Story Drift of Buildings with Various Shapes using Etabs Software

Jitendra Choubisa

Abstract: ***A stable and durable structure is a need of today's engineering world. From the tallest skyscrapers to the appealing houses, stability towards the external loads matters a lot. A large amount of manual work is needed to be done in order to perform the thorough analysis of structure, which in turn takes time. In order to save time, computer aided modelling comes handy. Etabs is such kind of software. With its easy to use user interface it can handle complex tasks. In this paper a comparison is done for the story drift, maximum bending moment & maximum base reaction for earthquake loading (static analysis) between 4 shapes of building (Box, H Shape, Hollow Shape and U shape) using Etabs software and it was found that structures with symmetry perform quite good at the time of earthquake loading. The graphs showed the story drifts in less amount for symmetric shapes H, Box and Hollow.***

Keywords: ***Story drift, Etabs, analysis, bending moment, software, modelling, structures, design.***

I. INTRODUCTION

Nowadays most of the designs are done with the help of computer aided modelling. In regards to that here we are going to use Etabs to analyze different structures. Etabs is a great tool when economic design is needed, with its super easy UI you can control multiple aspects of modelling at once and with the accurate results one can study the structure. Here we are modelling mainly four shapes of building, viz. Box shape, H shape, Hollow Box Shape & U shape. We are going to model them for different stories, viz. 5- story, 10 story & 15 Story and then we will focus on mainly the story drift of topmost story, Maximum bending moment of a sample beam on 1 story & Maximum base reaction on a joint at the lowest point on 1 story.

The geometric properties used for the model are as follows:

1. Dimension of Structure: 30 X 20 m
2. Story Height : 3 m
3. Code used: **IS 1893:2002, IS 456:2000 & IS 875 (Part I):1997**
4. Earthquake Zone: III (Z = 0.16)
5. Earthquake force range: Base to Top story
6. Type Of Soil: Type II (Medium Soil)
7. Importance Factor: 1
8. Shapes: Box, H, U & Hollow
9. Support condition: Fix

II. LOADING CONSIDERATION

A. DEAD LOAD

S.no	Component	Dead Load
1	Beams	11.36 kN/m
2	Roof Beams	2 kN/m
3	Floors	2.5 kN/m^2.

Dead load for beam calculations:

Height of wall = Floor height – Depth of beam
= 3 – 0.4 = 2.6 m
Thickness of wall considered = 9 inches or 230 mm
Length considered as 1 m (unit)
Unit Weight of brick masonry = 19 kN/m^3 [6]
Dead Load of wall= (2.6 x 0.23) x 19 = 11.362 kN/m

Parapet wall load on roof beams is considered as 2 kN/m.
Floor finish load of 0.5 kN/m^2 with a standard 2 kN/m^2 dead load for floors are used.
Self-weight of component is automatically get calculated by Etabs.

B. LIVE LOAD

S.No	Component	Live Load [2]
1	Beams	-
2	Roof Beams	-
3	Floors	3 kN/m^2

C. EARTHQUAKE LOAD

S.No	Component	Response Reduction [7]
1	EQ X+ Direction	5
2	EQ Y+ Direction	5

III. SHAPES OF MODEL IN STUDY

Four different shapes of buildings are modelled here in e-tabs. The shapes are H shape, Box Shape, Hollow Shape and U shape. Three of them are symmetric in shape and one is asymmetric. To test the models, grid is defined first and then the structure is drawn. Fig. 1 below shows the plan of models are as follows.

Revised Manuscript Received on March 15, 2020.
Jitendra Choubisa, Techno India NJR Institute of Technology, Udaipur, India. E-mail: **choubisa.jitendra7@gmail.com**

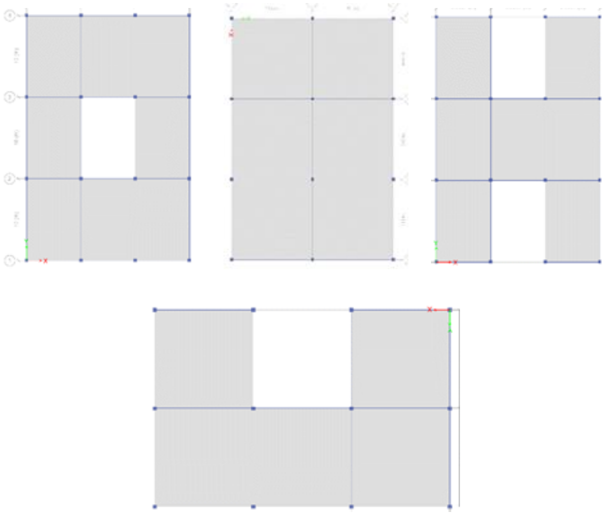


Fig. 1. Plans of Hollow, Box, H & U Shapes.

A. BOX PLAN (With Dimensions)

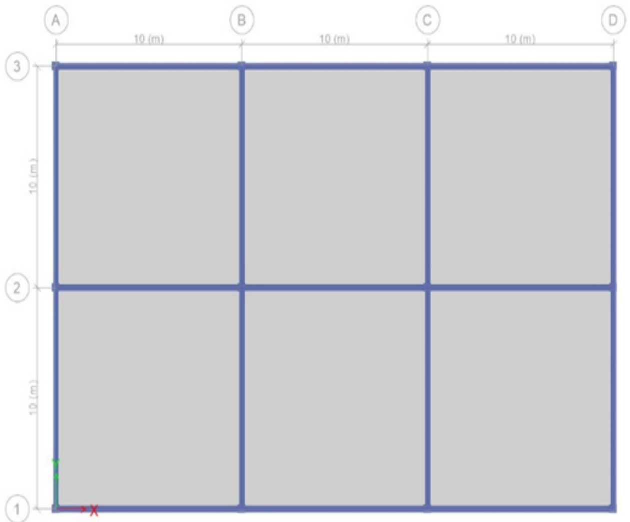


Fig. 2. Plan of Box Shaped Building

B. H Shape (With Dimensions)

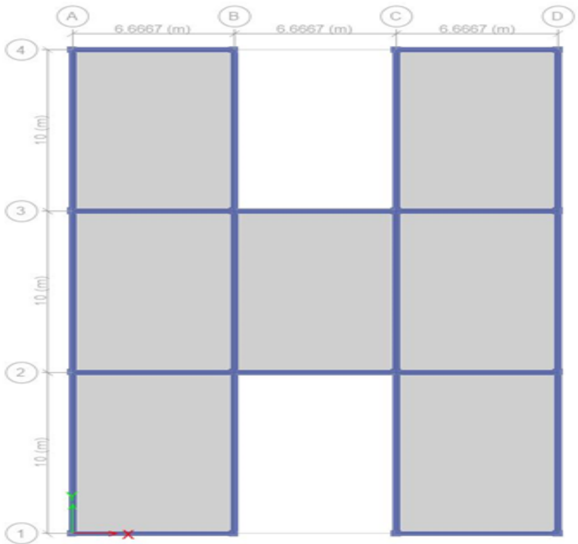


Fig. 3. Plan of H Shaped Building

C. Hollow Shape (With Dimensions)

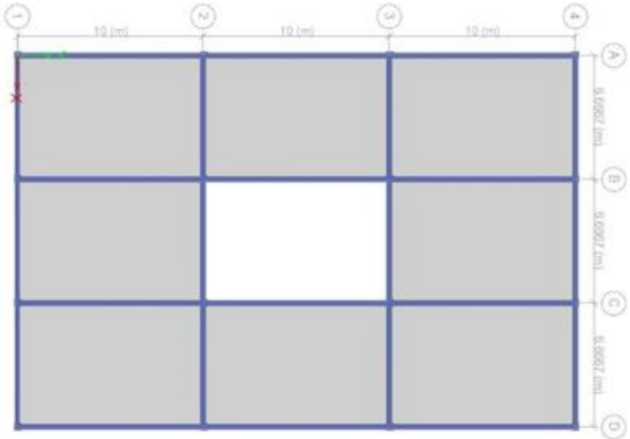


Fig. 4. Plan of Hollow shape

D. U PLAN (With Dimensions)

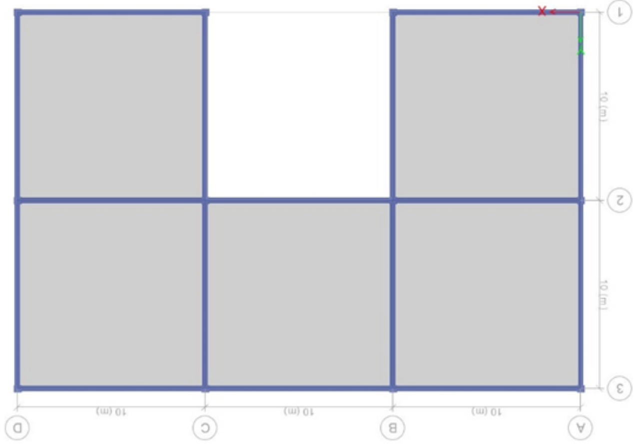


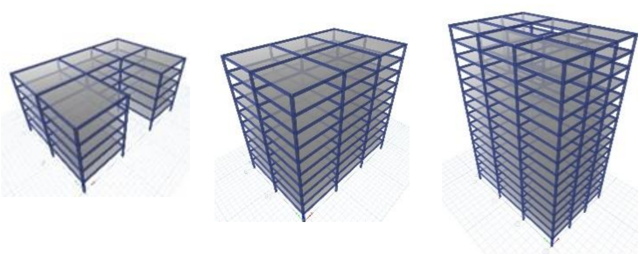
Fig. 5. Plan of U shape

IV. ELEVATIONS OF BUILDINGS

A. Number of stories and Story Height

Number of stories = 5, 10 & 15 Stories of each shape (total of 12 Cases to be studied)

Each Story Height = 3 m



U Shape 5 Story Box shape 10 Story Hollow 15 Story

Fig. 6. Elevations

Each of the 4 shapes are modeled and analysed at all the stories. So a total of 12 case have been studied for this research work.

U Shape is aligned such that its longer span runs parallel to the positive x axis and shorter spans along the positive y axis. The orientation of asymmetric building plays a vital role in earthquake and wind attacks.

V. MEMBER SIZES & MATERIAL PROPERTIES

A. MEMBER SIZES

Table- I: Sizes of Members

S.NO	MEMBER	SIZE
1	Beams	250 x 400 mm
2	Columns	400 x 400 mm
3	Slab	150 mm
4	Walls	230 mm

B. MATERIAL PROPERTIES

Table- II: Material Properties [5]

S.NO	MEMBER	MATERIAL
1	Beams	M25 Concrete
2	Columns	M25 Concrete
3	Slab	M25 Concrete
4	Walls	Brick Masonry
5	Steel	Fe 415

VI. METHODOLOGY

The process of modelling is as follows:
Step-1 Preparation of grid and stories.
Step-2 Defining Material properties.
Step-3 Defining Members & their respective sizes.
Step-4 Placing members on their respective places.
Step-5 Defining Load patterns & Load combinations.
Step-6 Applying Dead loads on beams and floors.
Step-7 Applying Live loads on floors.
Step-8 Applying support conditions.
Step-9 Model checking is done.
Step-10 Analyzing the model

VII. PRE- ANALYSIS MODEL

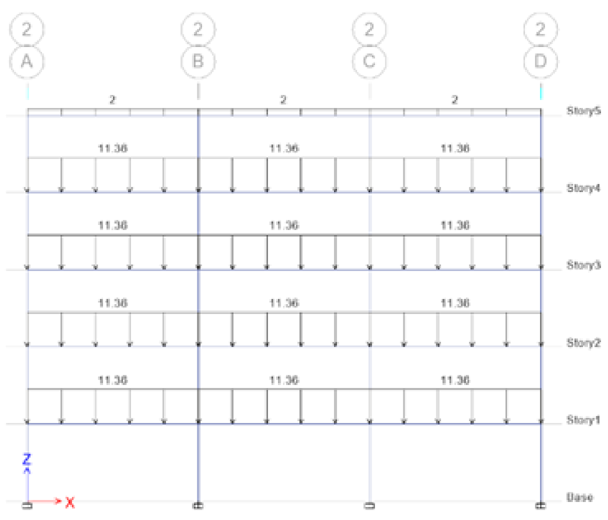


Fig. 7.Dead Load on floor beams & Roof beams

Fig. 8.H Shape 15 Story

VIII. POST ANALYSIS RESULTS

Table- III: Story Drift Results

COMPARISION BETWEEN STORY DRIFT (in mm)				
Drift of TOPMOST story in X- Direction (mm)				
S.NO	**SHAPES**	**5 STORY**	**10 STORY**	**15 STORY**
1	**Box**	13.396	28.257	46.73
2	**Hollow**	10.139	21.45	33.18
3	**H Shape**	10.166	21.768	34.13
4	**U Shape**	13.904	27.61	45.02
Above drifts are due to earthquake loading Eq X+				

Table- IV: Base Reactions

COMPARISION BETWEEN MAX. BASE REACTION (in kN)				
Base reaction on sample column in Fz-Direction (kN)				
S.NO	**SHAPES**	**5 STORY**	**10 STORY**	**15 STORY**
1	**Box**	1618	3403.45	5317.73
2	**Hollow**	1211.14	2590.53	4111.34
3	**H Shape**	1251.98	2603.47	4000.11
4	**U Shape**	3272.02	3509.63	5384.66
Above reactions Are Due To **(DL + LL)** Loading				

Table- V: Bending Moments

COMPARISION BETWEEN MAX. BENDING MOMENTS (in kN-m)				
Maximum bending moment on a sample beam (kN-m)				
S.NO	**SHAPES**	**5 STORY**	**10 STORY**	**15 STORY**
1	**Box**	330.14	326.84	325.16
2	**Hollow**	129.91	126.04	122.87
3	**H Shape**	127.91	128.01	128.19
4	**U Shape**	355.63	355.82	356.1
Above moments Are Due To **1.5(DL + LL)** Loading				

IX. COMPARISON OF RESULTS

A. STORY DRIFT:

As it can be seen that story drift is varying in each and every story of all the shapes under EQ X+ & EQ Y+ loading. It is now evident from results that Hollow Shape is getting lowest story drift in every case (Highlighted cell).

B. MAXIMUM BASE REACTION ON SAMPLE COLUMN:

Here again from the results we can see that Hollow Shape is getting lowest reaction for the base (Highlighted cell) under (DL+LL) unfactored loading. Alongside H shape again is performing well in this case also.

C. MAXIMUM BENDING MOMENT ON SAMPLE BEAM:

Hollow shape again is giving good results here with quite less maximum moment for the 1.5 (D.L+LL) load combination.

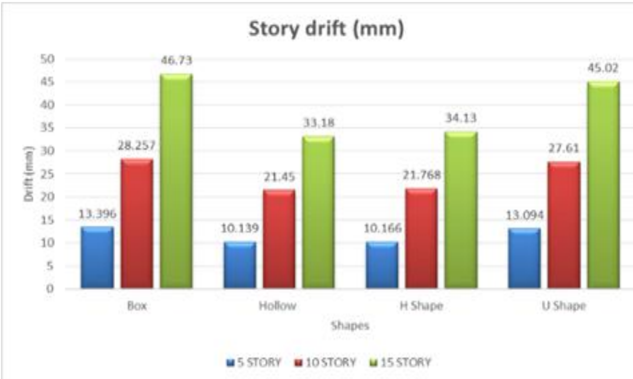


Fig. 9.Graph of Story Drift of various shapes and story

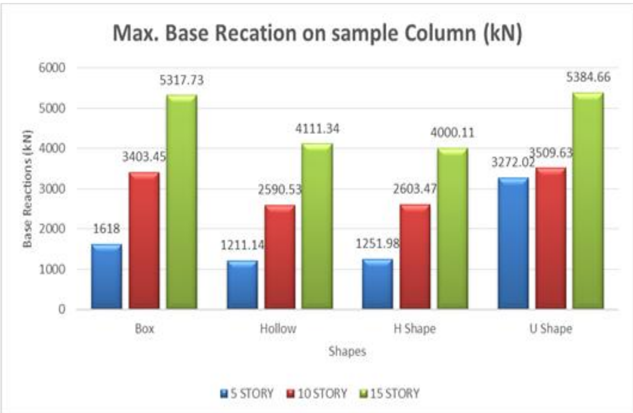


Fig. 10. Graph of Base Reaction of various shapes and story

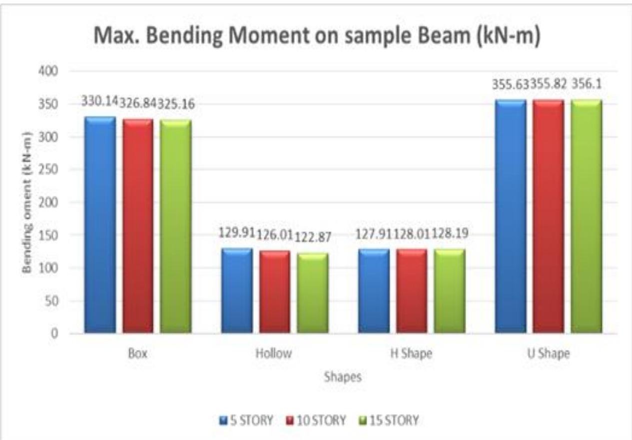


Fig. 11.Graph of Bending Moment of various shapes & story

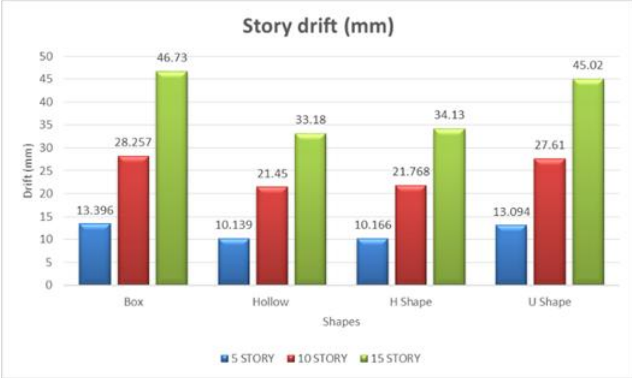


Fig. 12.Graph of Story Drift due to EQ Y+

Table- VI: Topmost Story Drift (in mm)

COMPARISION BETWEEN STORY DRIFT (in mm)				
Drift of TOPMOST story in Y- Direction (mm)				
S. no	SHAPES	5 STORY	10 STORY	15 STORY
1	**Box**	13.71	29	49.44
2	**Hollow**	11.41	24.1	36.91
3	**H Shape**	11.03	23.31	35.63
4	**U Shape**	13.03	27.61	44.81
Above drifts are due to earthquake loading Eq Y+				

An interesting pattern of story drift was seen in H Shape, when it behaves very well in EQ Y+ direction. It shows that longer spans deflects more in the respective loading direction and shorter spans deflects less.

Here it can be concluded that H Shape is also a good choice in selection of base profile of a building against the seismic & wind loads.

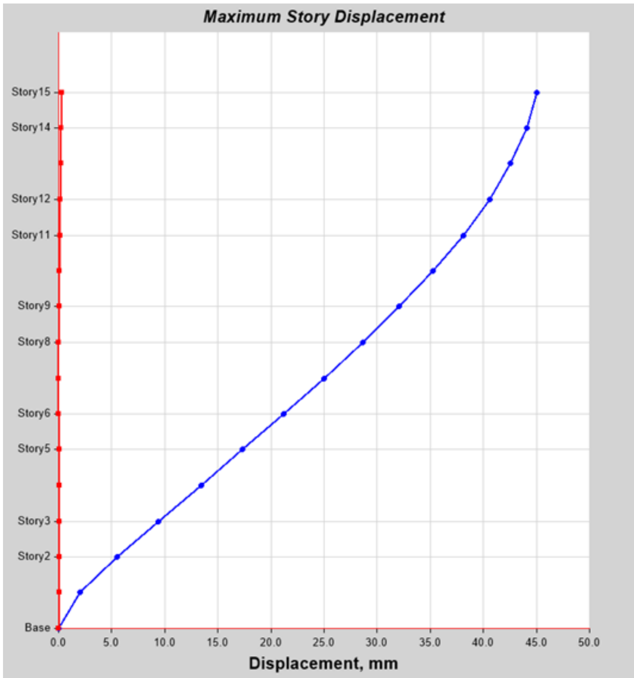


Fig. 13.Story Drift graph of U Shape model under EQ X+ loading

X. CONCLUSIONS

A. Box Shape:

i) Story drift for 15 story is the highest in Box Shape. Hence it is not suitable for the respective loading.
ii) Base reactions are also quite high than others so again not economic.
iii) High Bending moment in box shape will require more steel. Hence increasing the cost of building. So it will be not economic.

B. Hollow Shape:

i) Story drift is lowest among all the shapes, hence it is quite suitable.
ii) Base reactions are quite low also, so again it'll be a good choice.
iii) Lowest bending moment makes it quite favorable for planning.

C. H Shape:

Performance of H Shape is almost same as that of Hollow Shape. Hence H and hollow shape both can be used depending upon the space requirements

D. U shape:

This shape is performing quite badly in all the perspectives. Story drift is highest among all the shape. Base reaction are also quite big and high bending moment makes it quite uneconomic for the present case. Maybe its orientation can do some good to the problem.
So, at last we can conclude that **H & Hollow shape** can be economic for the high-rise building prone to earthquake attacks. Whereas Box will be given priority after them. And U shape must have to be avoided.
Building having symmetric shapes can handle wind load and earthquake efficiently. Also the placement of shear walls plays and important role against the overall drift. In some cases it was found that bracing also helps in reducing the drift caused by wind and seismic. The U shape which performed badly in this analysis can be improved by adjusting its orientation and with the help of bracing and shear walls, it can be made stiff against the seismic & wind loads.

XI. FUTURE SCOPE

Nowadays the main challenge in the civil engineering world is to design the buildings against earthquake. The simplistic approach in this paper will guide the planners for selecting the base plan of any building prone to earthquake attacks. The symmetric shapes will help the planners to get and basic idea about how the building will behave under seismic attack. For more complex parameters dynamic approach for earthquakes must have to be done so as that one can get accurate results.

REFERENCES

1. R. Agarwal, Prof. A Tiwari, Comparison of Design Result of Multi Story Structure using ETABS and STAAD PRO Software, published in IJESC, Vol 7, Issue No. 8.
2. M. Sabeer, D. Gouse Peera, Comparison design result of RCC building using staad and etabs software, published in IJIRAE, Vol 2 (Aug 2015), Issue 8.
3. Prashanth, Anshuman, Pandey, A. Herbert, Comparison of design results of a Structure designed using STAAD and ETABS Software, published in IJCSE, Vol 2, No 3, 2012.
4. Ramanand Shukla, Prithwish Saha, Comparative study of a G+10 storied building using ETABS and STAAD, published in IJSRST, Vol 3, and Issue 6.
5. V.ramanjaneyulu, Dharmesh.m, V.chiranjeevi, Comparative study on design results of a multi-storied building using staad pro and etabs for regular and irregular plan configuration, published in IRJET, Vol, and Issue 1.
6. Sayyed A. Ahad, Hashmi S Afzal, Pathan Tabrej, Analysis and Design of Multistory Apartment Building Using ETABS, published in IJECS, Volume 6 Issue 5 May 2017.
7. Ali Kadhim Sallal, Design and analysis ten storied building using ETABS software-2016, published in IJRAET, Volume 4; Issue 2; May 2018.
8. Rinkesh R Bhandarkar, Utsav M Ratanpara, Mohammed Qureshi Seismic Analysis & Design of Multistory Building Using Etabs, published in IJEDR Volume 5, Issue 2, 2017.

AUTHORS PROFILE

Jitendra Choubisa, Lecturer, Civil Engineering Department, Techno India NJR Institute of Technology, Udaipur (India).

.