

Comparative Static and Dynamic Study on Seismic Analysis of Uniform and Non Uniform Column Sections in a Building

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ABSTRACT: An attempt is made to understand difference of dynamic and static earthquake analysis and corresponding shear forces arising in 8 -storied reinforced concrete frame structure with column section varying at certain floor levels for case1 of the model and column section remaining uniform throughout the building in case2 of the model . The comparison between two models is made for both static and dynamic earthquake analysis. Conclusions are derived regarding the effects of varying column sections and uniform column section between two models. The values of storey drift, storey maximum displacements, storey shear forces were plotted for both cases of models. Both models were checked for Soft Storey and reinforcement of columns were designed and compared with each other.

KEYWORDS: Static Analysis, Dynamic Analysis, Comparative, Soft Storey, Uniform, Non-Uniform, Storey Shear

I. INTRODUCTION

Many of the buildings are analysed for earthquake loads and designed accordingly. This study includes analysis of RCC frame by both static and dynamic methods and hence compare the difference between the two methods. Static method includes seismic coefficient method and dynamic method includes response spectrum method. It is intended to know comparative variation in shear forces, displacements and drifts in columns for both cases of the building where except column size all loading conditions are same. Both cases of building are designed for 20 different load combinations given by ETABS and selection of appropriate model is done based on analysis and design results.

[1]S.S. Patil et al analysed high rise buildings by response spectrum method using STAADPRO with various conditions of lateral stiffness system. Analysis was done with response spectrum method. Analysis produced the effect of higher modes of vibration & actual distribution of forces in elastic range in a better way. Test results including base shear, story drift and story deflections were presented and got effective lateral load resisting system.

[2] Bahador Bagheri et al analysed about Comparative damage assessment of irregular building based on static and dynamic analysis. In order to evaluate the damage of building, a procedure that compares displacement demands obtained by various methods of analysis, and their displacement capacities was proposed. To achieve objective, a 20 storey irregular building was modeled, and the displacement demand of model had been obtained, using equivalent static, time history and response spectrum analysis. ELCENTRO and CHI-CHI recorded accelerograms were used to perform time history analysis on building.

[3] B. Srikanth et al analysed 20 storied building by both methods. . In Response Spectrum Method, the time periods, natural frequencies and mode shape coefficients were calculated by MATLAB program then remaining process was done by manually. The modal combination rule for Response Spectrum Analysis was SRSS. The main parameters

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considered in this study to compare the seismic performance of different Zones i.e. II and V were Base Shear, Storey Moment and lateral forces.

[4] Sayed Mahmoud and Waleed Abdallah studied about response analysis of multi-storey RC buildings under equivalent static and dynamic loads according to Egyptian code. This research studied reinforced concrete building as a typical fourteen storey flat slab-column system located in Cairo. In order to account for the modal damping effect, the complete quadratic combination (CQC) technique, which takes into account the statistical coupling between closely spaced modes caused by modal damping, was used for modal combination. The first modelling step with ETABS involves defining the physical properties of the used materials.

[5] Mohammed Yousuf ,P.M. Shimpale did a research about "Dynamic Analysis of Reinforced Concrete Building with Plan Irregularities". Paper aimed towards the dynamic analysis of reinforced concrete building with plan irregularity. Four models of G+5 building with one symmetric plan and remaining irregular plan had been taken for the investigation.

II. STATEMENT OF THE PROBLEM

Case 1:

- Plan area =12(m)*12(m)
- Beam size =300(mm)*400 (mm)
- Column size =300(mm)*600 (mm) -1st storey
=300(mm)*500(mm) - 2nd 3rd 4th storey
=300(mm)*400(mm) - 5th 6th 7th 8th storey
- Slab =125 mm
- Beam length and column c/c spacing =4m
- Typical storey height = 3m
- Bottom storey height = 4m
- Live load =3kN/m²
- Wall load =10 kN/m in all beams
- Beam clear cover =25 mm
- Column clear cover =40 mm
- M25, Fe415 ,Zone V , Soil Type (II)

Case 2:

- Column size =300(mm)*600(mm) throughout the building

All other values are kept same as in case 1.

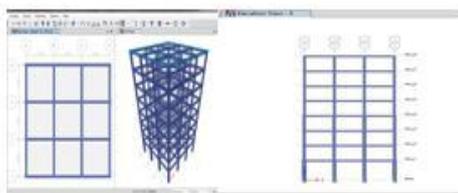


Fig: 1 Plan, 3D& Elevation of case1

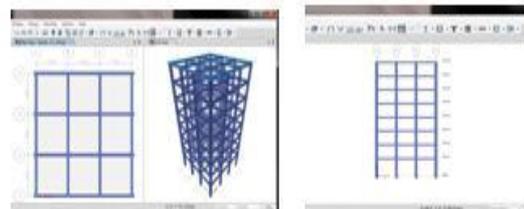


Fig: 2 Plan, 3D & Elevation of case2

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III. ANALYSIS RESULTS

Analysis was done in ETABS. Results from both static and dynamic analysis were obtained. The values of displacements, storey shears, storey stiffness, time periods were compared between two models.

Table 1 Displacement for x direction for both cases of models

storey no	static method		dynamic method	
	case1 displacement X(mm)	case2 displacement X(mm)	case1 displacement X(mm)	case2 displacement X(mm)
1	5.2	5.3	5.1	5.2
2	11.4	10.9	10.9	10.4
3	17.8	16.6	16.5	15.5
4	23.9	22.1	21.5	20
5	30.8	27.1	26.8	23.8
6	36.6	31.2	31.1	26.9
7	40.9	34.4	34.1	29.1
8	43.3	36.3	35.7	30.4

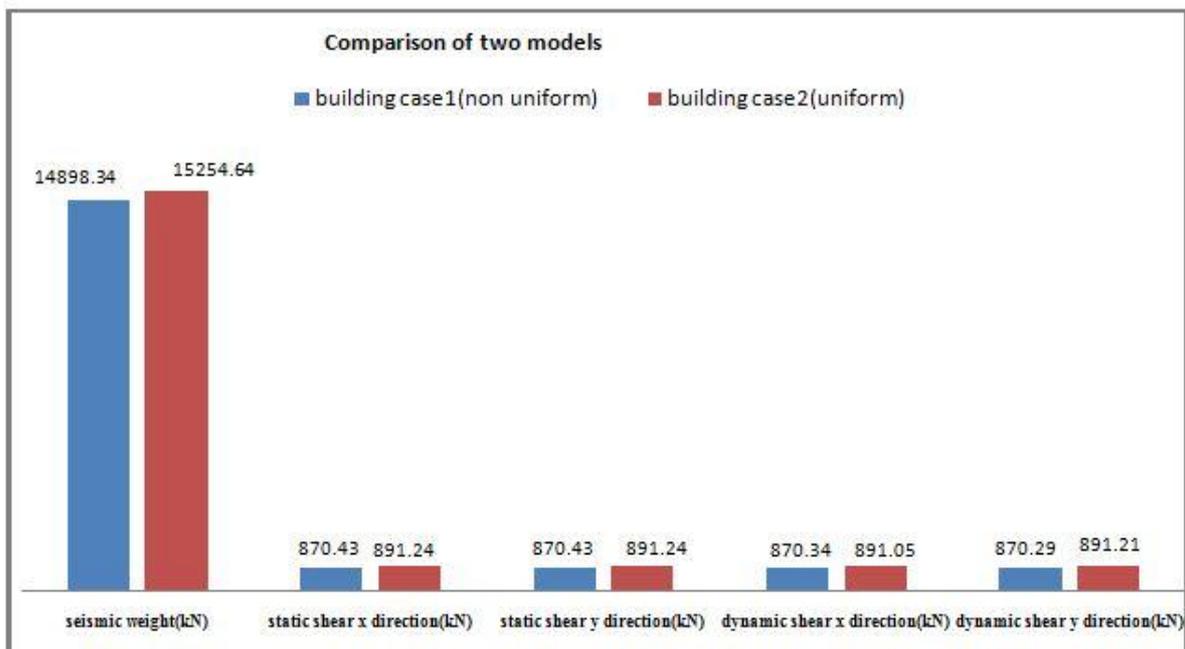


Fig: 3 Static and Dynamic Base Shear, Seismic weight comparison for both cases

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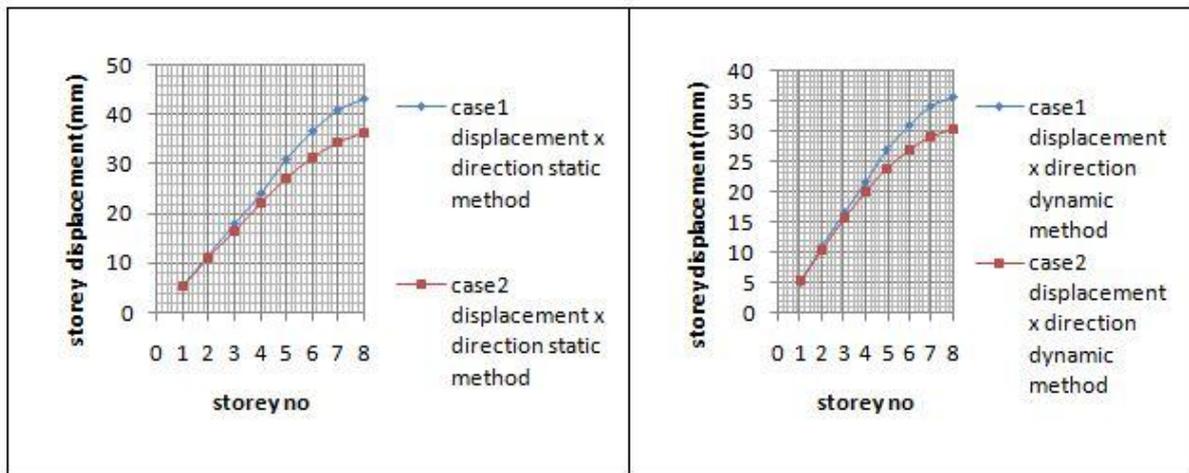


Fig: 4 Storey Displacement by static and dynamic methods for both cases

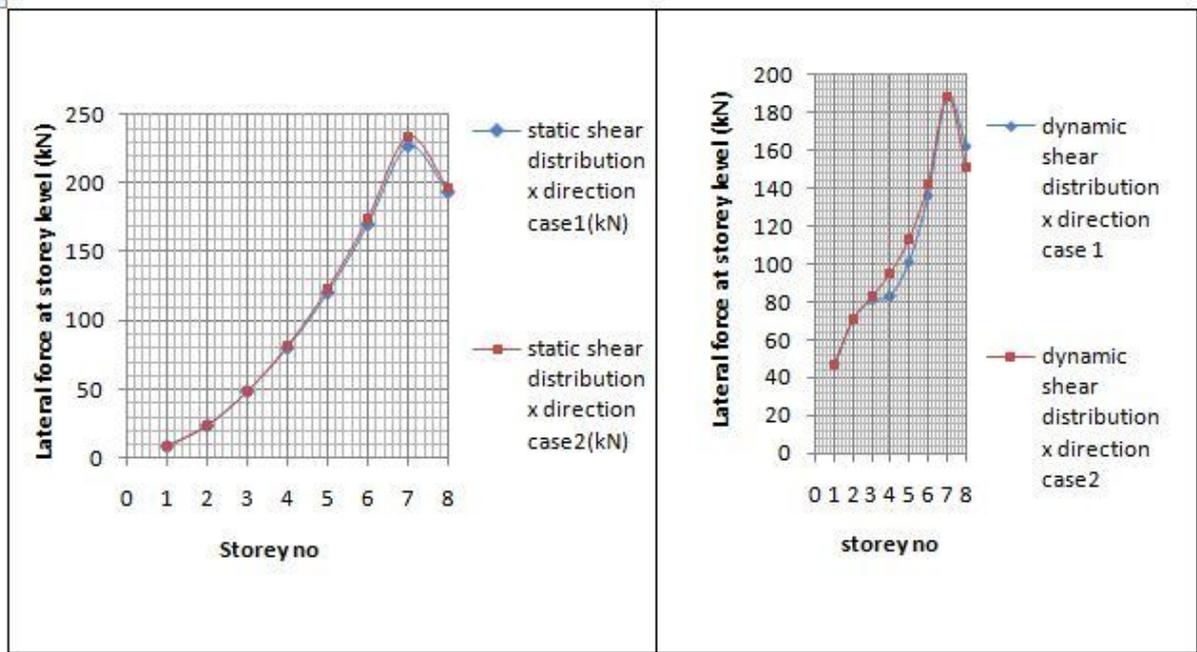


Fig: 5 Static and Dynamic base shear distribution for both cases in all storeys

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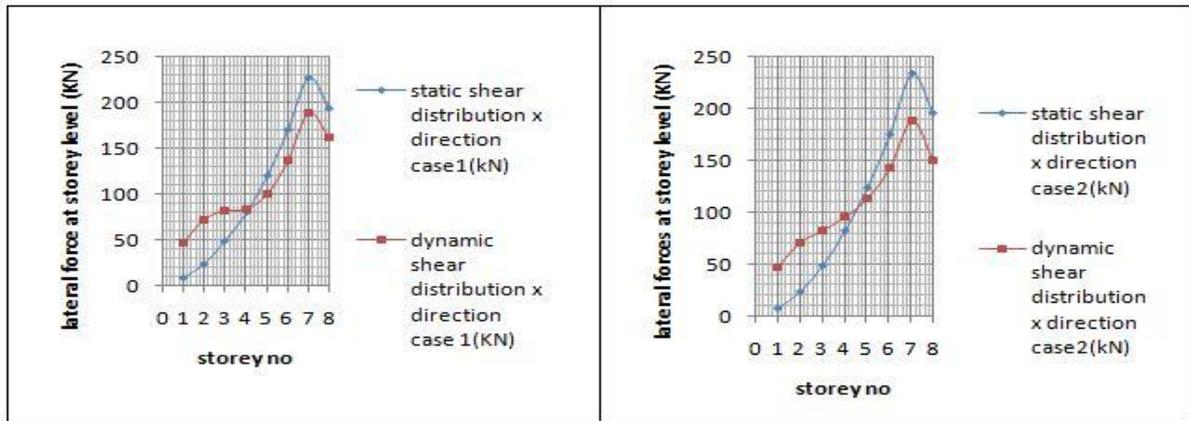


Fig: 6 comparison of lateral force due to static and dynamic shear distribution within a same model

Table 2 Storey stiffness

storey	stiffness along Y direction		soft storey check		Result
	case 1 (kN/m) y direction	case 2 (kN/m) y direction	case 1 $[(k_i/k_{i+1}) < 0.7]$	case 2 $[(k_i/k_{i+1}) < 0.7]$	
8	66870.58	79161.24			No
7	77622.65	94995.97	1.16	1.20	No
6	78904.28	96854.94	1.02	1.02	No
5	79575.00	97528.51	1.01	1.01	No
4	89517.50	98148.70	1.12	1.01	No
3	90523.48	98854.50	1.01	1.01	No
2	89639.75	97559.03	0.99	0.99	No
1	71344.54	71456.88	0.80	0.73	No

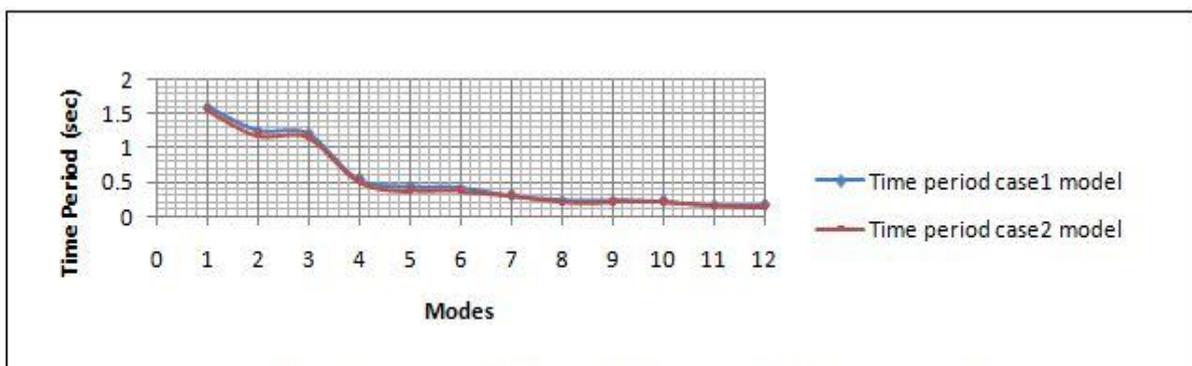


Fig: 7 Comparison of time period between case1 and case2 model

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IV. DESIGN RESULTS

Both cases of buildings were designed for 20 load combinations given by ETABS software. The longitudinal reinforcement of all columns in each storey was found out. Summation of reinforcement per metre length of all column in a storey was calculated for both buildings. Graph is plotted between reinforcements in column and compared with two cases in each storey. It is seen that from case2 to case1 total seismic weight of building decreases by **2.33 %**. From case2 to case1 total reinforcement of columns increases by **10.23%**. Details are shown by table and figure below.

Table 3 Sum of total reinforcement of columns in a storey

storey no	Total sum of reinforcement in all columns of particular storey in mm ² for case1 (non uniform)	Total sum of reinforcement in all columns of particular storey in mm ² for case2 (uniform size)	% change in reinforcement from case1 to case2	Remarks
1	150208	156608	4.26 %	Increase
2	90104	84528	-6.19 %	Decrease
3	79480	50632	-36.30 %	Decrease
4	50356	42296	-16.01 %	Decrease
5	48020	35632	-25.80 %	Decrease
6	36988	30748	-16.87 %	Decrease
7	23176	23904	3.14 %	Increase
8	15552	23040	48.15 %	Increase
Total	493884	447388	-9.41 %	Decrease

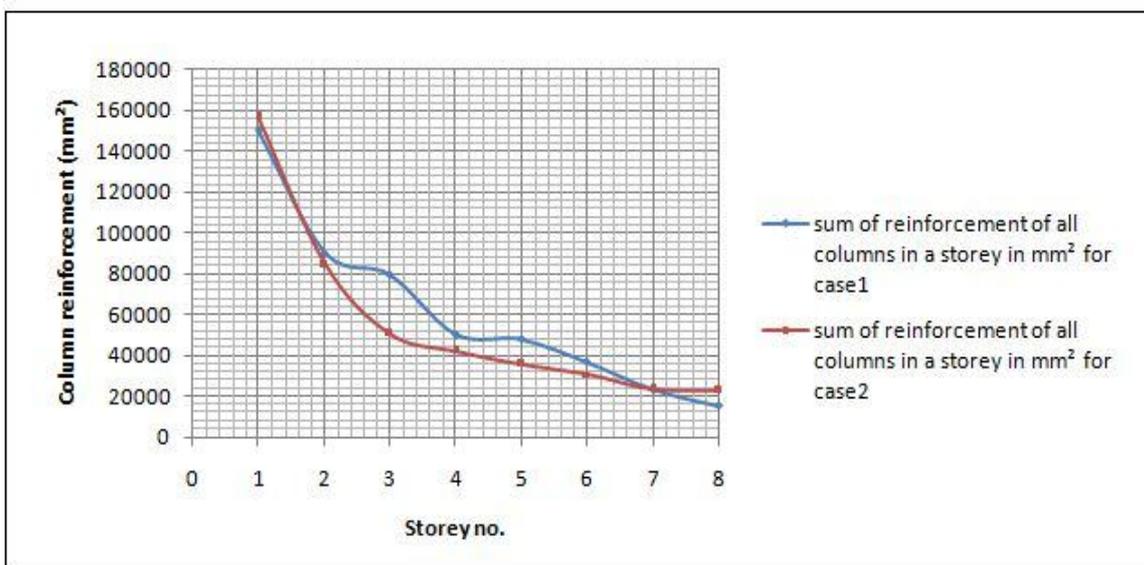


Fig: 8 Reinforcement variation of all columns in a storey for both cases

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V. CONCLUSIONS

a. Conclusions From Analysis

- It is seen that ETABS gives less value for dynamic shear by response spectrum method. Those values should be scaled up appropriately according to IS code **1893 -2000 clause 7.8.2.** to make it at least in the range of static shear by seismic coefficient method. For case1 scale up ratios were 1.7 for x direction and 2.05 for y direction similarly for case2 scale up ratios were 1.58 and 1.98 for x and y direction respectively.
- Due to increase in column size, seismic weight from case1 to case2 increases by 356 kN(2.29%) the values of base shear increases by 20 kN(2.27%) and displacement decreases by 5.4 mm(12.55%) (average) .
- If bottom storey height is made more than other storey height for parking purposes stiffness of bottom storey is decreased than upper stories so it is better to decrease the column section in upper storey so as to decrease the variation of stiffness between two storey and prevent soft storey effect. It is seen from table 2 that stiffness for y direction for case2 bottom storey is only 0.73 times stiffness of 2nd storey which is very near to critical margin (0.7). By decreasing column size in 2nd storey we can keep safety margin up to 0.8 as in case1.
- Top displacement values from dynamic analysis is 16 % lesser than the displacement from static analysis for both cases of building.
- Static approach gives higher values of forces and moments which makes building uneconomical hence consideration of dynamic approach is also needed.
- Lateral force at floor level due to static shear is almost same for both building but due to dynamic shear it is less in storey 4 & 5 in case1 and more in storey 8 than case2. (see Fig:5)
- From both buildings it is concluded that lateral force arising due to dynamic shear distribution is significantly more than force due to static shear in lower stories up to storey four after that for higher stories force due to static shear exceeds the force due to dynamic shear.(see Fig:6)

b. Conclusions From Design

- Except top storeys (7&8) it is seen that decrease in size of column yields increase in amount of reinforcement.
- At 1st storey where size of column is same, column reinforcement is more by 4.26 % for building with more seismic weight i.e. for case2.
- For top storeys (7 &8) the columns with lesser cross section case1 will need lesser reinforcement because minimum reinforcement of 0.8% of column section (IS456 code clause 26.5.3.1) is enough to carry developed earthquake induced forces and moments. In 7th and 8th storey, column reinforcement decreases by 3.04 % & 32.5 % from case2 (uniform) to case1 (non uniform).
- If column section is reduced in upper stories as in case1 the amount of reinforcement needed considering all columns of building as a whole will increase by 10.39 % and seismic weight of building decreases by 2.33 %.
- It is seen that total wt of reinforcement of column for case1 (non uniform section) is **12.85 tons** whereas total wt of reinforcement of columns for case2 (uniform section) is **11.8 tons** hence save in reinforcement from case1 to case2 is **1.05 tons**. If only 7th and 8th storey column section for uniform case is decreased as in non uniform case, further reinforcement of **0.3 tons** could be saved from **11.8 tons**.

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VI. DISCUSSIONS

It is observed that to get minimum reinforcement in building, it is better to decrease column section in storey 7th and 8th as in case1 and take uniform column section up to storey six as in case2. 7th and 8th storey columns in non uniform case has less reinforcement than uniform case. In higher stories there is very less axial loads and moments in columns so smaller section is ok.

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