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Comparative Study on Analysis of Multi Storied Building in Different Zones

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Abstract:- The analysis of a structural system to determine the deformations and forces induced via extranal loads or ground excitation is the fundamental step in the design of a structure to resist seismic forces. Many methods are available from linear analysis to a sophisticated nonlinear analysis depending on the purpose of the analysis in the design process. In this paper seismic response of a residential G+12 RC frame building is analysed by the linear analysis approaches of Equivalent Static Lateral Force and Response Spectrum methods using STAAD.Pro software as per the IS- 1893-2002-Part-1. These analysis are carried out by considering different seismic zones, medium soil type. Different response like lateral force, overturning moment, story drift, displacements, base shear are plotted in order to compare the results of the static and dynamic analysis.

Keywords — Equivalent Static Analysis, Response Spectrum Analysis, Base Shear, Lateral Force, overturning Moment, Story Drift

I. INTRODUCTION

The mass of the building being designed controls seismic design in addition to the building stiffness, because earthquake induces inertia forces that are proportional to the building mass. Designing buildings to behave elastically during earthquakes without damage may render the project economically unviable. As a consequence, it may be necessary for the structure to undergo damage and thereby dissipate the energy input to it during the earthquake.

When earthquakes occur, a building undergoes dynamic motion. This is because the building is subjected to inertia forces that act in opposite direction to the acceleration of earthquake excitations. These inertia forces, called seismic loads, are usually dealt with by assuming forces external to the building. So apart from gravity loads, the structure will experience dominant lateral forces of considerable magnitude during earthquake shaking. It is essential to estimate and specify these lateral forces on the structure in order to design the structure to resist an earthquake. The ductility of a structure is the most important factors affecting its seismic performance and it has been clearly observed that the well- designed and detailed reinforced structures behave well during earthquakes and the gap between the actual and design lateral force is narrowed down by providing ductility in the structure.

The following are the advantages of a reinforced concrete structure having sufficient ductility:

– A ductile reinforced concrete structure may take care of overloading, load reversals, impact and secondary stresses due to differential settlement of foundation.

– A ductile reinforced concrete structure gives the occupant sufficient time to vacate the structure by showing large deformation before its final collapse. Accordingly, the loss of life is minimized with the provision of sufficient ductility.

– Properly designed ductile joints are capable of resisting forces and deformations at the yielding of steel reinforcement. Therefore, these sections can reach their respective moment capacities, which is one of the assumptions in the design of reinforced concrete structures by limit state method.

Because of the above advantages, a building frame of SMRF is used for the model located in zones IV and V (CASE-4 and CASE-6) in alternative to OMRF and the results are compared with OMRF values for the same cases. Where, Ordinary Moment Resisting Frame (OMRF) is a moment-resisting frame not meeting special detailing requirements for ductile behaviour and Special Moment Resisting Frame (SMRF) is a moment-resisting frame specially detailed to provide ductile behaviour and comply with the requirements given in IS 4326 or IS 13920 or SP6 (6).

II. LITERATURE REVIEW

[1] Durgesh C. Rai (2005) provided guidelines were intended to provide a systematic procedure for the seismic evaluation of buildings, which could be applied consistently to a rather wide range of buildings. This document also discussed some cost effective strengthening schemes for existing older buildings which were identified as seismically deficient during the evaluation process.

[2] Sayed Mahmoud and WaleedAbdallah Saudi Arabia (2014) have done a research on response analysis of multistory RC buildings under equivalent static and dynamic loads according to Egyptian code. The objective of thisresearch is to assess the seismic performance of an existing shear wall residential building located in Cairo. Both`dynamic response spectrum (RS) and equivalent static force (ESF) methods are used in the seismic analysis. The design RS curve suggested by the Egyptian Code (EC) for seismic design is utilized to perform the dynamic analysis. The response analysis of the building under the acting seismic loads has been performed using ETABS, universal finite element analysis software for dynamic analysis. The results of the study show significant differences in building's responses obtained using ESF and RS analysis methods. It has been found that the application of static method in a specified direction results in responses in the same direction. However, the applications of dynamic RS method induces response in both directions regardless the direction of loading.

[4] S. Thenmozhi ,SunayanaVarma, A Malar (2014) in this study authors made comparison between base shear of Rc frame building situated in various seismic zones of India. They found that Etabs software gives high base shear results compared to Staad Pro and manual calculations. According to their research base shear increased 5.45% and 18.67% in case of Staad pro Etabs compared to manual results for zone2. Similarly for zone3, 4, 5 it has been increased 1.07% to 18.67%.

III. METHOD OF ANALYSIS

The most commonly used methods of analysis for determining the design seismic forces acting on a structure as results of ground shaking are based on the approximation that the effects of yielding can be accounted for by linear analysis of the building, using the design spectrum for inelastic systems. Forces and displacements due to each horizontal component of ground motion are separately determined by analysis of an idealized building having one lateral degree of freedom per floor in the direction of the ground motion component being considered. Such analysis may be carried out by the equivalent static procedure (static method) or response spectrum analysis procedure (dynamic method). Both the equivalent static and response spectrum analysis procedures lead directly to lateral forces in the direction of the ground motion component. The significant difference between linear static and linear dynamic analysis is the level of the forces and their distribution along the height of the structure. The equivalent static method is mainly suited for preliminary design of the building. The preliminary design of the building is then used for response spectrum analysis or any other refined method such as the elastic time history method. For this study, seismic analysis is carried out by linear static analysis and response spectrum analysis.

IV MODEL OF THE PROJECT

Building type: G+10 Residential Building
Plan area: 25(m)*20(m)
Beamsize:300(mm)*400 (mm)
Columnsize:500(mm)*500 (mm)
Beam clear cover to Longitudinal Rebar Group centroid: 50 mm
Column clear cover to confinement Bars: 40mm
Slab thickness: 150mm
Typical storey height: 3m
Bottom storey height: 4.2m
Live load, LL: 4kN/m²
External Wall load: 12kN/m
Partition and floor finishing load, FL: 2kN/m2
Earthquake Direction: X and Y
Seismic Zone: II, III, IV and V
Soil type: Type II (Medium Soil)
Materials: M30 and Fe415

Axes Spacing is 5m along both the lateral directions.

The model is divided into six cases depending on the location of seismic zones and frame type of the building as follows:

CASE-1: OMRF building located in Zone-II
CASE-2: OMRF building located in Zone-III
CASE-3: OMRF building located in Zone-IV
CASE-4: OMRF building located in Zone-V
CASE-5: SMRF building located in Zone-IV
CASE-6: SMRF building located in Zone-V

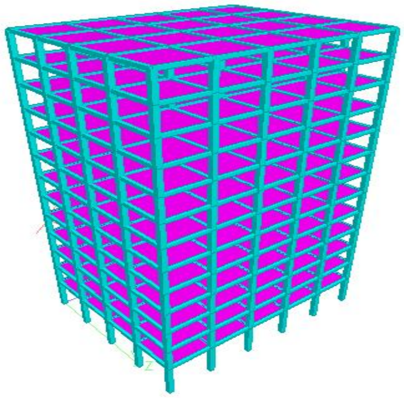

Fig. 1: 3D Rendered View of Model

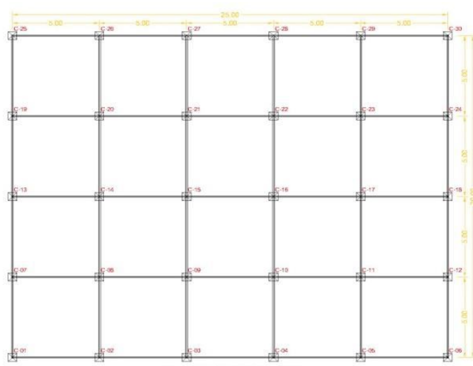

Fig. 2: Typical Model Layout

V SEISMIC ANALYSIS RESULTS

Seismic analysis carried out by the help of STAAD.Pro and the results of, base shear, lateral force, story shear, story displacement, overturning moment and story drift from both linear static and response spectrum analysis are compared for case one of all the six cases.

	BASE SHEAR			
	LINEAR STATIC ANALYSIS		RESPONSE SPECTURUM ANALYSIS	
	X	Z	X	Z
CASE I	2340.1	2082.66	2340.2	2082.98
CASE II	3744.16	3332.25	3745.23	3332.38
CASE III	5616.23	4998.38	5616.79	4998.74
CASE IV	10109.22	8997.08	8424.87	7497.84
CASE V	3369.74	2999.03	3369.79	2999.07
CASE VI	8424.35	7497.57	5054.47	4498.84

Table 1: Linear Static Analysis Base Shear

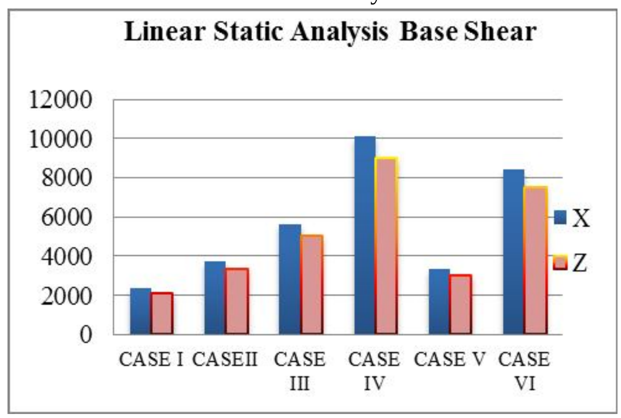

Fig. 3: Linear Static Analysis Base Shear

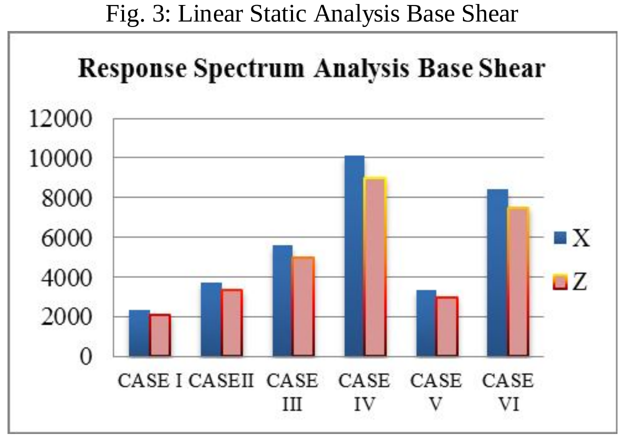

Fig. 4: Response Spectrum Analysis Base Shear

Storey	Height	CASE I : Lateral Force (kN)			
		Static		Dynamic	
		X	Z	X	Z
1	4.2	4.925	4.383	75.345	57.585
2	7.2	15.619	13.9	109.769	95.325
3	10.2	31.436	27.897	134.228	116.525
4	13.2	52.496	46.721	137.536	118.985
5	16.2	79.07	70.371	126.295	108.865
6	19.2	111.066	98.848	114.231	98.765
7	22.2	148.486	132.151	116.099	101.855

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8	25.2	191.329	170.281	140.296	125.095
9	28.2	239.595	213.237	185.738	166.765
10	31.2	293.285	261.02	244.079	218.805
11	34.2	352.397	313.629	303.861	270.735
12	37.2	416.933	371.065	354.082	312.93
13	40.2	403.55	359.154	423.744	291.255

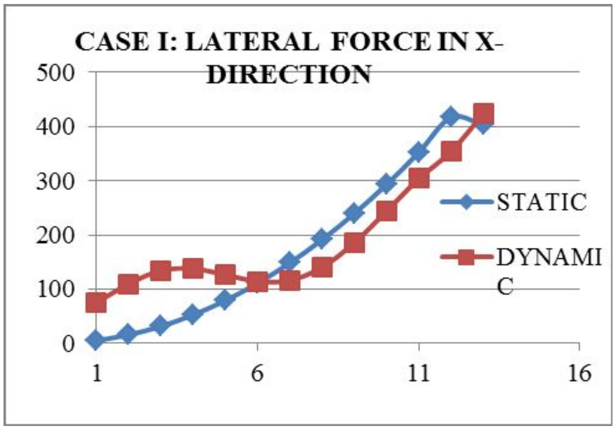

Fig. 4: Lateral Force in X-Direction Comparison in Static & Dynamic (Case I)

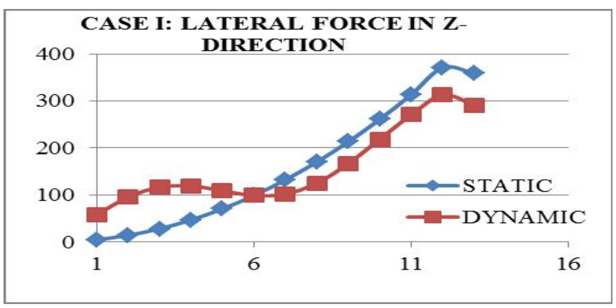

Fig. 5: Lateral Force in Z-Direction Comparison in Static & Dynamic (Case I)

Storey	Height	CASE I : Storey Shear (kN)			
		Static		Dynamic	
		X	Z	X	Z
1	4.2	2340.09	2082.65	2465.33	2083.49
2	7.2	2335.17	2078.27	2389.98	2025.90
3	10.2	2319.55	2064.37	2280.19	1930.58
4	13.2	2288.21	2036.47	2145.96	1814.05
5	16.2	2235.71	1989.75	2008.42	1695.07
6	19.2	2156.64	1919.38	1882.13	1586.20
7	22.2	2045.57	1820.53	1767.90	1487.44
8	25.2	1897.08	1688.38	1651.8	1385.58
9	28.2	1705.76	1518.10	1511.50	1260.49
10	31.2	1466.16	1304.86	1325.76	1093.72
11	34.2	1172.88	1043.84	1081.68	874.92
12	37.2	820.48	730.21	777.82	604.18
13	40.2	403.55	359.15	423.74	291.25

Table 3: Comparison of Storey Shear (Case I)

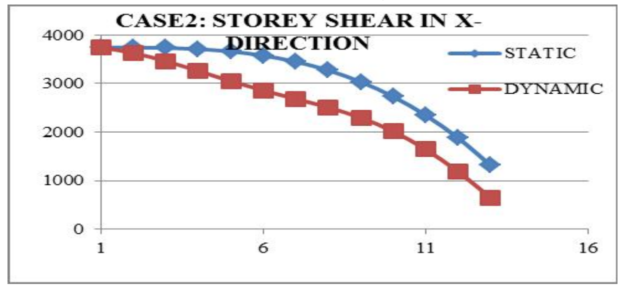

Fig. 6: Storey Shear in X-Direction Comparison in Static & Dynamic (Case I)

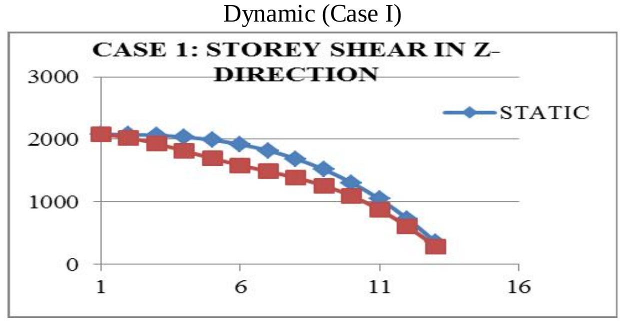

Fig. 7: Storey Shear in Z-Direction Comparison in Static & Dynamic (Case I)

Storey	Height	CASE I : Overturning Moment (kN)			
		Static		Dynamic	
		X	Z	X	Z
1	4.2	334668.89	297851.14	304453.45	250446.03
2	7.2	272128.53	242190.99	246712.65	202297.78
3	10.2	216593.69	192765.66	196141.81	160227.25
4	13.2	168017.51	149533.46	152411.55	123948.46
5	16.2	126305.95	112410.69	115119.18	93111.84
6	19.2	91301.52	81257.18	83852.09	67630.42

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7	22.2	62767.01	55861.83	58231.39	46367.62
8	25.2	40369.23	35928.09	37914.39	29837.14
9	28.2	23662.72	21059.51	22552.80	17463.42
10	31.2	12073.48	10745.24	11725.72	8871.16
11	34.2	4882.74	4345.58	4875.94	3560.08
12	37.2	1210.65	1077.46	1271.32	873.76

Table 4: Comparison of Overturning Moment (Case I)

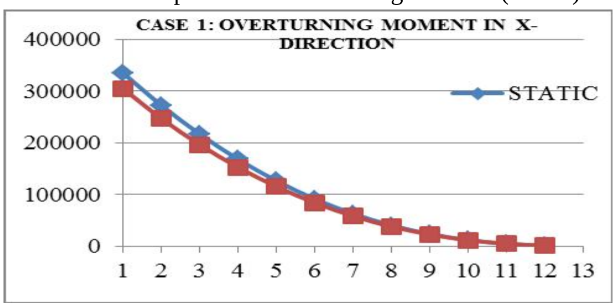

Fig. 8: Overturning Moment in X-Direction Comparison in Static & Dynamic (Case I)

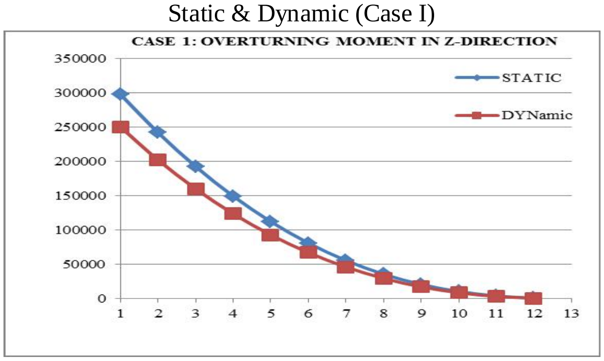

Fig. 9: Overturning Moment in Z-Direction comparison in Static & Dynamic (Case I)

Storey	Height	Storey Drift (In X Direction)					
		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
1	4.2	0.00	0.00	0.00	0.00	0.00	0.00
2	7.2	0.00244	0.0039	0.00584	0.00877	0.00701	0.01052
3	10.2	0.00347	0.00555	0.00833	0.0125	0.01	0.015
4	13.2	0.00346	0.00554	0.00831	0.01246	0.00997	0.01495
5	16.2	0.0034	0.00545	0.00817	0.01226	0.00981	0.01471
6	19.2	0.0033	0.00529	0.00793	0.0119	0.00952	0.01427
7	22.2	0.00315	0.00504	0.00757	0.01135	0.00908	0.01362
8	25.2	0.00294	0.00471	0.00706	0.0106	0.00848	0.01272
9	28.2	0.00267	0.00427	0.00640	0.0096	0.00768	0.01153
10	31.2	0.00232	0.00371	0.00557	0.00835	0.00668	0.1002
11	34.2	0.00189	0.00303	0.00454	0.00681	0.00545	0.00818
12	37.2	0.00139	0.0022	0.00333	0.005	0.004	0.006
13	40.2	0.00086	0.00138	0.00207	0.00311	0.00249	0.00373

Table 5: Comparison of Storey Drift by Linear Static Analysis

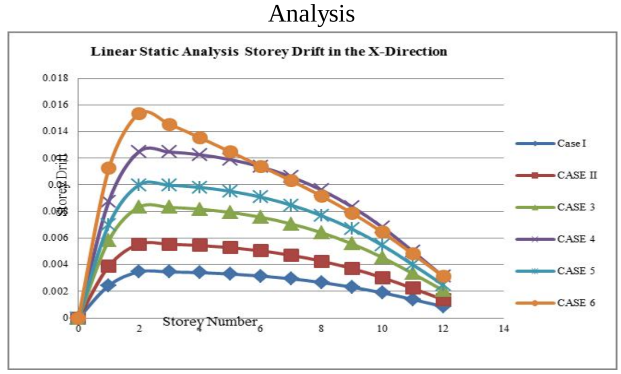

Fig. 10: Comparison of Storey Drift by Linear Static Analysis for all six cases in X-Direction

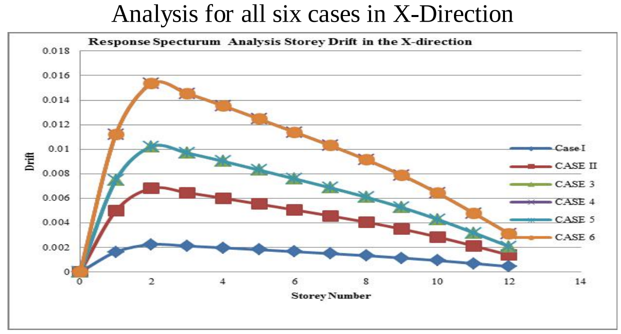

Fig. 11: Comparison of Storey Drift by Response Spectrum Analysis for all six cases in X-Direction

VI CONCLUSIONS

Based on the extensive and intensive analytical investigations, following inferences arrived at:

1) Dynamic story shear is less than static story shear for all cases.
2) From all cases, it is concluded that lateral force obtained from response spectrum method is higher than those obtained by equivalent static lateral force method for story one up to five and the rest higher stories have less values.
3) The maximum story displacement, overturning moment obtained from response spectrum method is lesser than those obtained by equivalent static lateral force method.
4) Equivalent static lateral force method gives higher values of forces and moments which makes building uneconomical hence consideration of response spectrum method is also needed.

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