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Analysis of the sky scraper structure using software

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***Abstract*–With the lot of loss of life and property due to failure of structure caused by earthquake and wind forces, now it is necessary to pay an attention to the adequate accuracy of strength in Composite Sky scraper structures. In this thesis, the sky scraper structure having height 392.36 meter is analyse under the effect of earthquake force and wind force by using ETABS-2015 that is the ultimate integrated software package for the structural analysis and design of buildings. In this thesis different bracing pattern and two types of earthquake analysis analyze. From the analysis, we will conclude the best bracing pattern and the results of two earthquake analysis.**

***IndexTerms*–Sky scraper structure, Seismic force, Wind force, ETABS 2015**

I. INTRODUCTION

In general, for design of tall buildings both wind as well as earthquake loads need to be considered. According to the provisions of Bureau of Indian Standards for earthquake load, IS 1893(Part 1):2002, height of the structure, seismic zone, vertical and horizontal irregularities, soft and weak storey necessitates dynamic analysis for earthquake load[1]. As per IS 875(Part 3):1987, when wind interacts with a building, both positive and negative pressures occur simultaneously, the building must have sufficient strength to resist the applied loads from these pressures to prevent wind induced building failure[1].

We consider two different seismic approaches for our study:

i. Response Spectrum Analysis
ii. Time History Analysis

Elcentro is taken for the time history analysis. The 1940 El Centro earthquake (or 1940 Imperial Valley earthquake) occurred at 21:35 Pacific Standard Time on May 18 in the Imperial Valley in south eastern Southern California near the international border of the United States and Mexico. It had a moment magnitude of 6.9 and a maximum perceived intensity of X (Extreme) on the Mercalli intensity scale.

We consider three different bracing pattern for our study:

1. Bottom to Top Single side bracing
2. Bottom to Top Diagonal bracing
3. Intermediate bracing

II. SKY SCRAPER STRUCTURE

A skyscraper is a tall, continuously habitable building of over 40 floors, mostly designed for office, commercial and residential uses. A skyscraper can also be called a high-rise, but the term skyscraper is often used for buildings higher than 150 m (492 ft). For buildings above a height of 300 m (984 ft), the term Supertall can be used, while skyscrapers reaching beyond 600 m (1,969 ft) are classified as Megatall. One common feature of skyscrapers is having a steel framework that supports curtain walls. Some early skyscrapers have a steel frame that enables the construction of load-bearing walls taller than of those made of reinforced concrete. Modern skyscrapers often have a tubular structure, and are designed to act like a hollow cylinder to resist lateral loads (wind, seismic, etc.). To appear more slender, allow less wind exposure and to transmit more daylight to the ground, many skyscrapers have a design with setbacks.

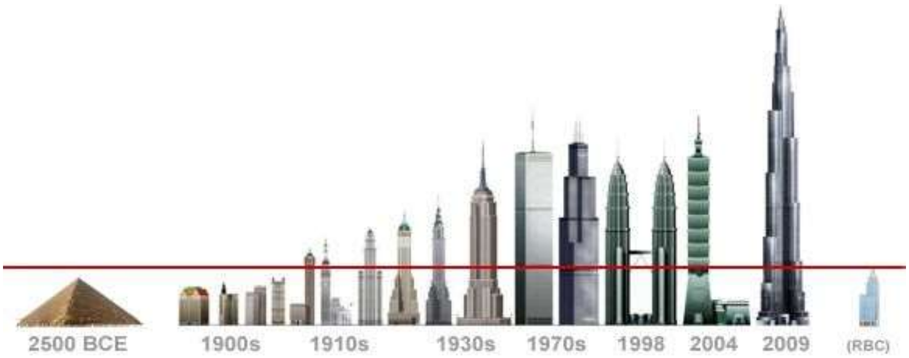

Figure 1: Sky scraper structures

III. MODELING PROCESS

Here A sky scraper structure with 5B+G+100 floors having total height 392.36 meter is selected for the analysis. Dead load, Live Load, Floor Finish Wind Load and Earthquake Load in X and Y-direction were applied on structure. Column, Beam and slab sections are of composite material. Bracing property is of steel. Floor height is 3.65 meter. Earthquake load is applied as per IS 1893:2002 for zone III. Wind load is applied as per IS 875 (part 3) : 1987 with wind speed of 44 m/s.

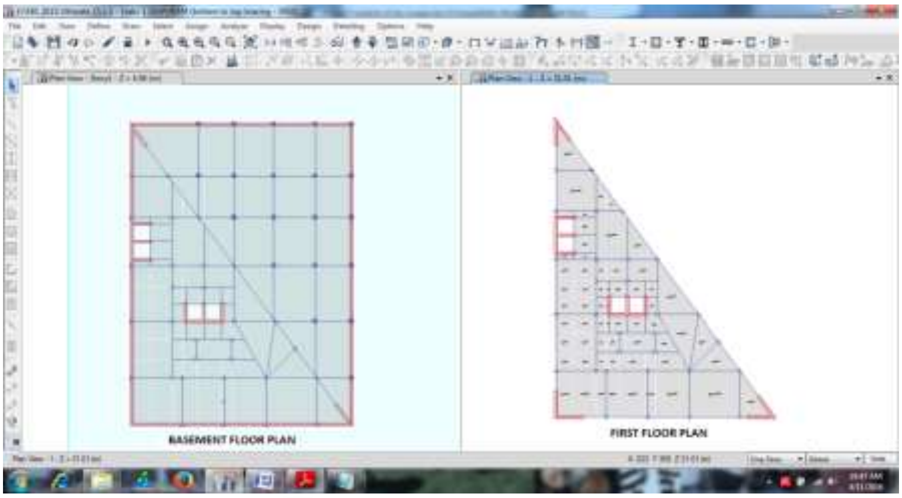

Figure 2: Plan of Basement and First floor

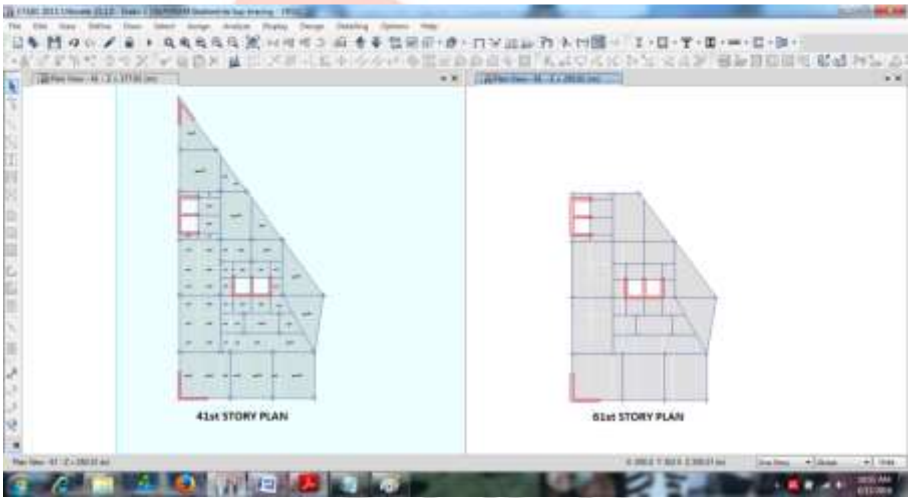

Figure 3: Plan of 41st floor and 61st floor

Material :
Concrete : M60 (columns), M30 (beam & slab)
Steel : Fe 345
Rebar : HYSD 550

Table 1 : Material Property

Property	Concrete	Steel
Young's Modulus E, (MPa)	38729.83	210000
Poisson's ratio (μ)	0.2	0.3
Density (Kg/mt3)	2549.291	7833.413

Table 2 : Load description

Load Description	Value
Dead load	Self weight
Live load (KN/mt2)	3.5
Floor finish (KN/mt2)	1.25
Wall load (KN/mt)	8

IV. ANALYSIS PROCESS

After completion of modeling process next step which carried out was analysis of building. Here we carried out analysis of the sky scraper structure. According to this analysis we had provided two different earthquake analysis. Here, in this thesis focus on results of value of drift.

V. RESULTS

Hereby, results are developed. The value of drift for the two different earthquake analysis and three different bracing pattern are obtained.

I. Results by "Response spectrum analysis" :

i. Case I – bottom to top single side bracing.

Table 3 : Story Drift for Case I – bottom to top single side bracing.

STORY	STORY DRIFT (mt)			
	EQX (max)	EQY (max)	WLX (max)	WLY (max)
100	0.083521	0.041524	0.021075	0.000837
95	0.085008	0.046438	0.021147	0.000897
90	0.085406	0.049089	0.021265	0.001147
85	0.082618	0.043705	0.021395	0.001477
80	0.076856	0.030016	0.021455	0.0018
75	0.073896	0.012297	0.021229	0.002026
70	0.068318	0.01271	0.020378	0.002021
65	0.057993	0.021061	0.018418	0.001585
60	0.04157	0.012283	0.014388	0.00125
55	0.034327	0.008774	0.012258	0.000949
50	0.031612	0.007248	0.011207	0.000673
45	0.030069	0.006085	0.011025	0.0007
40	0.028626	0.006708	0.01122	0.000898
35	0.026419	0.005826	0.010963	0.000975
30	0.024233	0.005098	0.010655	0.000999
25	0.021982	0.004453	0.01025	0.001117
20	0.019569	0.003875	0.009688	0.001229
15	0.016918	0.003346	0.008904	0.001335
10	0.013894	0.002837	0.007772	0.001422
5	0.009917	0.002192	0.005863	0.001337
0	0.000931	0.000139	0.000478	0.000055

ii. Case II – bottom to top Diagonal bracing.

Table 4 : Story Drift for Case II – bottom to top Diagonal bracing.

STORY	STORY DRIFT (mt)			
	EQX (max)	EQY (max)	WLX (max)	WLY (max)
100	0.036976	0.030529	0.005872	0.000978
95	0.037383	0.031754	0.006125	0.001199
90	0.038635	0.03361	0.006532	0.001542
85	0.039464	0.035318	0.006924	0.001835
80	0.039599	0.036314	0.007222	0.002044
75	0.038855	0.037602	0.00734	0.002116
70	0.036952	0.038804	0.007173	0.002009
65	0.033615	0.036371	0.006637	0.001656
60	0.030628	0.024796	0.005464	0.000874
55	0.03042	0.020894	0.005008	0.000572
50	0.03052	0.019399	0.005105	0.000529
45	0.030468	0.018314	0.005645	0.000697
40	0.03019	0.017314	0.006123	0.00086
35	0.02901	0.016325	0.006366	0.000966
30	0.027595	0.015292	0.006541	0.001023
25	0.025885	0.014167	0.006607	0.001036
20	0.023802	0.012895	0.006524	0.001135
15	0.021247	0.011364	0.006235	0.001236
10	0.017983	0.009688	0.005632	0.001297
5	0.01314	0.007465	0.004355	0.001178
0	0.001069	0.000611	0.000317	0.000015

iii. Case III – Intermediate bracing.

Table 5 : Story Drift for Case III – Intermediate bracing.

STORY	STORY DRIFT (mt)			
	EQX (max)	EQY (max)	WLX (max)	WLY (max)
100	0.064842	0.021606	0.011293	0.002068
95	0.066693	0.022458	0.011764	0.00241
90	0.069193	0.023713	0.012451	0.002853
85	0.071679	0.02511	0.013243	0.003341
80	0.072974	0.026783	0.013869	0.003712
75	0.072702	0.02801	0.014245	0.003986
70	0.069996	0.028082	0.014111	0.004023
65	0.064456	0.026151	0.013279	0.003664
60	0.054447	0.019807	0.011126	0.002509
55	0.052417	0.018137	0.010135	0.001973
50	0.051313	0.017249	0.009576	0.001649
45	0.050126	0.016613	0.008998	0.001321
40	0.049003	0.016019	0.008903	0.001207
35	0.046025	0.015242	0.008847	0.001252
30	0.042779	0.014262	0.008706	0.001237
25	0.039309	0.013193	0.008475	0.001183
20	0.035458	0.011964	0.008101	0.001092
15	0.031049	0.010484	0.007525	0.000953
10	0.025768	0.008566	0.006633	0.000749
5	0.018501	0.006661	0.005054	0.000828
0	0.001658	0.000536	0.000433	0.000029

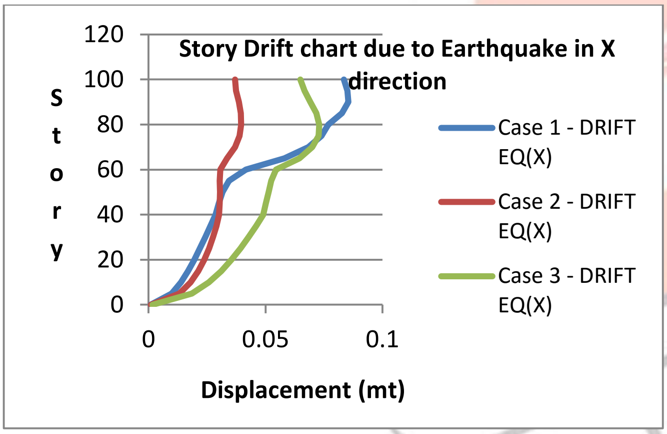

Figure : 4 story drift due to EQ in X-direction

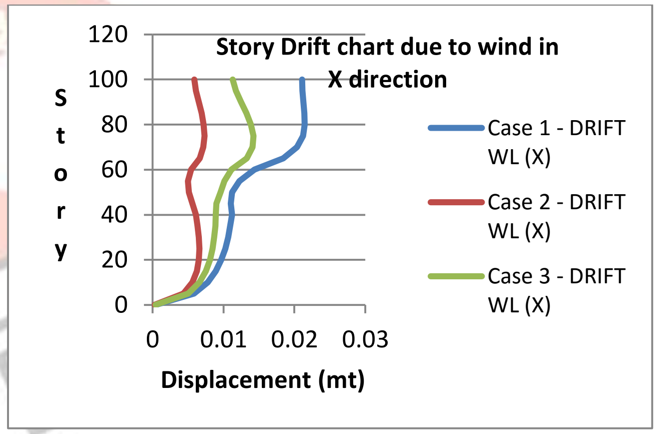

Figure : 5 story drift due to WIND in X-direction

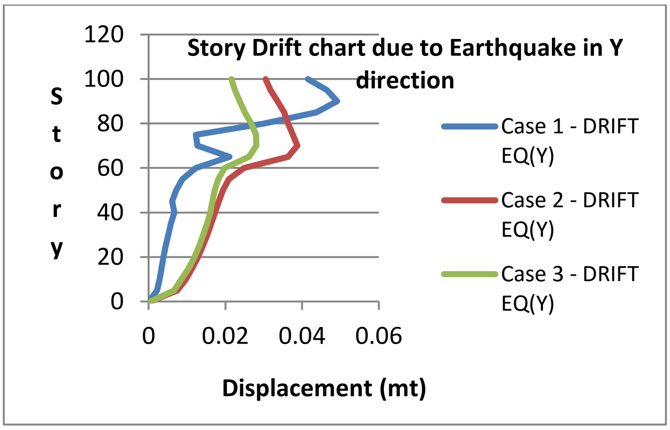

Figure : 6 story drift due to EQ in Y-direction

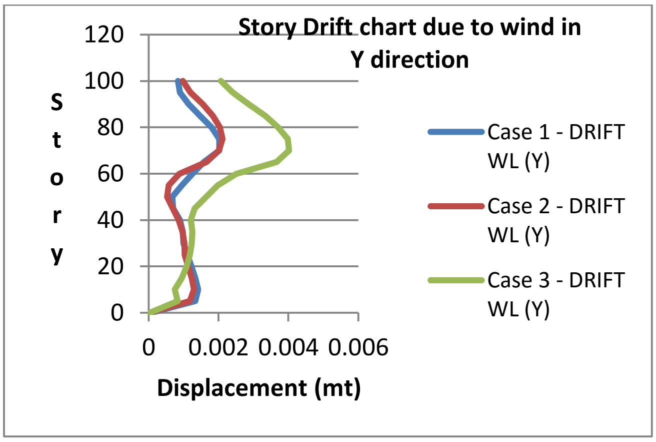

Figure : 7 story drift due to WIND in Y-direction

II. Results by "Time History analysis" :

iv. Case I – bottom to top single side bracing.

Table 6 : Story Drift for Case I – bottom to top single side bracing.

STORY	STORY DRIFT (mt)			
	EQX (max)	EQY (max)	WLX (max)	WLY (max)
100	0.112502	0.061587	0.023607	0.003217
95	0.117910	0.063589	0.02451	0.003385
90	0.118457	0.066514	0.025103	0.003029
85	0.111581	0.062751	0.02437	0.001779
80	0.105387	0.052487	0.022429	0.002261
75	0.102159	0.051477	0.022329	0.00388
70	0.097012	0.052687	0.02265	0.004385
65	0.088495	0.054331	0.020619	0.003441
60	0.075495	0.049271	0.015327	0.002441
55	0.060774	0.042187	0.012844	0.001539
50	0.054006	0.040661	0.011683	0.001193
45	0.046934	0.037114	0.011318	0.000968
40	0.041890	0.036001	0.011582	0.000668
35	0.040524	0.033221	0.011312	0.00052
30	0.038664	0.030147	0.010975	0.000624
25	0.036014	0.028745	0.010533	0.000722
20	0.029574	0.025501	0.009928	0.000799
15	0.025422	0.023514	0.009094	0.000838
10	0.020644	0.014582	0.007907	0.000811
5	0.012006	0.006221	0.005939	0.000693
0	0.003271	0.000504	0.000487	0.000011

v. Case II – bottom to top Diagonal bracing.

Table 7 : Story Drift for Case II – bottom to top Diagonal bracing.

STORY	STORY DRIFT (mt)			
	EQX (max)	EQY (max)	WLX (max)	WLY (max)
100	0.079125	0.042056	0.022309	0.005007
95	0.081338	0.042957	0.023348	0.0049
90	0.082653	0.044026	0.02421	0.00356
85	0.084481	0.045278	0.023655	0.001128
80	0.083002	0.045697	0.021566	0.002802
75	0.082974	0.047258	0.022318	0.004635
70	0.079004	0.049558	0.022768	0.004776
65	0.072146	0.047551	0.020647	0.003281
60	0.063529	0.036524	0.015242	0.001707
55	0.051227	0.031821	0.012729	0.000793
50	0.049557	0.030079	0.011555	0.000491
45	0.043394	0.027496	0.011285	0.000449
40	0.041901	0.026112	0.011576	0.00059
35	0.037814	0.024159	0.011332	0.00068
30	0.032015	0.021005	0.011014	0.000775
25	0.031507	0.019675	0.010586	0.000862
20	0.024024	0.016583	0.00999	0.000928
15	0.023857	0.016202	0.009159	0.000955
10	0.017259	0.015879	0.007968	0.000995
5	0.009357	0.012403	0.005985	0.000893
0	0.002065	0.001975	0.000486	0.00001

vi. Case III – Intermediate bracing.

Table 8 : Story Drift for Case III – Intermediate bracing.

STORY	STORY DRIFT (mt)			
	EQX (max)	EQY (max)	WLX (max)	WLY (max)
100	0.092346	0.032519	0.019901	0.002116
95	0.095284	0.033298	0.020799	0.002228
90	0.093846	0.035189	0.021574	0.002145
85	0.094086	0.036958	0.021298	0.001746

80	0.091057	0.038254	0.019982	0.000981
75	0.089602	0.038574	0.019147	0.001173
70	0.087006	0.036254	0.01972	0.002032
65	0.083364	0.034196	0.018483	0.002204
60	0.073604	0.026851	0.014407	0.002276
55	0.058843	0.024698	0.012399	0.001839
50	0.052019	0.023015	0.011425	0.001686
45	0.050126	0.023001	0.01058	0.001563
40	0.049862	0.021597	0.010691	0.001314
35	0.049005	0.020132	0.010471	0.001114
30	0.041586	0.019821	0.010185	0.000899
25	0.039997	0.018722	0.009803	0.000668
20	0.035699	0.015244	0.009265	0.00043
15	0.030682	0.013255	0.008513	0.000455
10	0.026824	0.012472	0.007429	0.000475
5	0.015625	0.009611	0.005608	0.000407
0	0.003957	0.000899	0.000479	0.000013

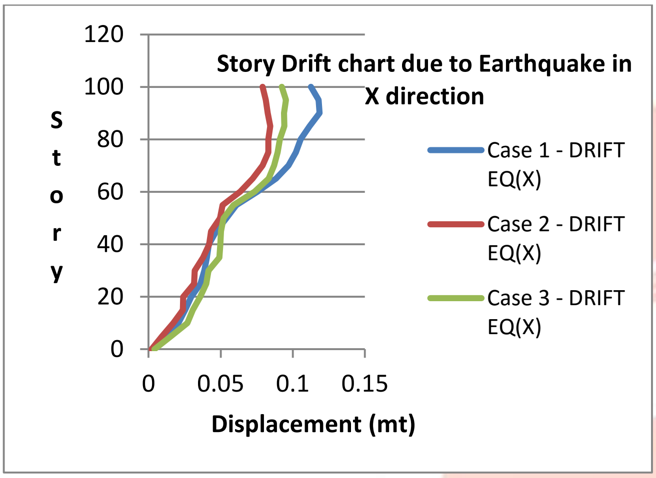

Figure : 8 story drift due to EQ in X-direction

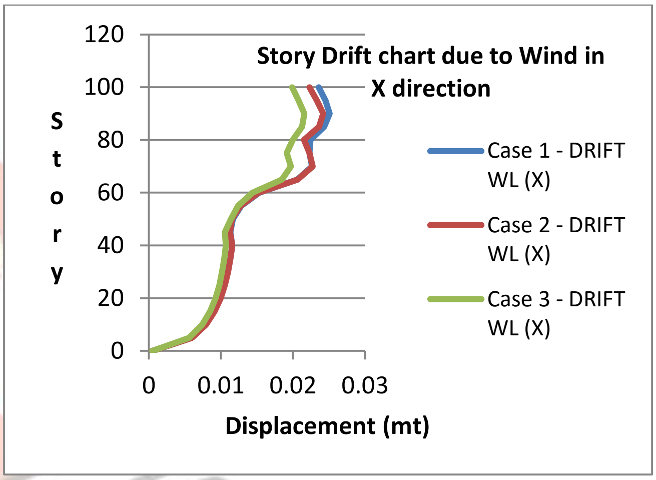

Figure : 9 story drift due to WIND in X-direction

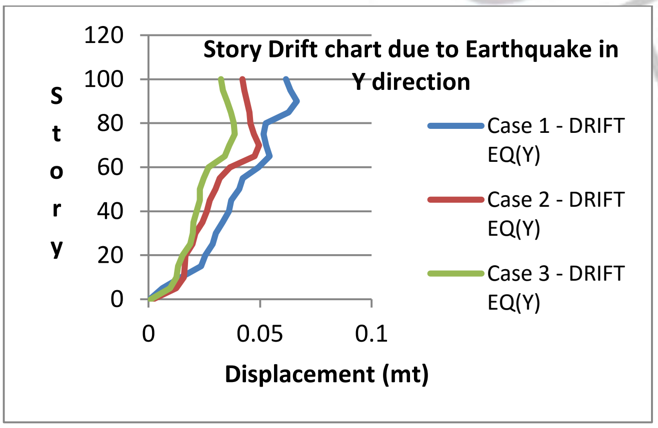

Figure : 10 story drift due to EQ in Y-direction

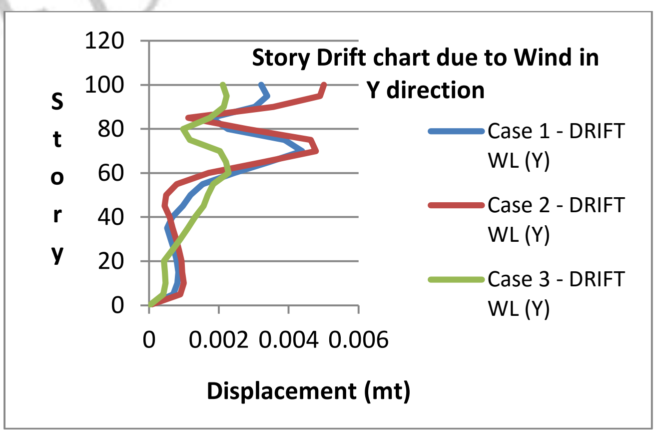

Figure : 11 story drift due to WIND in Y-direction

VI. Conclusion

1. From the three basic pattern of bracing against the lateral loads, we found out "Diagonal bracing pattern from bottom to top" is more effective than other two pattern. How much percentage diagonal bracing pattern is more effective than other two bracing pattern, it is shown in the below table as diagonal bracing pattern is taken as 100%:

Table 9 : Percentage comparison table for Diagonal bracing for Response spectrum results

Accordingly Response Spectrum Results		
Load Case	Single side bottom to top bracing	Intermediate Bracing
Story Acceleration	140.68%	102.47%
Story Drift	225.88%	175.36%
Column Force (Wind)	272.61%	233.20%

Table 10 : Percentage comparison table for Diagonal bracing for time history analysis results

Accordingly Time History (ELCENTRO) Results		
Load Case	Single side bottom to top bracing	Intermediate Bracing
Story Acceleration	102.38%	122.42%
Story Drift	142.19 %	116.71%
Column Force (Wind)	84.95%	81.40%

2. "Time history method" is worst than "Response spectrum method" for the sky scraper structure.
3. The variation of the results by seismic analysis is more than that of the wind analysis because of depending on many design factors. One of the most important factors is the weight of the building. The Ductile frames are recommended for tall building or when earthquake govern the design.

VII. Acknowledgment

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