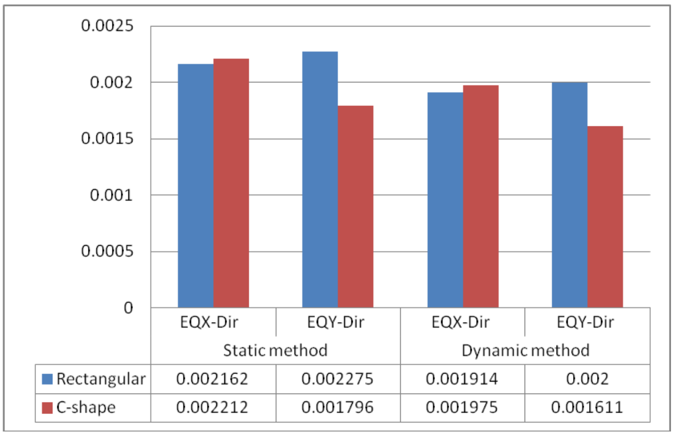


Fig 5.5 Graphical Representation of drift value in C shape building

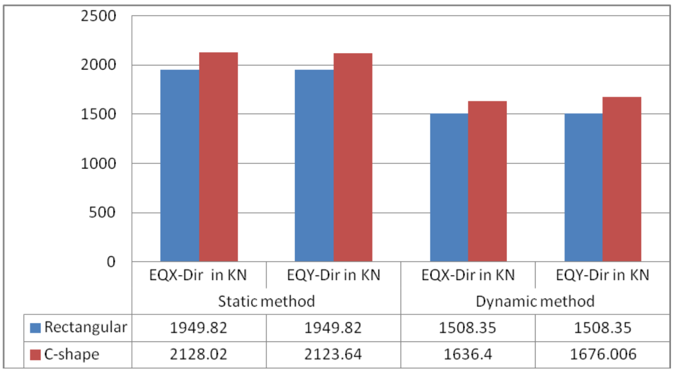
From the above results it have been seen that the maximum storey drift for 15th storey in rectangular and C shape buildings.



	EQX-Dir	EQY-Dir	EQX-Dir	EQY-Dir
	Static method		Dynamic method	
Rectangular	0.002162	0.002275	0.001914	0.002
C-shape	0.002212	0.001796	0.001975	0.001611

Fig 5.6 Graphical Representation of Drift value in 15th Story

5.3 Base Shear force



	EQX-Dir in KN	EQY-Dir in KN	EQX-Dir in KN	EQY-Dir in KN
	Static method		Dynamic method	
Rectangular	1949.82	1949.82	1508.35	1508.35
C-shape	2128.02	2123.64	1636.4	1676.006

Fig 5.7 Graphical Representation of Base Shear Force

The figure shows that the Base shear force value from dynamic analysis is 9 % more than the base shear force from static analysis for both different building.

5. Overturning moment

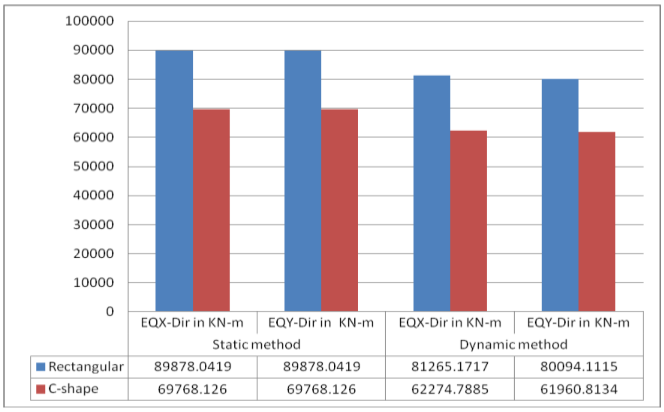


Fig 5.8 Graphical Representation of Base Overturning Moment

From the above results it have been seen that overturning moment in rectangular shape building is more than C shape building.

6. Stiffness

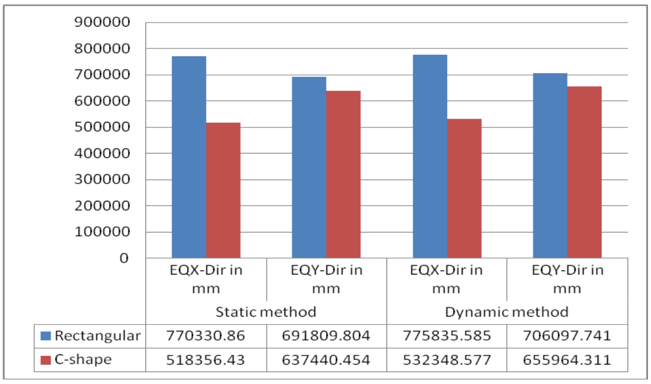


Fig 5.9 Graphical Representation of stiffness values in 1st story

From the above results it have been seen that the maximum stiffness for 1th storey. The stiffness decreases with the increase in storey height. Stiffness in rectangular shape building is more than C shape building.

VI. CONCLUSIONS

Based on the observations from the analysis results, the following conclusions can be drawn.

- Comparison of all the parameters are made which can give us better idea about the behaviour of the building is rectangular shape is always better of C-shape.
- As a result of comparison between static method and response spectrum method it has been observed that the values obtained by static analysis of base shear and top storey displacement are higher than response spectrum analysis.
- It has been observed that the higher values obtained by base shear and top storey displacement.
- The maximum storeys drift for 15th storey in rectangular and C shape buildings.
- Base shear force value from dynamic analysis is 9 % more than the base shear force from static analysis for both different building.
- Top displacement values from dynamic analysis is 12 % lesser than the displacement from static analysis for both different building.
- To the initial stiffness of the building reduces with increasing damage. Stiffness of building increase to decrease deformation.

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