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Comparison between Equivalent Static and Non Linear Time History Analysis of Regular and Irregular Shape of Buildings

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ABSTRACT: An earthquake is a natural phenomenon brought about by abrupt brutal trembling of the earth crust which takes place at on underneath the ground. The magnitude and intensity of earthquake cannot be predict but we can reduced the damages and failure of structure caused by earthquake by adopting plan Regularity and Irregularity. . In present study, Multi-storey Regular and Irregular shape with different plan area for G+14 stories have been modeled using ETABS software for seismic zone. This paper studies the performance of the building during static analysis and performance of building during earthquakes shakes. For this purpose earthquake data for two different areas Ahmadabad and Mangalore have been studied. This paper enlightens the precision of Time history analysis in comparison with Equivalent Static Analysis by using IS 1893: 2002 part 1 codal provision in Etab software with regards maximum displacement, Storey Shear, Storey Stiffness and Storey Drift.

KEYWORDS: Earthquake, Regular and irregular buildings, Equivalent Static Analysis, Time History Analysis, Displacement, Drift, Stiffness, Base Shear.

I. INTRODUCTION

An earthquake is a natural causally or phenomenon brought about by abrupt brutal trembling of the earth crust which takes place at on underneath the ground. Here word natural is critical, since it avoids stun waves brought about by nuclear tests, manmade explosives, etc. Structural reaction to seismic is a unique wonder that depends upon dynamic characteristics of structures and the intensity, frequency and duration content of the energizing ground motion. In spite of the fact that the seismic action is dynamic in nature, construction standards frequently prescribe equivalent static load method for design of earthquake resistance structures because of its effortlessness. This is finished by concentrating on the transcendent first mode reaction and creating proportionate.

Dynamic analysis turns out to be much progressively mind boggling and faulty when non-linearity in material and geometries is considered. Consequently, the analytical devices utilized in earthquake designing have been a subject for further improvement and refinement, with huge advances accomplished in recent years. Earthquake is developed by sudden release of energy in earth's crust that develops seismic waves. Earthquake forces are accidental & uncertain natural hazards. Hence, its Structural Engineering primary responsibility to consider all possible data from previous experience and also possible hazards that structure might be, later on, for safe design of formwork. Seismic loads are primarily concerned for structural design with structural safety during ground motion, yet, functionality and potential for economic misfortune are additionally of concern. Seismic loading requires a comprehension of the basic execution under enormous inelastic distortions. A engineer requires the instruments for dissecting structures under the impact of these sorts forces.

This topic made an analytical study to determine response of various normal and unpredictable structure by static and Dynamic strategies during tremor. The study involves the equivalent static and Non-linear Dynamic analysis i.e. time history analysis of G+14 celebrated normal and unpredictable structures in Etab software.

For Time History investigation previous tremor movement records for Ahmadabad and Mangalore is taken to examine reaction of the structures. For investigating seismic conduct of structure, models of the structures needed to choose the boundary is most extreme relocation, story float and base shear in kN qualities various pieces of the structure. Practices of structures were found by differentiating responses as above boundary for ordinary and unpredictable structures.

II. RELATED WORK

Nonika.N.Mrs. GargiDanda De: He studied when irregular buildings are analyzed at the point when sporadic structures are broke down utilizing straight identical static examination and Response range investigation thinking about various seismic zones as per code arrangements, the outcomes acquired features the significance of firmness of the structure. The Base shear and lateral displacements are gradually increment in zone factors for both the models. The horizontal dislodging is less in ordinary model contrast with vertical unpredictable model. The float is seen in the story which the solidness is decreased. As firmness builds recurrence of the structure increments. Firmness is subject to mass of the structure, as tallness of the structure builds mass likewise increments. From the general investigation and perception it tends to be presume that,Base shearand parallel removal increments as the seismic power increments from zone-2 to zone-5 which shows increasingly seismic interest the structure should meet.

Rakshith Gowda K.R,Bhavani Shankar:The bare frame structure displays the most extreme removals and the structure with complete infill shows least relocations contrasted with all other in both static and dynamic stacking for both vertically normal and sporadic structures. The bury story float was seen to be most extreme in vertically unpredictable structure when contrasted and that of normal structure. For standard casing the greatest entomb story was seen in uncovered casing static investigation in X-course while in model with tenth floor delicate story in Y-bearing. The Base shear esteems are seen to be more for the casings with complete infill, while the exposed casing models display the base an incentive in both X and Y-bearing. The removal is seen to be least in ordinary structure when contrasted and the sporadic structure for timeframe mode-1. Thus it very well may be inferred that the ordinary structure is more secure than unpredictable structure.

Arvind reddy and. Fernandes: Explored the response of standard and plan erratic structures under zoneV. Static and Dynamic techniques were coordinated usingETABS. The expulsions of both typical and irregular models were taken a gander at for the changed systems and it was induced that static methodgave highir migrations stood out from dynamic technique.

Bahador Bagheri, Ehsan Salimi Firoozabad and Moham-madreza Yahyaei: Have displayed a multi-story erratic structures with 20 stories using programming packs ETABSand SAP-2000for seismic in india. Moreover dealswith the effectof the assortment of the strcture height onthe assistant response of the shar divider building. Dynamic respones ofWorking under genuine quakes, "el-centro1949" and "chi-chi tawan1999" havebeen explored by them this paper includes the exactness and accuracy of timehistory examination in relationship with themost generally got respnse range assessment and equivalentStatic assessment.

YUAN jing et al. (2011): Have analyzed seismic breakdown procedure of a ten-story rc edge structures from versatile stage to split, at that point to crumple is mimicked and examined utilizing the limited component programming named ANSYS/LS-DYNA. The reenactment result is in great agreement with the genuine seismic breakdown process. The shortcomings of skyscraper edge structures under seismic power are established. The counter seismic limit of skyscraper edge structures' base layer is frail and disintegrating of the solid of pillar section joints brought about by shear disappointment of the joints is the significant explanation behind seismic breakdown of casing structures.

III. METHODOLOGY

Seismic Analysis is subset of structural engineering , it is the count of response of buildings structures and other structures. It is the part of design of Earthquake engineering. Earthquake designing has created parcel since from the good 'ol days, and a part of the more awesome plans at present use unprecedented seismic protective segments either in the establishment (base detachment) or appropriated all through the structure. Investigating such structures requires specific unequivocal limited Component PC code, which parcels time into amazingly little, much like ordinary PC games as often as possible have "actual motors". Amazingly tremendous and complex structures can be shown along these lines.

The Different Seismic analysis methods used for estimating the demand on structures are classified as below:-

- | | |
|---------------------------------------|---------------------------------|
| I. Linear equivalent static Analysis. | II. Response Spectrum analysis. |
| III. Linear dynamic analysis. | IV. Nonlinear Static Analysis. |
| V. Nonlinear dynamic analysis. | |

- a. **Equivalent static Analysis:-** All design against Seismic burdens consider the dynamic nature of heap. Notwithstanding, for normal structures investigation by comparable straight static strategy is adequate. This is permitted in numerous codes of training for standard. It begins with an assessment of base shear burden and its course on each story dictated by using conditions given in the code. Equivalent static investigation in this way work for low to medium ascent structures without huge coupled parallel modes, in which just the main mode toward every path is considered. In the identical static analysis strategy, the reaction of the structure is expected as straight flexible way. To assess equal direct static the IS 1893-(Part I)2002 has given a recipe.
- b. **Non-Linear time history Analysis:-** Time History examination is where stacking and reaction are assessed at progressive time increases, steps are given and more detail data of the seismic conduct of structure. The most notable way to deal with describes aground movement is with a period history record. The movement boundaries may be speeding up, speed, or relocation, all three together. Time history of ground movement are used truly for the time territory assessment of structures presented to deterministic seismic wellsprings of information. At any assessing station, ground developments are recorded in three balanced manners; two of them are levelly and the third is in the vertical heading.
- c. **Linear Dynamic Analysis:-** The linear static methodology of building is modeled with linearly elastic stiffness of the structure. The equivalent damps the approximate qualities for the lateral load to close to the yield point. Plan tremor requests for the LSP are spoken to by static horizontal powers whose whole is equivalent to the pseudo sidelong burden. To design the earthquake load to ascertain the interior forces will be sensible rough of expected during to configuration earth shake.
- d. **Response Spectrum Analysis:** This procedure permits the various techniques for response of a structure to be thought of. This is needed in numerous development norms for all except for very direct or complex structures. The helper response can be portrayed as a mix of various modes. PC examination can be used to choose these modes for a structure. Following are such blend methods: complete - top characteristics are incorporated square base of the total of the squares(SRSS) ,complete quadratic blend (CQC)- a procedure that is an upgrade for Stressor Closely partitioned modes. The outcome of RSM assessment from the response scope of a ground development commonly not exactly equivalent to that which would be resolved clearly from a direct ground-breaking examination using that ground development really, considering the way that information of the stage is lost during the time spent making the response range.
- e. **Nonlinear Dynamic Analysis:-** Nonlinear powerful examination utilizes the blend of ground development record with amity gritty primary model, thusly is good for making results with decently low weakness. In nonlinear amazing assessments, the natty4 lumpy helper model presented to aground-development record produces assessments of part bends for each degree of chance in the model and the secluded responses are combined using plans, for instance, the square-root total of squares. In no direct extraordinary examination, the no straight properties of the structure are considered as a component of a period zone assessment. This system is the most exhaustive, and is needed by some development laws for structures of exceptional plan or of special importance. Nevertheless, the decided response can be incredibly tricky to the traits of the individual ground development.

IV. ANALYTICAL MODELLING

For comparative study, two shapes of the buildings regular and irregular shapes have been considered for seismic analysis. The Regular and Irregular building are different and analyzed by static Analysis by IS -18932002 part1 and Nonlinear dynamic analysis method. The Time History analysis have been done for two different earthquake records.



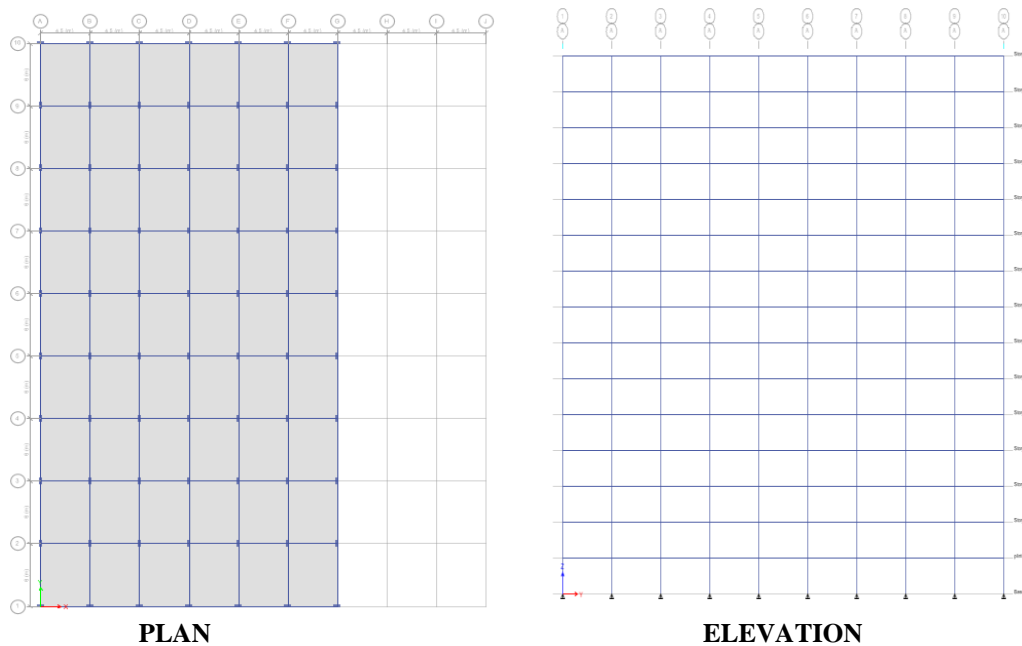
Table I. Detailed Data of the Analyzed Structural Systems

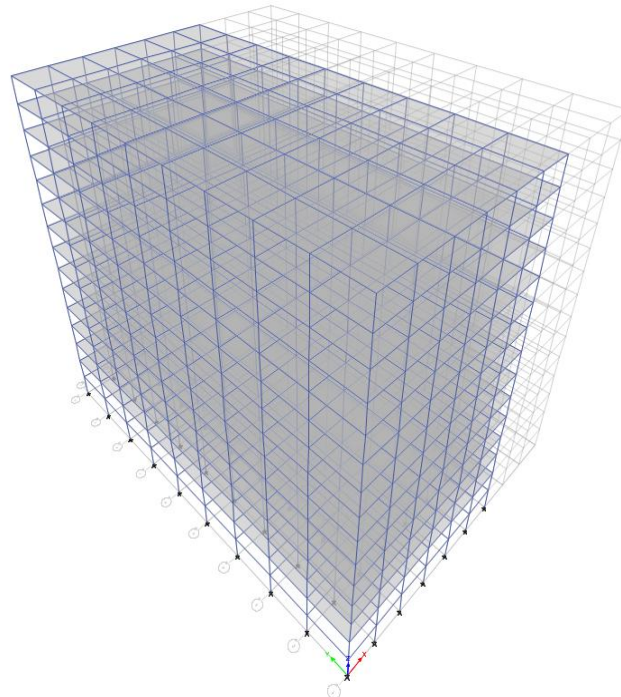
Type of Structural system	G+14 Regular Building	G+14 Irregular Building
Slab (mm)	150mm Thick.	
Column (mm)	300mmX 650mm	
Beam size (mm.)	250mm X 550mm	
Material Properties..	For Concrete M 25 and For Steel Fe415.	
External Wall	230mm thick	
Internal Wall	115mm thick	
Height of each floor	3	
Density (kn/m3)	25	
Liveload (Kn/m2)	3	
Floor finish (kn/m2)	1	
Seismic Zone	IV	
Wind Speed (m/s)	39	
Soil type	Medium hard rock	

Modeling of building:

- model 1: G+15 storied regular shape building Equivalent static method.
- model 2: G+15 Storied regular shape Building by Time history method in Ahmadabad.
- model 3: G+15 Storied regular shape Building by Time history method in Mangalore.
- model 4: G+15 storied irregular shape building Equivalent static method.
- model 5: G+15 Storied irregular shape Building by Time history method in Ahmadabad.
- model 6: G+15 Storied irregular shape Building by Time history method in Mangalore.

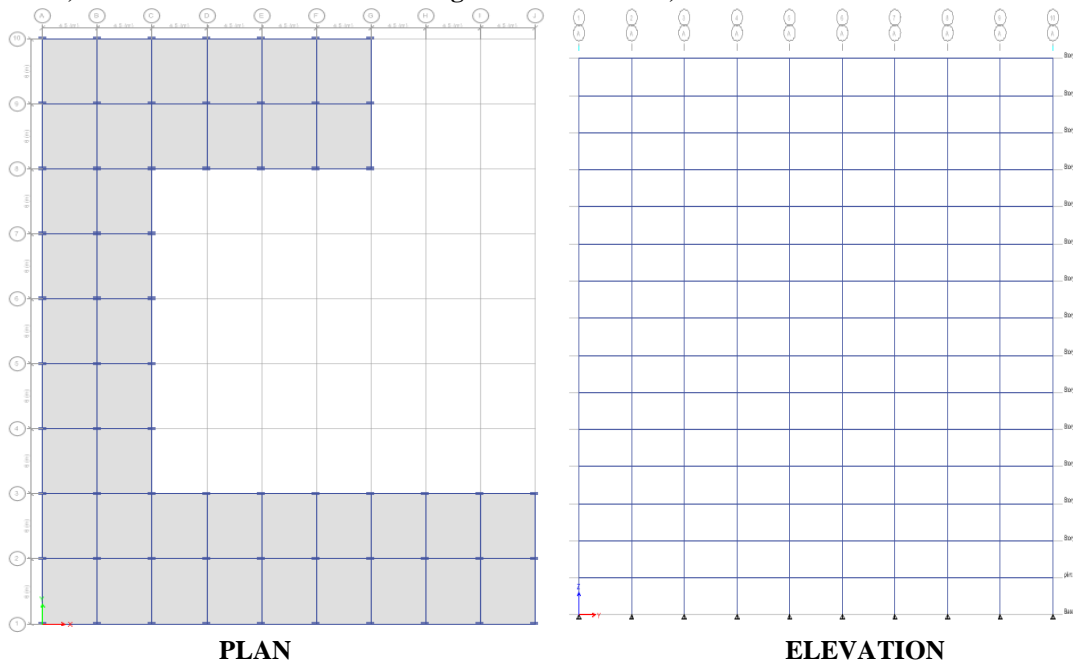
I) Plan, Elevation and 3D-View of Building Models Model -1, 2 & 3

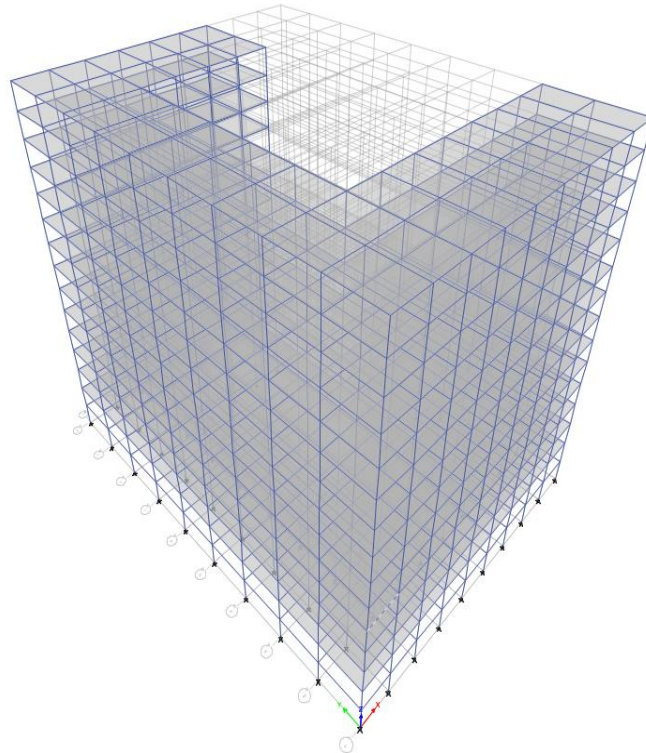




3D VIEW

II. Plan, Elevation & 3D-View of Building Models Model - 4, 5 & 6.





3D VIEW

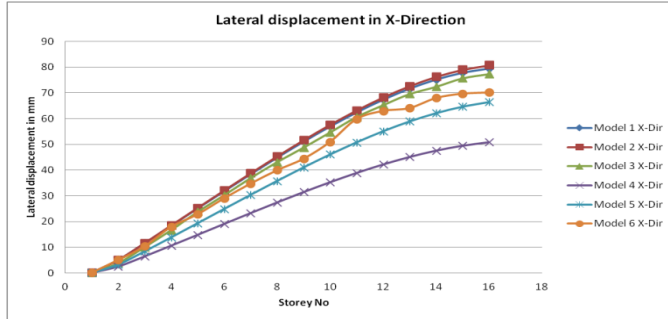
V. RESULTS AND DISCUSSION

Lateral Displacements

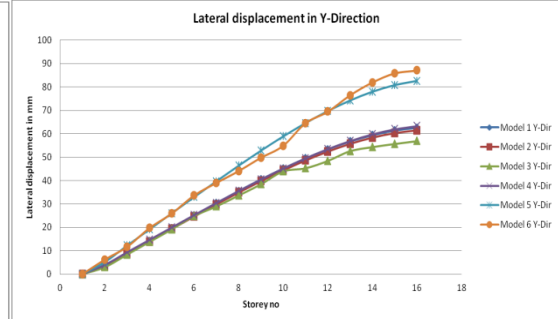
The lateral displacement of each floor is tabulated in below tables for Equivalent static method and time history method for regular and Irregular Shape. At the top of Storey the lateral displacement values are higher and gradually decreasing towards the bottom storey's.

Table 5.1 Lateral Displacements in both X and Y directions

Lateral Displacements												
Storey No	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir
RF	79.483	62.534	80.731	61.446	77.256	56.941	50.792	63.287	66.341	82.603	70.091	87.042
14	77.817	61.342	78.974	60.273	75.593	55.729	49.426	61.919	64.545	80.801	69.634	85.824
13	75.174	59.366	76.237	58.328	72.295	54.385	47.501	59.762	62.021	77.972	67.924	81.921
12	71.632	56.654	72.597	55.663	69.475	52.642	45.044	56.901	58.805	74.228	64.023	76.432
11	67.322	53.308	68.187	52.372	65.135	48.457	42.129	53.444	54.992	69.71	62.923	69.421
10	62.371	49.427	63.133	48.557	60.542	45.324	38.832	49.489	50.683	64.545	59.739	64.521
9	56.894	45.106	57.554	44.31	54.539	43.973	35.226	45.129	45.973	58.853	50.867	54.865
8	50.999	40.43	51.557	39.714	48.652	38.452	31.38	40.447	40.951	52.745	44.326	49.742
7	44.781	35.476	45.241	34.845	42.987	33.652	27.356	35.521	35.699	46.319	39.859	44.043
6	38.328	30.314	38.692	29.772	36.796	28.942	23.212	30.42	30.289	39.665	34.659	38.964
5	31.715	25.003	31.99	24.552	30.112	24.875	18.998	25.203	24.789	32.861	28.935	33.574
4	25.008	19.594	25.201	19.236	23.658	19.114	14.759	19.922	19.258	25.976	22.758	25.852
3	18.263	14.133	18.382	13.87	16.54	13.749	10.538	14.623	13.75	19.066	17.864	19.649
2	11.49	8.67	11.546	8.503	9.956	8.342	6.383	9.334	8.329	12.17	10.297	11.628
1	4.951	3.322	4.95	3.257	3.725	2.937	2.432	3.927	3.174	5.121	4.983	6.179
BASE	0	0	0	0	0	0	0	0	0	0	0	0



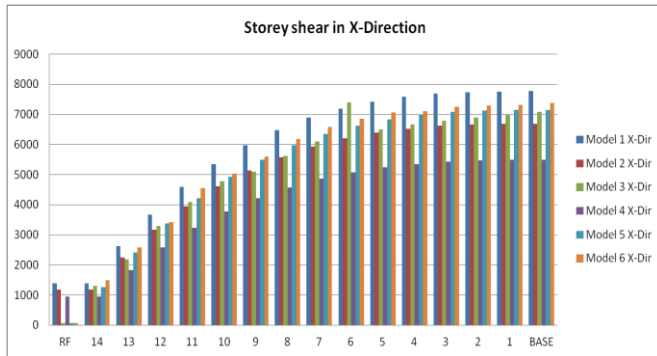
Lateral displacement in X-Direction



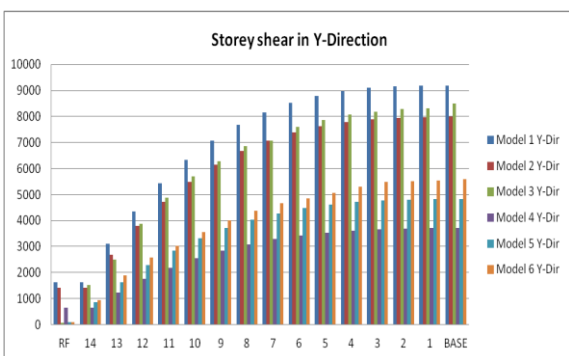
Lateral displacement in Y-Direction

Storey Shear

The sum of design of lateral forces all levels above the Storey viable. Storey shear in one of the important parameter of the structural design engineering point of view. The variation of storey shear under the Equivalent Static Method of earthquake load and Time History Method load is presented in below table.



Storey shear in X-Direction



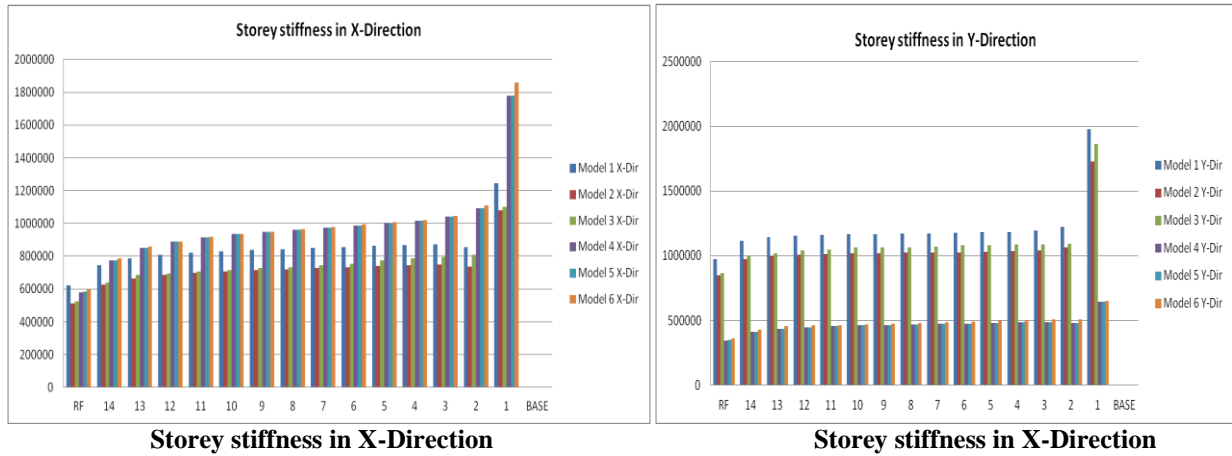
Storey shear in Y-Direction

Storey Stiffness

The lateral Stiffness of story is commonly characterized as the proportion of story shear to story drift. For frames exposed to regular lateral, load distribution, variation in the lateral stiffness of a given story for the few load cases are small enough to be ignored.

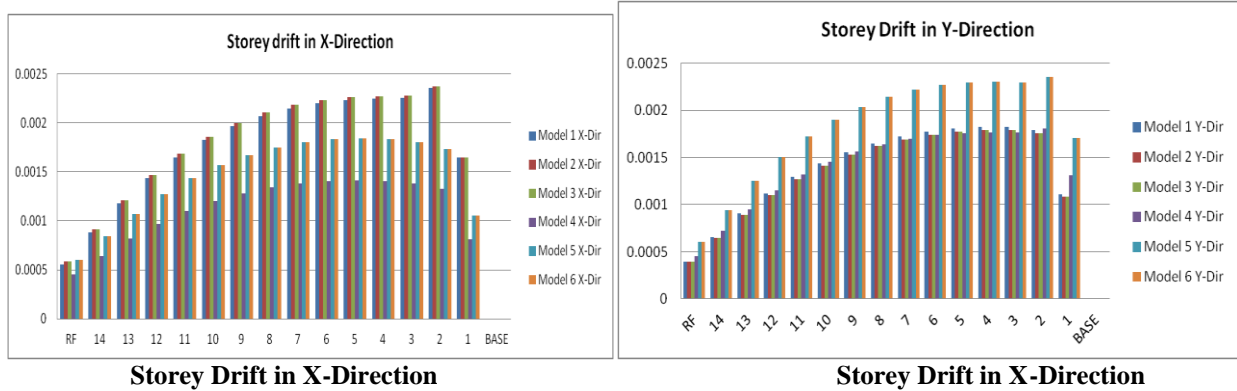
Table 5.2 Storey stiffness in both X and Y directions

Storey No	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir
RF	622035	975667	511255	851267.5	523436	868364.64	579176	345636	584159	347727	597842	358654
14	746613	1114100	625678	972288.4	637639	997354.84	774583	411906	775685	412252	785218	427585
13	786143	1142800	664059	997325.4	687650	1018797.7	849679	435060	849872	435133	859330	458320
12	806957	1153997	684571	1007068	695439	1039374.9	889908	447438	889812	447428	889990	461096
11	820067	1160378	697596	1012614	705366	1048728.6	915742	455314	915531	455271	918543	464091
10	829442	1164811	706957	1016466	714877	1062352.8	934524	460972	934262	460916	937631	469874
9	836859	1168308	714387	1019504	726599	1065983.6	949591	465454	949309	465393	950199	472652
8	843284	1171360	720836	1022156	734268	1066383.3	962794	469321	962508	469260	964287	478421
7	849313	1174255	726894	1024672	743659	1069376.3	975311	472918	975031	472859	97931.5	484975
6	855366	1177207	732979	1027240	755287	1079352.5	988009	476481	987739	476425	996218	489053
5	861711	1180459	739367	1030075	775840	1080374.3	1001675	480184	1001420	480133	100854	495606
4	868717	1184712	746417	1033814	787366	1085973.6	1017561	484130	1017323	484085	102090	499818
3	871430	1193244	749933	1041454	796387	1087036.5	1039672	487791	1039449	487751	104684	507215
2	854150	1220741	735772	1066898	806438	1092871.8	1090707	480333	1090470	480292	110813	510124
1	1243952	1977699	1078438	1729221	1099548	1863836.9	1780897	644778	1780684	644776	185983	651755
BASE	0	0	0	0	0	0	0	0	0	0	0	0



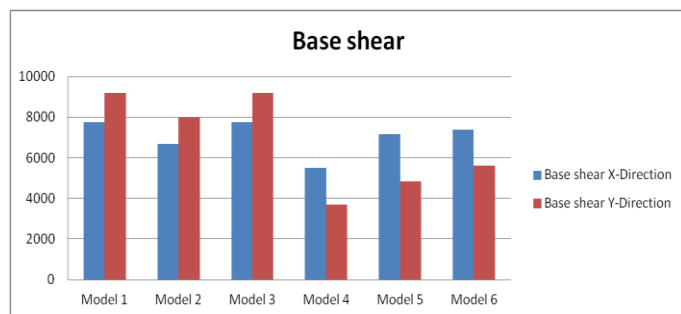
Storey Drift

The displacement of one level comparative with the other level beneath or above is known as Story drift. Story drift is the degree to which a structure influences or twists. Limits are regularly imposed on story drift so a structure isn't intended to be adaptable to the point that the resulting drift during an earthquake causes excessive damage. The permissible limit for storey drift is 0.004 times of the storey height so as to minimize the damages which can occur during the earthquake ground motion. The analysis of building models shows permissible limits of storey drifts. The storey drifts of each model are computed and tabulated in below tables and the results are compared.



Base Shear

Model	Base shear	
	X-Direction	Y-Direction
Model 1	7767.8	9197.545
Model 2	6688.095	7987.857
Model 3	7767.771	9197.5448
Model 4	5488.091	3703.3174
Model 5	7153.49	4828.029
Model 6	7372.937	5598.921



VI. CONCLUSION

1. The displacement obtained by Equivalent static method by Regular shape is greater than irregular shape in X-direction and lesser in Y-direction.
2. The displacement obtained by Equivalent static method for regular shape is greater than displacement obtained by Time History method regular shape.
3. The displacement obtained by Equivalent static method for Irregular shape is greater than displacement obtained by Time History method for irregular shape.
4. The distinct of displacement values between static and dynamic analysis at lower stories are insignificant but it increased at higher stories reached at its top storey or roof.
5. The displacement, storey shear, storey stiffness, storey drift and base shear obtained by Equivalent static method are higher than values obtained by Dynamic method for regular shape.
6. The displacement, storey shear, storey stiffness, storey drift and baseshear obtained by Equivalent Static method are higher than values obtained by Dynamic method for irregular shape.
7. The results of Equivalent Static analysis are approximately uneconomical because value of displacement are higher than Dynamic analysis.
8. The Time History Analysis is a elegant tool to visualize performance level of a building under a given earthquake. Seismic performance of structure can be obtained by selecting adequate recorded ground motion for time history analysis.
9. As a result of comparison the BaseShear obtained by static method by regular shape is greater than irregular shape in Y-dir. And lesser in X-dir.
10. As a result of comparison between static and nonlinear dynamic analysis it is seen the base shear obtained by dynamic analysis are lesser than static analysis for regular structure and baseshear obtained by static analysis are higher than dynamic analysis for irregular structure.
11. Time History analysis is a significant tool to summarize the performance of a structure under a given earthquake. Seismic Analysis of structure is finished by selecting an adequate ground motion data for time history analysis.

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