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Comparative Study of Static and Dynamic Seismic Analysis of Multistoried RCC Building by ETAB: A Review

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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. This paper presents a review of the previous work done on multistoried buildings vis-à-vis earthquake analysis. It focuses on static and dynamic analysis of buildings.

Keyword- RCC Buildings, Equivalent Static Analysis, Response Spectrum Method

I. INTRODUCTION

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. Earthquake, a natural calamity has taken toll of millions of lives through the ages. The earthquake ranks as one of the most destructive events recorded so far in India in terms of death toll & damage to infrastructure. The major cities affected by the earthquake are Bhuj, Gandhidham, and Rajkot etc. Every earthquake leaves a trail of misery because of the loss of life and destruction.

Reinforced concrete multi-storied buildings in India were for the first time subjected to a strong ground motion shaking in Bhuj earthquake. It has been concluded that the principal reasons of failure may be attributed to soft stories, floating columns, mass irregularities, poor quality of construction materials and faulty construction practices, inconsistent earthquake response, soil and foundation, effect of pounding of adjacent structures. All over world, there is high demand for construction of tall buildings due to increasing urbanization and spiraling population, and earthquakes have the potential for causing the greatest damages to tall structures. Since 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, snow etc. or some other kind of excitation such as earthquake , shaking of the ground due to a blast nearby etc. In essence all these loads are dynamic including the self-weight of the structure because at some point in time these loads were not there. 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. If a load is applied sufficiently slowly, the inertia forces (Newton's second law of motion) can be ignored and the analysis can be simplified as static analysis. Structural dynamics, therefore, is a type of structural analysis which covers the behavior of structures subjected to dynamic (actions having high acceleration) loading. Dynamic loads include people, wind, waves, traffic, earthquake and blasts. Any structure can be subjected to dynamic loading. Dynamic analysis can be used to find dynamic displacements, time history, and modal analysis.

II. LITERATUR REVIEW

Balaji U & Selvarasan M. E. [1] studied a residential building G+13 storied. The building was analyzed for earthquake loads using ETABS. Assuming that the material properties were linear, static and dynamic analysis was performed. These non-linear analyses were carried out by considering severe seismic zones and the behavior was assessed by taking types II soil condition. Different response like displacement & base shear were calculated and it was observed that displacement increased with the building height.

Anirudh Gottala, shaik Yajdhani et al [2] studied static and dynamic analysis of G+9 multistoried building. Linear seismic analysis was done by static method (Seismic Coefficient Method) and dynamic method (Response Spectrum Method) using STAAD-Pro as per the IS-1893-2002-Part-1. Parameters such as Bending moment, Axial force, Torsion, Displacement, Nodal displacement, beam and column end forces etc. were calculated. The authors concluded that,

- The values for Moments are 35 to 45 % higher for Dynamic analysis than the values obtained for Static analysis.
- The values of Torsion of columns are negative for Static analysis and for Dynamic analysis the values of torsion are positive.
- The values of Nodal Displacements are 50% higher for Dynamic analysis than the values obtained for Static analysis.
- Nodal Displacements and Bending moments in beams and columns due to seismic excitation showed much larger values compared to that due to static loads.

Mahesh N. Patil, Yogesh N. Sonawane [3] studied seismic analysis of 8 storey building. A 22.5m x 22.5 m, 8 storey multi storey regular structure was considered for the study. Storey height was 3m. Modeling and analysis of the structure was done on ETABS software. Analysis of the structure was done and then the results generated by the software were compared with manual analysis of the structure using IS 1893:2002.

Mohammed Rizwan Sultan, D. Gouse Peera [4] studied behavior of the structure in high seismic zone and also evaluated Storey overturning moment, Storey Drift, Displacement, Design lateral forces etc. For this purpose, a 15 storey-high building of four totally different shapes like Rectangular, L-shape, H-shape, and C-shape were used for comparison. The complete models were analyzed with the assistance of ETABS 9.7.1 version. In the present study, Comparative Dynamic Analysis for all four cases had been done to evaluate the deformation of the structure. Authors indicate that,

- Building with severe irregularity produces more deformation than those with less irregularity particularly in high seismic zones. And conjointly the storey overturning moment varies inversely with height of the storey.
- The storey base shear for regular building is highest compared to irregular shaped buildings. Storey drift permitted is 0.004.times the height of storey
- Storey drift increases with increase in height of the storey up to 7th storey reaching to maximum value and then it again starts decreasing (Fig 1). The maximum storey drift permitted is 0.004 x height of storey.

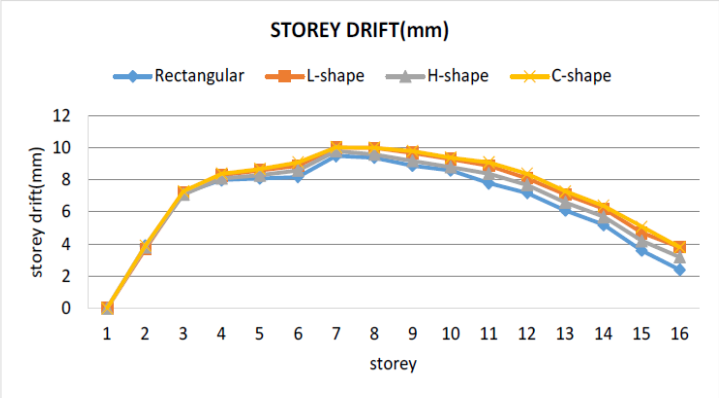

Fig. 1 Shows variation of Storey Drift with Height of storey

Mohit Sharma, Savita Maru [5] studied static and dynamic analysis with the help of STAAD-Pro software using the parameters for design as per the IS 1893-2002-part-1for the zones-2 and 3. G+30 storied regular building was analyzed. These buildings had the plan area of 25m x 45m with a storey height 3.6m each and depth of foundation was 2.4 m and total height of chosen building including depth of foundation was 114 m.

Table I comparison of displacement for vertical member

		STAIC ANALYSIS				DYANAMIC ANALYSIS
		Zone II	Zone III		Zone II	Zone III
Beam	L/C	X-Trans mm	X-Trans mm	L/C	X-Trans mm	X-Trans mm
301	1 EQX	31.376	33.881	1REX	43.372	43.996
302	1 EQX	31.377	33.882	1REX	43.373	43.997
303	1 EQX	31.378	33.883	1REX	43.374	43.998
304	1 EQX	31.378	33.883	1REX	43.374	43.998
305	1 EQX	31.377	33.882	1REX	43.373	43.997

The authors concluded that,

- For zone 2 and zone 3, the values of torsion at different points in the beam are negative and for Dynamic Analysis the values for Torsion are positive.
- Moments and Displacement at different points in the beam was 10 to 15% and 17 to 28 % higher for Dynamic Analysis than the values obtained for Static Analysis for moment and displacement at same point.

S. Mahesh, B. Panduranga Rao [6] studied residential building of (G+11) regular and irregular configuration for earthquake and wind load using ETABS and STAAD PRO V8i. Assuming the material property to be linear, static and dynamic analysis was performed. This analysis was carried out by considering different seismic zones and for each zone; the behaviour was assessed by taking three different types of soils namely Hard, Medium and Soft. Authors compared both the regular and irregular configurations. Following conclusions were drawn,

- The base shear values and story drift values were more in regular configuration than irregular configuration.
- Base shear value was more in the zone 5 and that in the soft soil in regular configuration.
- Story drift value was more in the story 13 in the regular configuration.

NI NI WIN1, KYAW LIN HTAT [7] studied static and dynamic analysis of irregular reinforced concrete building due to earthquake. In the study, computer aided analysis of twelve-storied reinforced concrete building was

carried out for static and dynamic analysis by using ETABS (Extended Three dimensional Analysis of Building System) software. Load consideration was based on Uniformed Building Code (UBC-1997). The structure was designed in accordance with American Concrete Institute (ACI-318-99) design code. Firstly, the proposed building was analyzed with static analysis. Secondly, dynamic analysis with response spectrum method was used. In this paper, the results of static and dynamic (response spectrum) analysis such as displacement, storey shear, storey moment and storey drift were compared. Authors found that,

- In X-direction, displacements obtained static analysis were less than dynamic (response spectrum) analysis from storey 1 to 4 but were higher than in response spectrum from storey 5 to 12. In Y-direction, displacements obtained in static analysis were less than dynamic (response spectrum) analysis. (Fig 2)
- The difference of storey moment between static and response spectrum analysis was higher in X-direction than in Y-direction. In both directions, the difference of storey drift was insignificant. For irregular high-rise buildings, static analysis was insufficient and it would be prudent to use dynamic analysis.

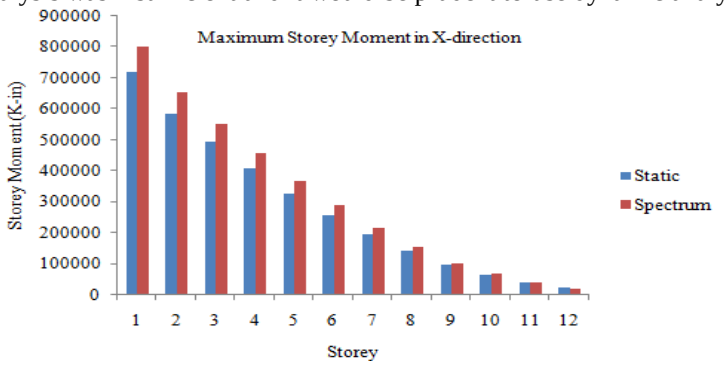

Fig. 2 Maximum Storey Moment of Stories in Static and Response Spectrum method in X-direction

E. Pavan Kumar, A. Naresh [8] studied the seismic analysis of structure by static and dynamic analysis in ordinary moment resisting frame and special moment resisting frame. Equivalent static analysis and response spectrum analysis were the methods used in structural seismic analysis. They considered a residential building of G+ 15 story for the seismic analysis that was located in zone II. The total structure was analyzed by computer using STAAD.PRO software (Fig 3).

The static and dynamic analysis of OMRF and SMRF was carried out and it was concluded that,

- The special moment resisting frame structure was good in resisting seismic loads.
- The results of static analysis in OMRF & SMRF values were low when comparing to that of dynamic analysis in OMRF & SMRF values. Hence the performance of dynamic analysis SMRF structure was quite good in resisting the earthquake forces compared to that of the static analysis OMRF & SMRF.

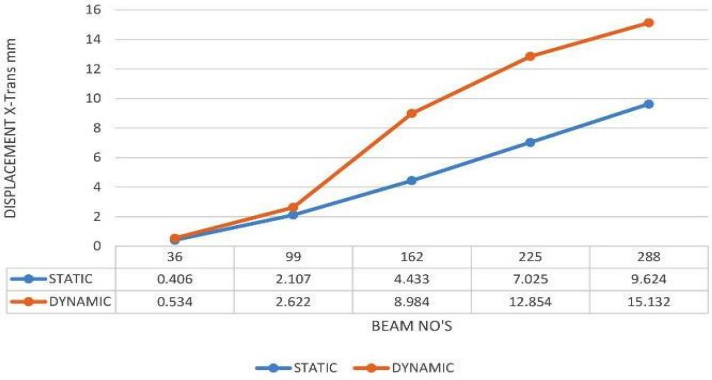

Fig. 3 Static & dynamic analysis of Displacement in SMRF

A. S. Patil and P. D. Kumbhar [9] studied nonlinear dynamic analysis of a ten storied RCC building considering different seismic intensities and seismic response of the building was studied. The building under consideration was modeled with the help of SAP 2000 Software. Five different time histories had been used considering seismic intensities V, VI, VII, VIII, IX and X on Modified Mercalli's Intensity scale (MMI) for establishment of relationship between seismic intensities and seismic responses. Authors concluded that, similar variation patterns were observed in Seismic responses such as base shear and storey displacements with intensities V to X. From the study it was recommended that analysis of multistoried RCC buildings using Time History method was necessary to ensure safety against earthquake force.

T. Mahdi, V Soltangharaie [10] studied seismic behavior of three concrete intermediate moment-resisting space frames with unsymmetrical plan in five, seven and ten stories. In each of these three cases, plan configurations of the structure contained reentrant corners. Nonlinear static and linear dynamic procedures had been used to analyze these structures. To measure the accuracy of these two methods, the non-linear dynamic analysis had been used. Although the differences between the results of these two methods with the nonlinear dynamic procedure were quite wide, the linear dynamic analysis showed slightly better results than nonlinear static analysis.

Bahador Bagheri, Ehsan Salimi Firoozabad et al [11] studied static and dynamic analysis of Multi-storey irregular buildings. A 20 storied building had been modeled using software packages ETABS and SAP 2000 v.15 for seismic zone V in India. Dynamic response of building under actual earthquakes, EL-CENTRO 1949 and CHI-CHI Taiwan 1999 had been investigated. The storey plan was changing on different floors. The building had been analyzed by using the equivalent static, response spectrum and time history analysis, based on IS codes.

The authors concluded that,

- The maximum displacement was increasing from first storey to last one as height of building increased.
- The maximum displacement of center of mass, obtained by time history analysis for both earthquakes at 16th floor was less than 15th floor which was against the general trend line. It was as a result of plan properties in those stories where the location of center of mass changed in X and Y directions.(Fig.4 and Fig.5)
- Building with severe irregularity produced more deformation than those with less irregularity particularly in high seismic zones. Conjointly the storey overturning moment varied inversely with height of the storey.
- The storey base shear for regular building is highest compare to irregular shaped buildings.

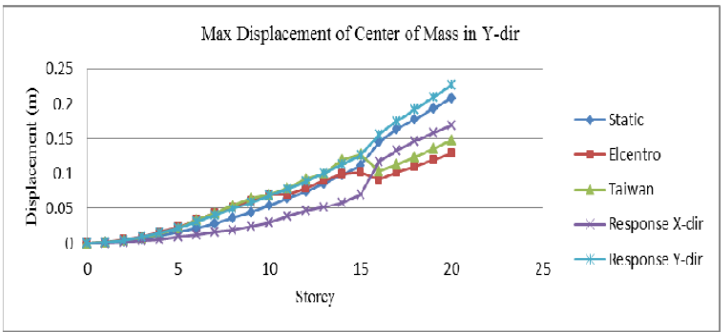

Fig. 4 Maximum Displacement of Center of Mass in Y- direction

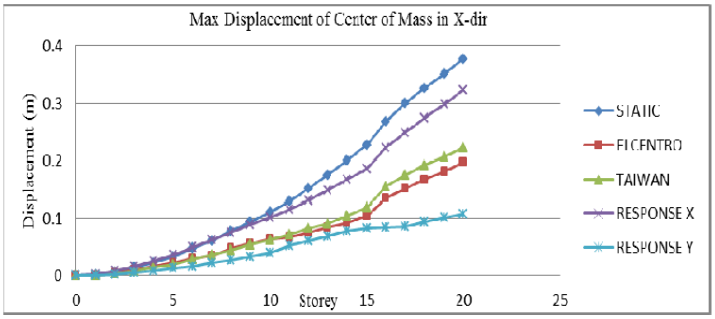

Fig. 5 Maximum Displacement of Center of Mass in X-direction

III. CONCLUSION

This paper presents a review of the comparison of static and dynamic analysis multistoried building. Design parameters such as Displacement, Bending moment, Base shear, Storey drift, Torsion, Axial Force were the focus of the study. It was found that,

- The difference of values of displacement between static and dynamic analysis is insignificant for lower stories but the difference is increased in higher stories and static analysis gives higher values than dynamic analysis.
- Static analysis is not sufficient for high rise buildings and it's necessary to provide dynamic analysis.
- Building with re-entrant corners experienced more lateral drift and reduction in base shear capacity compared to regular building
- When compared to irregular configuration the story drift value is more in the regular configuration. Story drift is increased as height of building increased.
- Base shear value is more in the zone 5 and that in the soft soil in irregular configuration.
- Irregular shapes are severely affected during earthquakes especially in high seismic zones.
- The irregular shape building undergoes more deformation and hence regular shape building must be preferred.
- The results of equivalent static analysis are approximately uneconomical because values of displacement are higher than dynamic analysis.

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