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Linear and Non Linear (Pushover) Analysis of An Irregular Shape Multistorey Building with Different Shear Wall Position

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Abstract: **Nowadays, many of the buildings are traced by irregular in both plan and vertical configurations. Due to these irregularities in arrangement and deficient in symmetry might imply vital eccentricity between the stiffness centre and building mass, and give rise to damage in the form of coupled lateral response. One of the most commonly used lateral load resisting system is the shear wall system. Shear walls may be defined as the vertical planar elements, made up of RCC material and efficient in resisting lateral loads produced due to seismic actions. The irregularity of the building may be horizontally or vertically. In the present study an irregular shape multistory building is analyzed using shear walls at different positions to know the seismic behavior through seismic parameters like Time period, Base Shear, Storey Drift, Storey Displacements, Column Moments and Beam Moments. The analysis is carried out on different models using Equivalent Static Force Method (linear), Response Spectrum Method (linear), and Pushover Analysis Method (non linear) using ETABS application software.**

Keywords— Base Shear, Equivalent Static Force Method Pushover, Pushover Analysis Method, Response Spectrum Method, Shear Wall, Seismic Parameters, Storey Drift, Time Period.

I. INTRODUCTION

One of the most commonly used lateral load resisting system is the shear wall system. Shear walls may be defined as the vertical planar elements, made up of RCC material and efficient in resisting lateral loads produced due to seismic actions. The irregularity of the building may be horizontally or vertically. Shear walls helps in reducing the dimensions of the beams and columns, which in turn helps in reducing the cost of the buildings. In the present study the shear wall is used as a barrier for resisting the lateral forces and also to reduce the lateral stiffness and lateral deflections when seismic actions come into picture.

II. LITERATURE REVIEW

Dr. S. A. Halkude, Mr. C. G. Konapure, Ms. C. A. Madgundi conducted investigation on “Effect of Seismicity on Irregular Shape Structure”. In their G+11 Building by varying the percentage length of shear wall along with possible combinations of shear wall location, they concluded that the seismic effects were resisted effectively by providing the closed box type shear walls [1]. Dr. H.S. Chore, P.A.Dode, N.L.Sawakare studied the “Effect of Shear Wall on Response of Multi-storied Building Frame”. In their study on G+12 rcc building by considering two types of structural systems, they concluded that the large dimension of shear wall helps in taking the major amount of horizontal forces [2]. S.A. Halkude, C.G. Konapure and S.M.Birajdar carried reaserch work on “Effect of Location of Shear Walls on Seismic Performance of Buildings”. In their work on a G+9 storey building (2 cases) consisting of 10% and 20% shear wall length in each case respectively they concluded that as the shear wall length increases the stiffness of the structure also increases [3]. Kashiwa Sagar K., Prof. M.R.Wakchaure, Anantwad Shirish studied the “Effects of Numbers and Positions of Shear Walls on Seismic Behavior of Multistory Structure”. They concluded that the stiffness of the building increases by adding shear wall to the structure thus reducing damage [4]. Aung Mon, Tin Tin Htwe did research work of “Study on Performance of Discrete Staggered Shear Walls in 25-Storeyed RC Building”. In their G+24 building having irregular vertical rectangular shape they concluded that the use of diagonal shear wall structure is more suitable than zigzag shear wall structure [5].

III. BUILDING DESCRIPTION

The plan of the RC SMRF building is as shown in the Fig 1 . The plans of the various models are as shown in the Fig 2 below. In this study the plan configuration is same for all the models. Each model is of 15 storeys with a depth of the foundation equal to 2m. Each storey height is kept equal to 3.2m for all the various building models. An irregular shape in plan configuration building in zone IV is considered for the study. Floor live load is taken exactly half (50%) for the calculation of the seismic weight. The design data applied for all the different building models is given below in Table 3.1.

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Table 3.1 Salient Features of the Building

Sl.No.	Specifications	Details
1.	Type Of Structure	SMRF
2.	Zone	IV
3.	Layout	as Shown in the fig.1
4.	Number of Stories	(G+15)
5.	Ground Storey Height	3.2m
6.	Floor-To-Floor Height	3.2m
7.	Wall Thickness	0.23m
8.	Live Load	3.0 KN/m^2
9.	Materials	M25 and Fe500
10.	Seismic Analysis	ESA, RSA And Pushover
11.	Design Philosophy	Limit State Method Conforming To IS 456 : 2000
12.	Size of Column	(0.35x0.90) m
13.	Size of Beams in Longitudinal and Transverse Direction	(0.23x0.60) m
14.	Total Thickness of Slab	0.150 m

IV. MODELLING AND ANALYSIS

In the present study about 13 models where considered with following models such as bare frame, full infill, shear wall at different positions with infill. The analysis is done using ETABS. The plan layout for all the models is same as shown in the Fig 1 below. Model 3 to Model 13 are same as Model 2 but only the infill is replaced by Shear Wall at required positions. The shear wall run throughout the height of the building and has constant 5m length in every model.

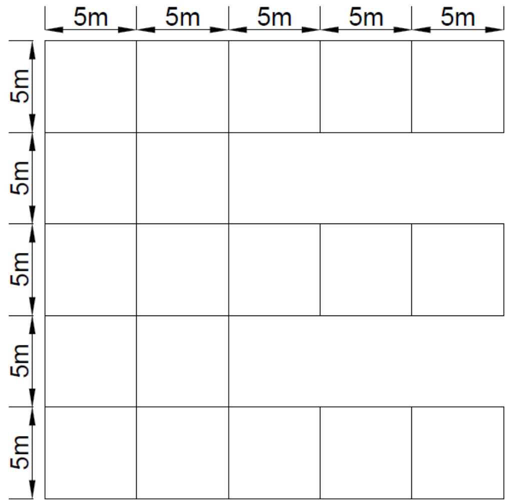

Fig 1. Plan Layout

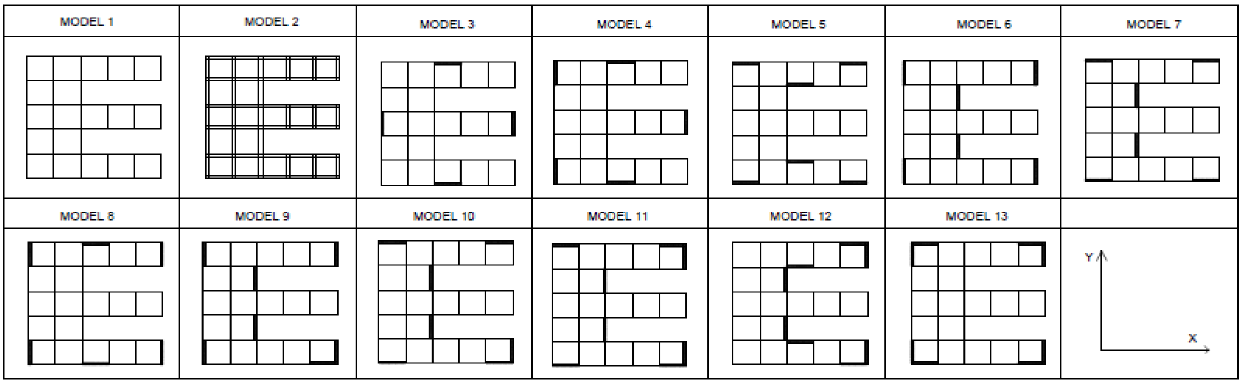

Fig 2. Proposed Model

Model 1: Bare Frame with mass of infill .Model 2: with brick infill masonry wall run throughout the height of the building. Model 3: With 2 horizontal shear wall and 2 vertical shear walls at middle of outer edges. Model 4: With 3 vertical shear walls (i.e. 2 at outer corners and 1 at middle) and 2 horizontal shear walls (i.e. at middle of top and bottom) at the edges. Model 5: With 6 horizontal shear walls with 4 at outer edge corners and at middle of inner edges. Model 6: With 6 vertical shear walls, 4 at outer edge corners and 2 at middle of inner edge. Model 7: With 6 shear walls, 4 horizontal at outer edge corners and 2 vertical at middle of inner edges. Model 8: With 6 shear walls, 4 vertical shear walls at outer edge corners and 2 horizontal shear walls at middle of outer edges. Model 9: With 7 shear walls, 6 vertical shear walls (4 at outer edge corners and 2 at inner edges) and one horizontal shear walls at outer edge corner. Model 10: With 7 shear walls, 4 horizontal at outer edge corners and 3 vertical shear walls (2 at inner edge and 1 at outer edge). Model 11: With 8 shear walls, 4 vertical (2 at inner edge and 2 at outer edge corners) and 4 horizontal at outer edge corners. Model 12: With 8 shear walls, 4 vertical (2 at inner edge and 2 at outer edge corners) and 4 horizontal (2 at inner edge and 2 at outer edge corners).Model 13: With 8 shear walls, 4 vertical and 4 horizontal at outer edge corners.

V. RESULTS AND DISCUSSION

5.1. Fundamental Time Period

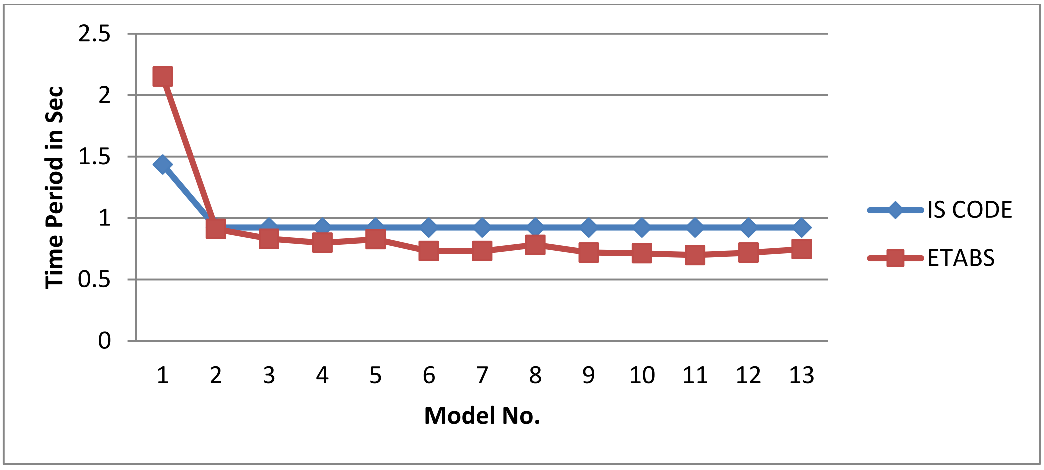

Chart 1. Time Period Vs Models.

The above graph (Chart 1.) shows the variation of time period for the different models obtained using IS code and ETABS analysis. It shows that natural time period of bare frame model from ETABS analysis resulted in higher value as compared to the value obtained from the IS code. Time period is smallest for model 11 in ETABS analysis when compared to other infill category models (i.e. from Model 2 to Model 13). Therefore it can be clearly understood from the Chart 1 that the infill and the shear walls, decrease the natural time period of the building.

5.2. Design Seismic Base Shear

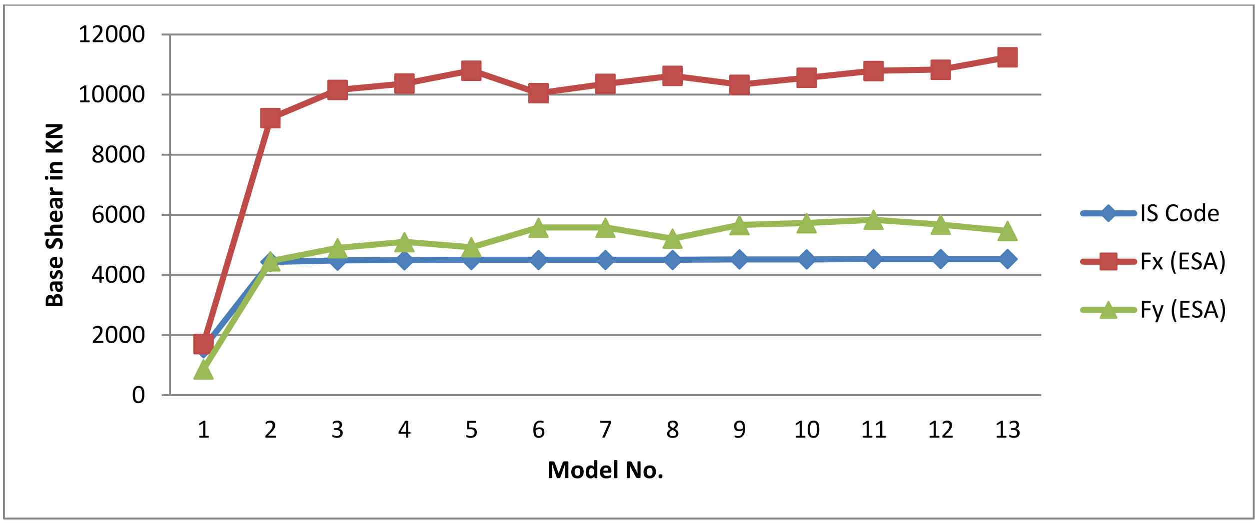

Chart 2. Base shear Vs Models

From the graph (Chart 2) it is seen that the values of Base Shear for the Bare Frame in both the methods are least as compared to other models. The IS code method graph lies at the bottom, which means that the codal method gives the lower values of base shear than ETABS.

International Journal of Engineering Research & Technology (IJERT)
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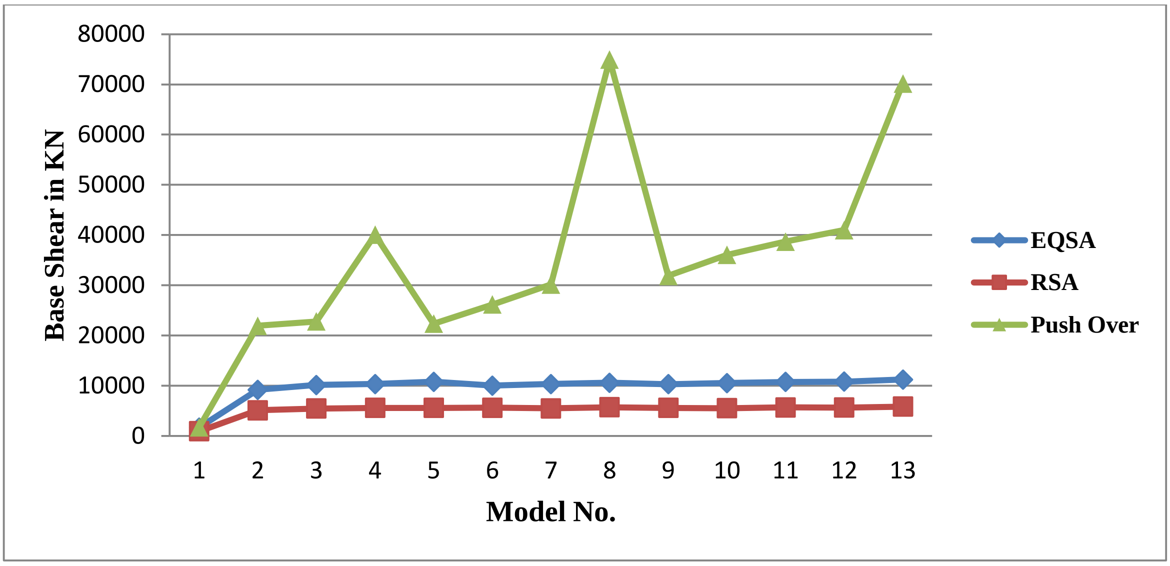

Chart 3. Comparison of Base shear by ESA, RSA, and Pushover for various Models along longitudinal direction.

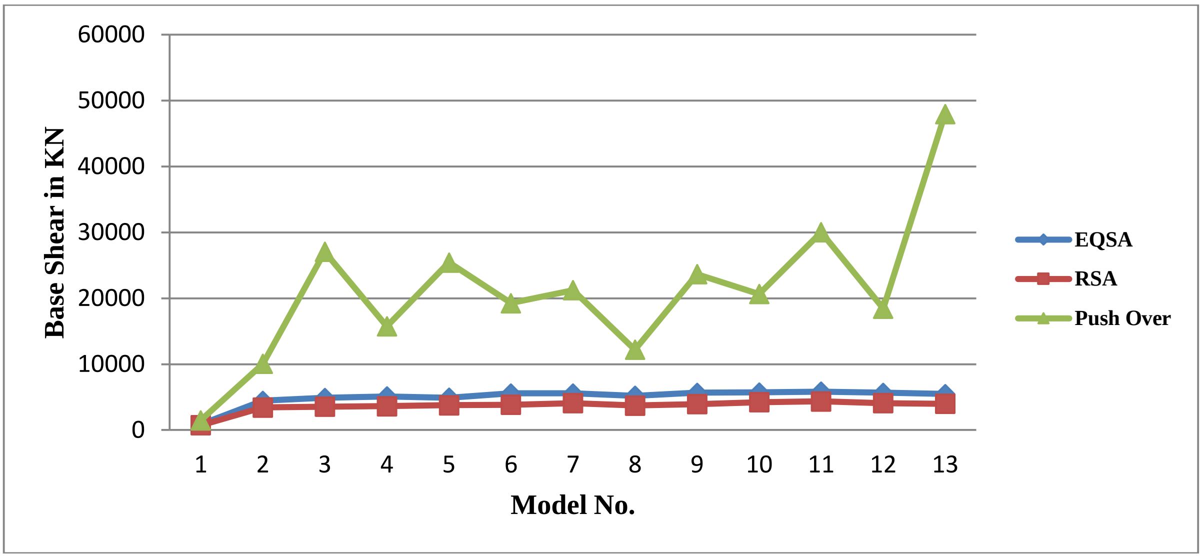

Chart 4. Comparison of Base shear by ESA, RSA, and Pushover for various Models along transverse direction

The above graph (Chart 3 and Chart 4) for Base shear shows least value for the Bare Frame (Model 1) in all the 3 methods of analysis performed using ETABS. Pushover analysis lies at the top, showing higher values with greater variation of Base shear in different models.

5.3. Storey Drifts

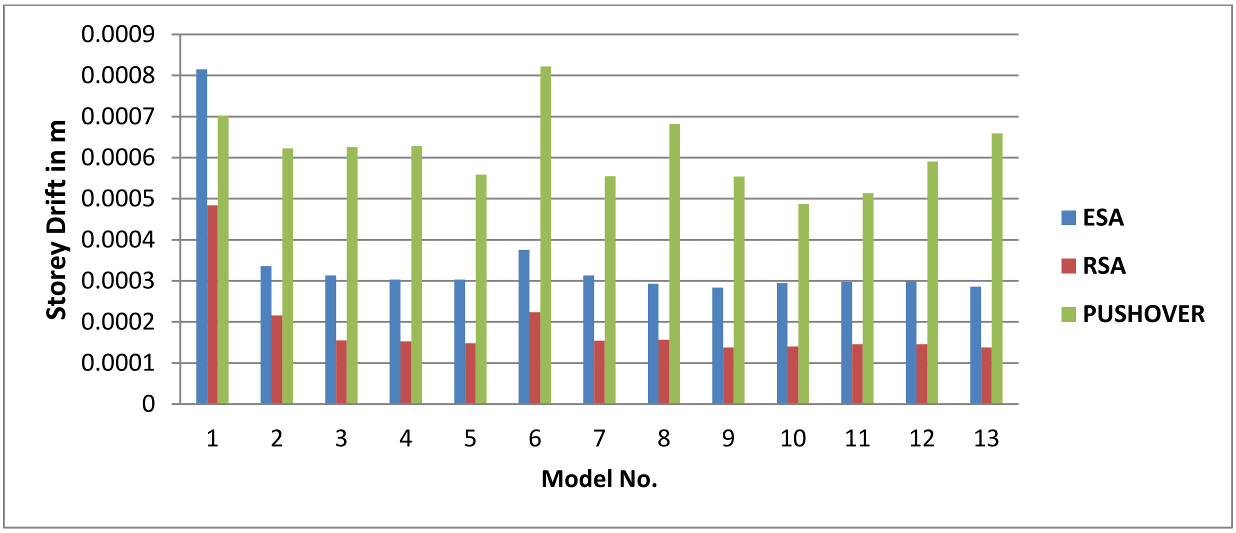

Chart 5. Comparison of Storey Drift, Models and Methods of Analysis along longitudinal direction

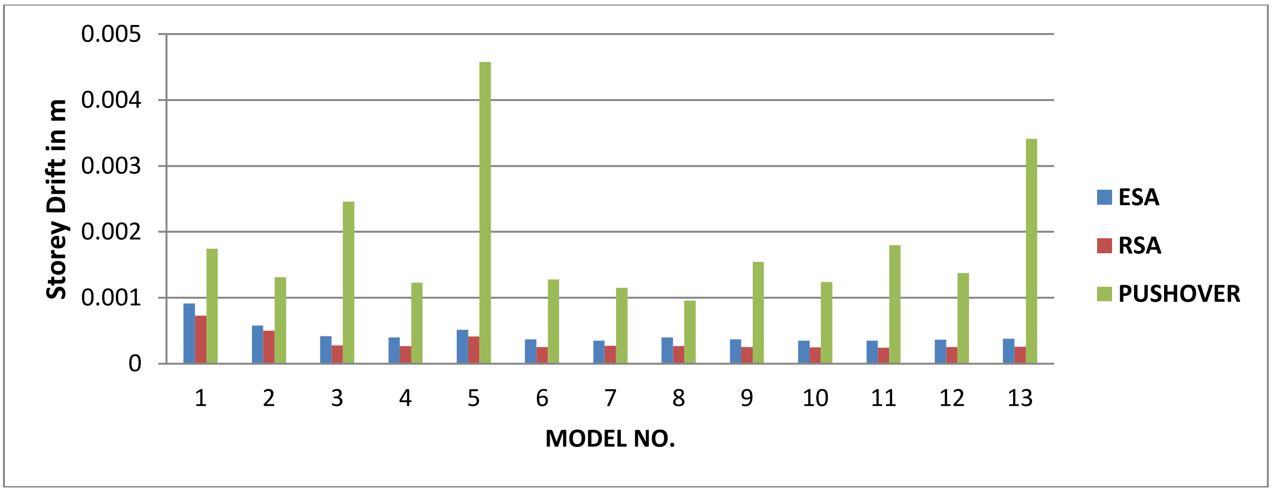

Chart 6. Comparison of Storey Drift, Models and Methods of Analysis along transverse direction

The graphs Chart 5 and Chart 6 show the comparison of Story drift values of different models along transverse and longitudinal direction obtained using ESA, RSA and Pushover analysis. From the above charts we can see that the values of drift are maximum in case of pushover analysis for models with shear walls. The Model 13 and Model 11 in RSA shows the minimum values of Storey drift along transverse and longitudinal direction respectively in RSA when compared to other models with shear walls. The storey drift values are maximum for Bare frame model along longitudinal in ESA and for model 5 along transverse in Pushover analysis

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5.4. Storey Displacement

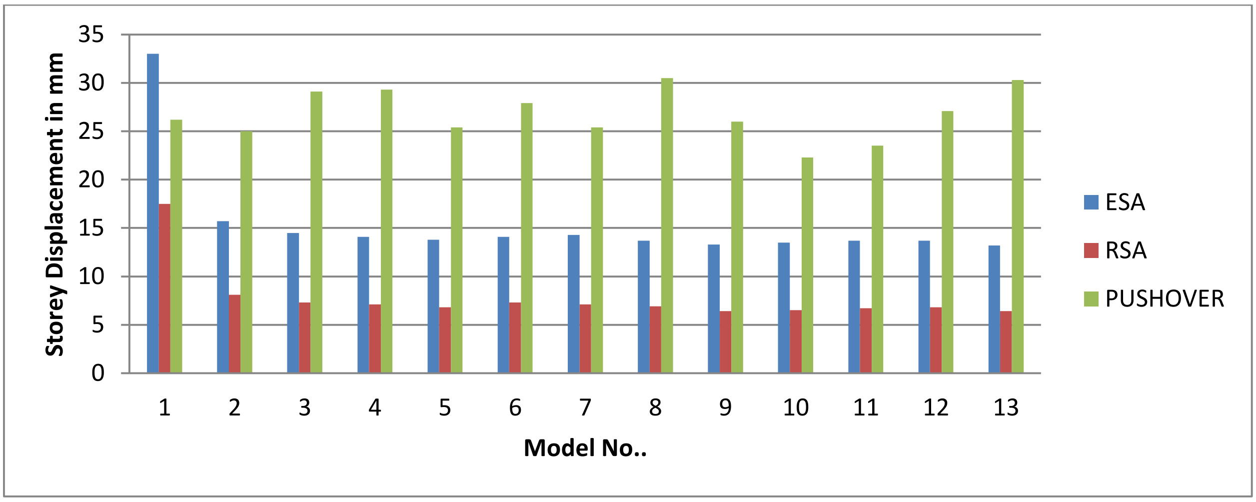

Chart 7.Comparison of Storey Displacement, Models and Methods of Analysis along longitudinal direction.

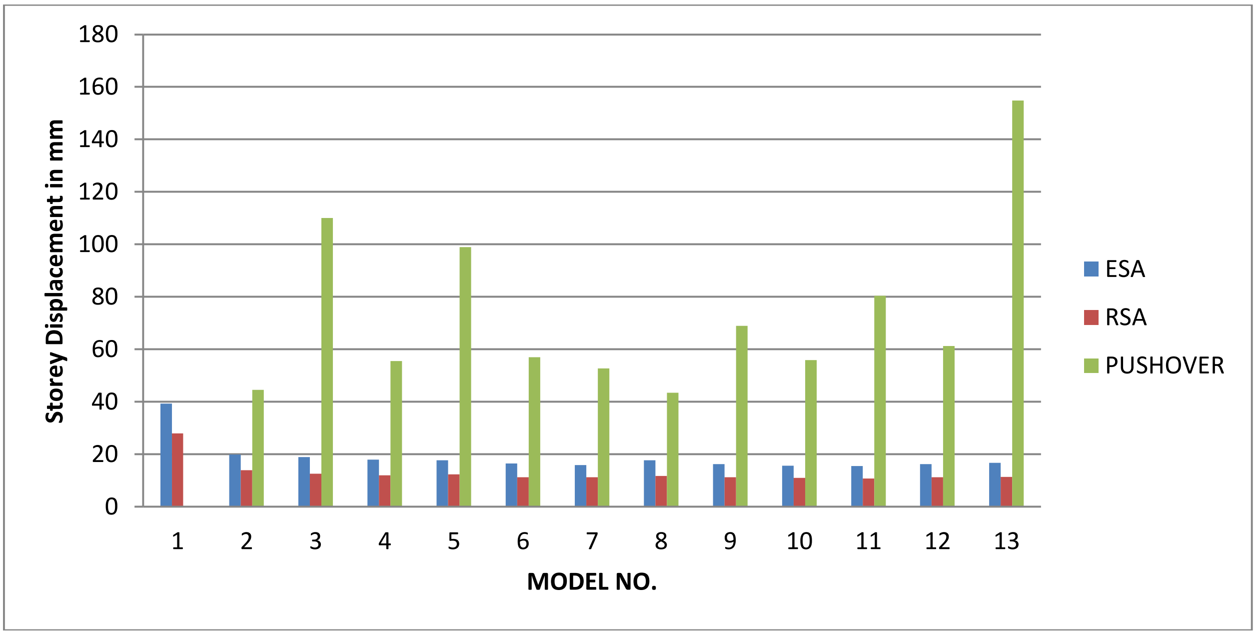

Chart 8. Comparison of Storey Displacement, Models and Methods of Analysis along transverse direction.

The Chart 7 and Chart 8 shows the comparison of Story displacement values of different models along transverse and longitudinal direction obtained using ESA, RSA and Pushover analysis. From the charts it is seen that Model 9 and Model 13 showed minimum values of storey displacement in RSA along longitudinal direction. Model 11 along transverse direction in RSA showed minimum value when compared to the other models with shear walls. Graphs also show that the storey displacement is maximum for Bare Frame along longitudinal direction in ESA and also along transverse direction for model 13 in Pushover analysis.

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5.5. Beam Moments and Column Moments

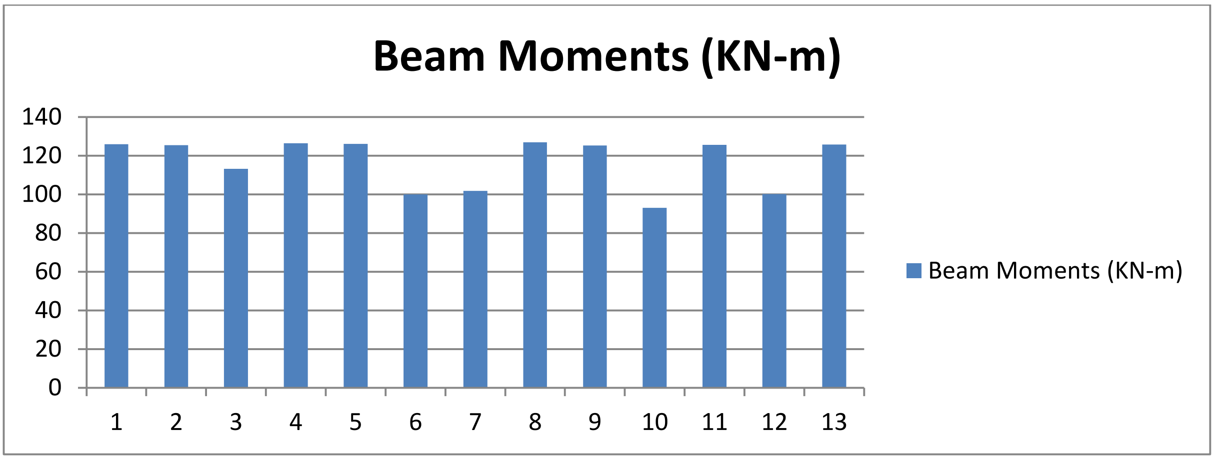

Chart 9. Beam Moment Vs Model No.

The Chart 9 shows the maximum values of beam moments for each model obtained by comparing ESA, RSA and Pushover analysis. It is found that the Beam moment for the model 8 is maximum (126.8980 KN-m) and model 10 (93.0701 KN-m) is minimum when compared to other models in all the methods of analysis.

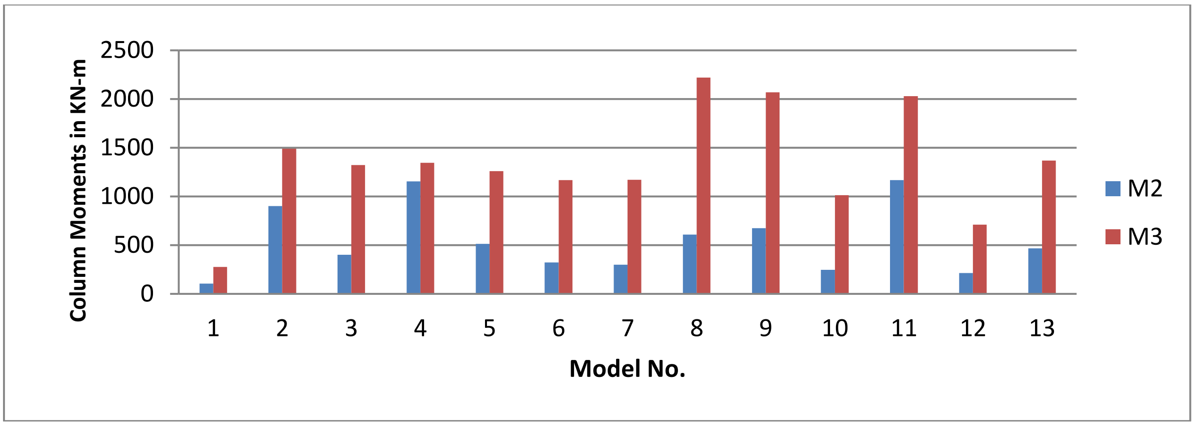

Chart 10. Column Moments for Different Models

The Chart 10 shows the maximum values of beam moments for all the 13 models obtained from ESA, RSA and Pushover analysis. It can be noted that the column moments are maximum for Model 11 (M2 = 1166.4374KN-m) and Model 8 (M3 = 2219.2285 KN-m) and minimum for the Model 1 (M3 = 103.15KN-m and M3 = 273.88 KN-m).

VI. CONCLUSION

1. From the analysis using ETABS the fundamental Time Period showed lower values than IS code method, hence the time period can be reduced by providing shear walls at centre and outer edge corners in longitudinal direction for the irregular shape buildings.
2. From both IS Code and ETABS (ESA, RSA and Pushover) methods the Bare Frame is found to have least Base Shear values. It increases as the shear walls are added to the structure.
3. Pushover analysis give higher values of base shear in all the models compared to other methods of seismic analysis.
4. Design Seismic Base Shear obtained from using IS Code method is not in a good agreement with the values obtained from Equivalent Static method of analysis in ETABS.
5. The Storey Drift values are within the limits specified by the IS 1893-2002 (Part 1).
6. Storey Drifts can be reduced by providing the shear walls at the outer edge corners in both direction and also vertical shear walls at centre of the structure. It increases with the reduction of

shear walls in the structure and is also maximum for the model with only longitudinal (horizontal) shear walls.

7. Increase in number of shear walls is effective in reducing the Storey Displacements.
8. Providing the shear walls at outer edge corners as well as at centre (vertical direction) helps in reducing the values of storey displacements.
9. The beam moments can be reduced by providing shear walls at outer edge corners in horizontal (longitudinal) direction and at centre in vertical (transverse direction) direction. It increases as shear wall number in both direction are nearly equal each other.
10. Column moments can be controlled by providing shear walls in both directions at centre as well as outer edge corners.
11. Hence from the above work it can be concluded that the model with shear walls at corners as well as at centre (with vertical orientation) helps in controlling the seismic parameters.

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