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Comparative Study of Static and Dynamic Seismic Analysis of Multistoried RCC Buildings by ETAB

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ABSTRACT
Reinforced Concrete (RC) building frames are most common types of constructions in urban India. These are subjected to several types of forces during their lifetime, such as static forces due to dead and live loads and dynamic forces due to earthquake. In the present work, two tall buildings (a G+10 and a G+25 structure), presumed to be situated in seismic zone III, are analyzed by using two different methods viz. equivalent static analysis method and response spectrum method, using ETAB 15 software. From analysis results, the parameters like storey drift, storey displacement, Axial Load, Bending Moments are determined for comparative study. Results established the superiority of the Response spectrum method over the Equivalent static analysis method.
Keywords: RCC Buildings, Equivalent Static Analysis Method, Response Spectrum Method, Story Drift

I. INTRODUCTION

A natural calamity, an earthquake has taken toll of millions of lives through the ages, in the unrecorded and recorded history. A disruptive disturbance that causes shaking of the surface of the earth due to underground movement along a fault plane or from volcanic activity is called earthquake. The earthquake ranks as one of the most destructive events recorded so far in India in terms of death toll & damage to infrastructure last hundred years. All over the world, there is a high demand for construction of tall buildings due to increasing urbanization and spiraling population, and earthquakes have the potential for causing the greatest damage to tall structures. Since the earthquake forces are random in nature and unpredictable, the engineering tools need to be sharpened for analyzing structures under the action of these forces. Structural analysis is mainly concerned with finding out the behavior of a structure when subjected to some action. This action can be in the form of load due to weight of things such as people, furniture, wind, snow etc. or some other kind of excitation such as earthquake, shaking of the ground due to a blast nearby, etc. The distinction is made between the dynamic and static analysis on the basis of whether the applied action has enough acceleration in comparison to the structure's natural frequency.

In the present work, two tall buildings (a G+10 and a G+25 structure), presumed to be situated in seismic zone III, are analyzed using two different methods viz. equivalent static analysis method and response spectrum method, using ETAB 15 software.

II. METHOD OF ANALYSIS

A. Equivalent Static Analysis

Analysis against earthquake effects must consider the dynamic nature of the load. However, for simple & regular structures, analysis by equivalent linear static analysis method is often sufficient. This is permitted in most codes of practice for regular, low- to medium-rise buildings.

B. Response Spectrum Method.

The method represents the maximum response of an idealized single degree freedom system having certain time period and damping, during earthquake ground motions. The maximum response plotted against an un-damped natural period and for various damping values can be expressed in terms of maximum absolute acceleration, maximum relative velocity or maximum relative displacement.

III. Modeling and Analysis

In the present work, two models of a G+10 and a G+25 story public building are analyzed as special moment resisting frames. The buildings are assumed to be situated in earthquake zone III. The rectangular plan dimension is 20.1 x 27.6 m. Grade of concrete used is M 30 and Grade of steel is Fe 500. Floor to floor height is taken as 3.2 m. Slab thickness (S1) is 150 mm. External wall thickness is taken as 230 mm. Internal wall thickness is assumed to be 115 mm. Building is assumed to be resting on hard soil. Density of plastered masonry wall is assumed as 20 kN/m³. For G+10 building, Beam size is taken as 230 x 400 mm whereas the column size is taken as 700 x700mm at G. L. (reduced to 600x600 mm after 4 storeys & 500 x 500 mm after 8 storeys). For G+25 building, beam size is taken as 230 x 500 mm whereas the column size is taken as1000 x 1000 mm at base. After each 5th storey, column size is reduced by 100mm to 900 x 900 mm, 800 x 800 mm, 700 x 700 mm & finally to 600 x 600 mm respectively.

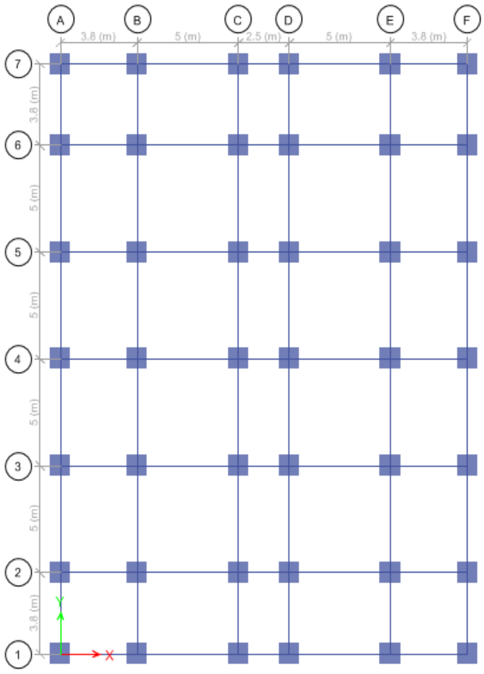

Fig.1: Plan of building

IV. Results and Discussion

The above two RCC frame structures are analyzed both statically and dynamically and the results obtained are graphically shown below.

A. Comparison of Storey Drift

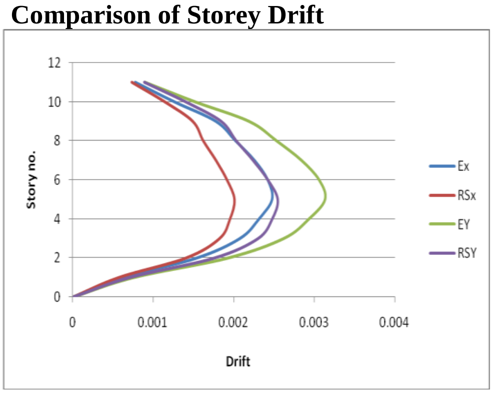

Fig. 2: Comparison of Storey Drift (G+10)

From Fig. 2 for x direction, it is observed that the maximum storey drift in Response spectrum analysis (RSx) is 21.17% less than Equivalent Static Analysis (Ex) method. Similarly, for Y-direction it is observed that the storey drift in Equivalent Static Analysis (Ey) is 21.33 % more than the storey drift in Response Spectrum Analysis (RSy).

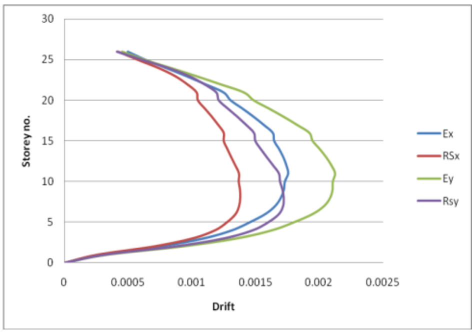

Fig. 3: Comparison of Storey Drift (G+25)

From Fig. 3 for x direction it is observed that the maximum storey drift in Response spectrum analysis (RSx) is 24.12 % less than Equivalent Static Analysis (Ex) method. Similarly, for Y-direction it is observed that the maximum storey drift in Response Spectrum Analysis (RSy) is 23.10% less than the corresponding storeys drift in Equivalent Static Analysis (Ey).

B. Comparison of Storey Displacement

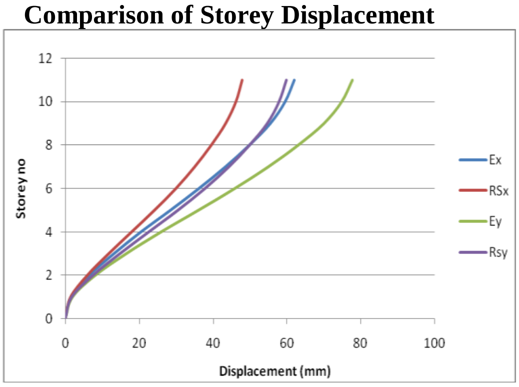

Fig. 4: Comparative Storey Displacement (G+10)

From Fig. 4, for x direction, it is observed that the maximum storey displacement in Response spectrum analysis (RSx) is 22.74% less than Equivalent Static Analysis (Ex) method. Similarly, for Y-direction it is observed that the storey displacement in Response Spectrum Analysis (RSy) is 22.93% less than the storey displacement in Equivalent Static Analysis (Ey).

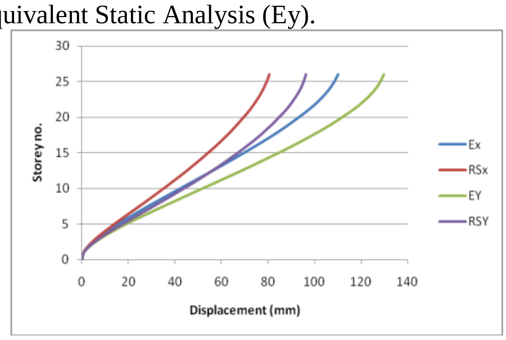

Fig. 5: Comparative Storey Displacement (G+25)

From Fig. 5 for x direction, it is observed that the maximum storey displacement in Response spectrum analysis (RSx) is 26.88% less than Equivalent Static Analysis (Ex) method. Similarly, for Y-direction it is observed that the storey displacement in Response Spectrum Analysis (RSy) is 25.94 % less than the storey displacement in Equivalent Static Analysis method (Ey).

C .Comparison of axial load for Columns

From Fig. 6, it is observed that the axial load for corner column A1 in Response spectrum analysis (RSx) is 7% less than Equivalent Static Analysis (Ex) method. Similarly, for Y-direction it is observed that the axial load for column A1inResponse Spectrum Analysis (RSy) is 8% less than Equivalent Static Analysis value (Ey).

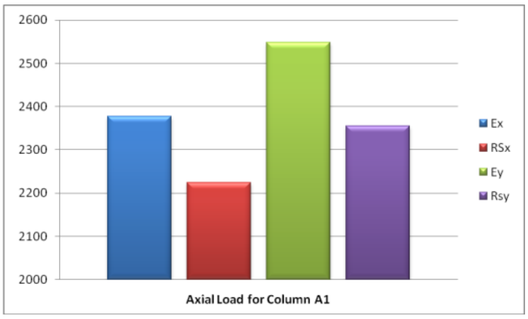

Fig. 6: Max axial load for corner column A1 (G+10)

From Fig. 7 below, it is observed that the axial load for peripheral column C1 in Response spectrum analysis (RSx) is 5% less than Equivalent Static Analysis (Ex) method. Similarly, for Y-direction it is observed that Peripheral column load C1 in the Response Spectrum Analysis (RSy) is 7% less than Equivalent static method.

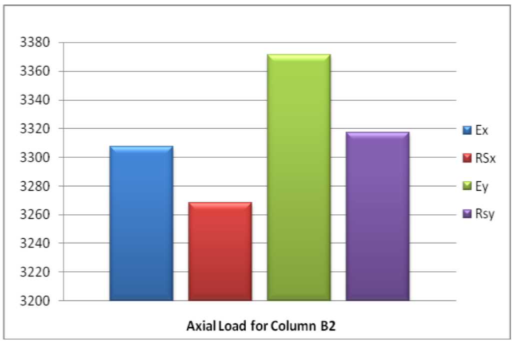

Fig. 7: Max load for peripheral column C1 (G+10)

From Fig. 8 below, it is observed that the axial load for interior column B2 in Response spectrum analysis (RSx) is 2 % less than Equivalent Static Analysis (Ex) method for a G+10 building. Similarly, for Y-direction it is observed that interior column B2 load in the Response Spectrum Analysis (RSy) is 2% less than Equivalent Static Analysis value (Ey) for the same building.

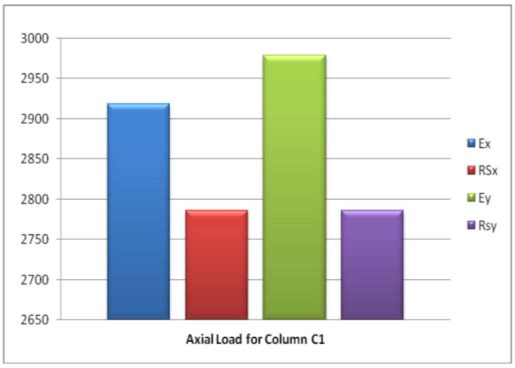

Fig. 8: Max load for interior column B2 (G+10)

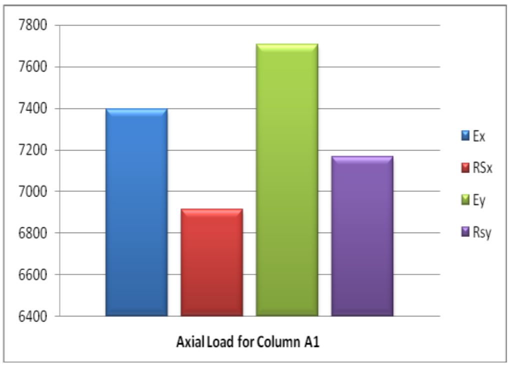

Fig. 9: Max Load for Corner Column A1 (G+25)

From Fig. 9 above, it is observed that the axial load for corner column A1 in Response spectrum analysis (RSx) is 6 % less than Equivalent Static Analysis (Ex) method for a G+25 building. Similarly, for Y-direction it is observed that column A1 in Response Spectrum Analysis (RSy) carries 7 % less load than Equivalent Static Analysis (Ey).

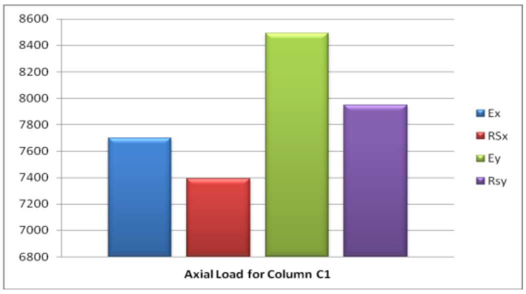

Fig. 10: Max load for peripheral column C1 (G+25)

From Fig. 10 above, it is observed that the axial load for peripheral column C1 in Response spectrum analysis (RSx) is 4 % less than Equivalent Static Analysis (Ex) method. Similarly, for Y-direction it is observed that Peripheral column load C1 in the Response Spectrum Analysis (RSy) is 7 % less than Equivalent Static Analysis (Ey).

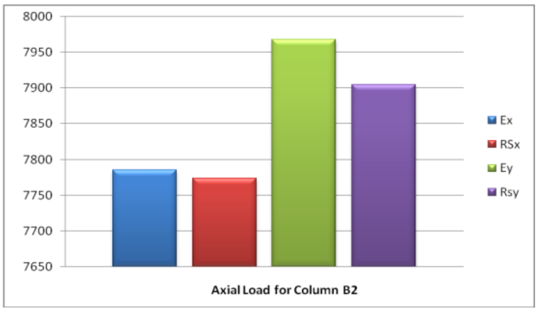

Fig. 11: Max load for interior column B2 (G+25)

From Fig. 11 above, it is observed that the axial load for interior column B2 is approximately same in Response spectrum analysis (RSx) and Equivalent Static Analysis (Ex) method. Similarly, for Y-direction it is observed that interior column load B2 in the Response Spectrum Analysis (RSy) is just 1% less than Equivalent Static Analysis (Ey).

D.Comparison of Beam End B. M.

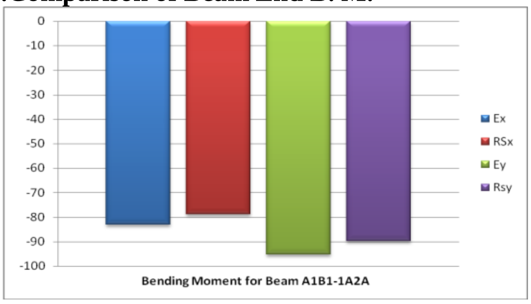

Fig. 12: Max. B. M. for beam A1B1-1A2A (G+10)

From Fig. 12 above, it is observed that the bending moment for end beam A1B1in Response spectrum analysis (RSx) is 6 % lesser than Equivalent Static Analysis (Ex) method. Similarly, for Y-direction end beam 1A2A has 5% less moment than Equivalent Static Analysis (Ex) method. From Fig. 13 below, it is observed that the bending moment for peripheral beam B1C1 in Response spectrum analysis (RSx) is 5% less than Equivalent Static Analysis (Ex) method. Similarly, for Y-direction peripheral beam 1B2B has 6% less moment from Response Spectrum Analysis (RSy) than Equivalent Static Analysis (Ey) method.

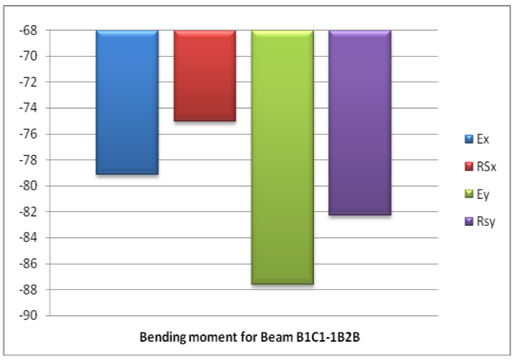

Fig. 13: Max. B. M. for beam B1C1-1B2B (G+10)

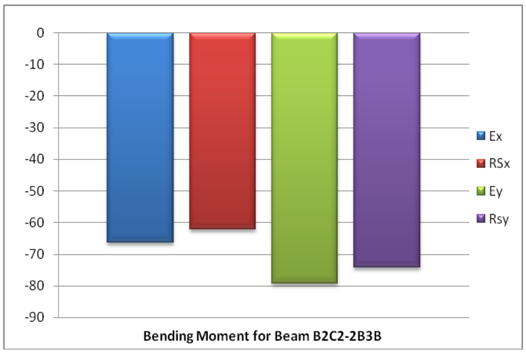

Fig. 14: Max. B. M. for beam B2C2-2B3B (G+10)

From Fig. 14, it is observed that the bending moment for internal beam B2C2 in Response spectrum analysis (RSx) is 4% less than Equivalent Static Analysis (Ex) method. Similarly, for Y-direction internal beam 2B3B in Response Spectrum Analysis (RSy) has 7% less moment than Equivalent Static Analysis value (Ey).

From Fig. 15 below, it is observed that the bending moment for end beam A1B1 in Response spectrum analysis (RSx) is 3% less than Equivalent Static Analysis (Ex) method for a G+25 building. Similarly, For Y-direction end beam 1A2A, B. M. in Response Spectrum Analysis (RSy) is 3% less than Equivalent Static Analysis (Ey), for the same building.

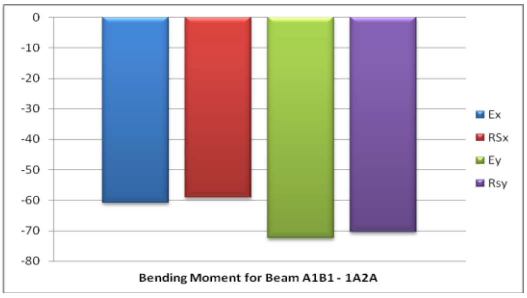

Fig. 15: Max. B. M. for beam A1B1-1A2A (G+25)

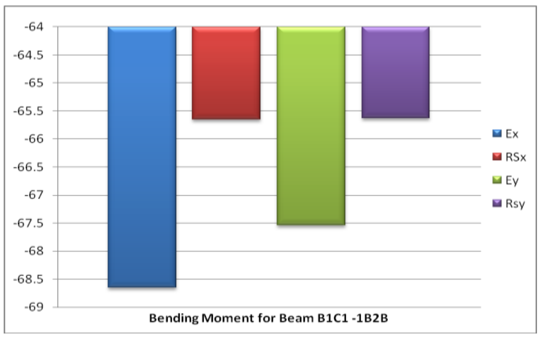

Fig. 16: Max. B. M. for beam B1C1-1B2B (G+25)

From Fig 16 above, it is observed that the bending moment for peripheral beam B1C1 in Response spectrum analysis (RSx) is 4% less than Equivalent Static Analysis (Ex) method in case of a G+25 building. Similarly, For Y-direction peripheral beam 1B2B, B. M. in Response Spectrum Analysis (RSy) is 3% less than the corresponding Equivalent Static Analysis value (Ey).

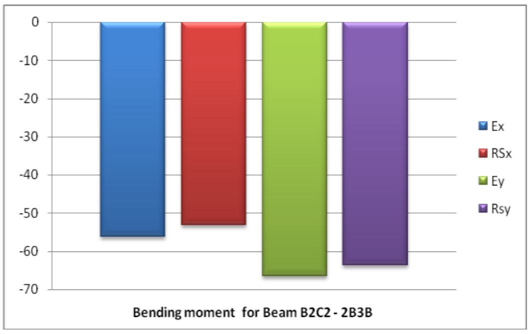

Fig. 17: Max. B. M. for beam B2C2-2B3B (G+25)

From Fig17 above, it is observed that the bending moment for internal beam B2C2 in Response spectrum analysis (RSx) is 3% less than Equivalent Static Analysis (Ex) method for a G+25 building. Similarly For Y-direction, B. M. for internal beam 2B3B in Response Spectrum Analysis (RSy) is 3% less than Equivalent Static Analysis (Ey) value.

V. CONCLUSION

i. Storey drift value for G+10 and G+25 are 22 to 25% less respectively, in dynamic analysis than static analysis. All the values are within the limits as per code requirement.
ii. As the height of storey increases, the displacement values too gradually increase. Top storey has maximum displacement value in both X-Y directions. For dynamic analysis, storey displacement for G+10 and G+25 buildings are 22 % & 26% less than the corresponding values in static analysis.
iii. Axial load for corner column and peripheral columns in G+10 and G+25 are 7% to 8% less in dynamic analysis than static analysis. However, axial load for interior column in G+10 and G+25 are only @2% less in dynamic analysis than static analysis
iv. Bending Moment for beams in G+10 building is 3% to7 % lesser than its static analysis counterpart. However, in G+25 building the difference is even lesser at 3% to 4% in dynamic analysis than static analysis
v. Dynamic analysis gives lesser values for all parameters than static analysis. Hence, dynamic analysis is economical.

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