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Dynamic Analysis of Multi-Storey Building with Openings in Shear Wall

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ABSTRACT

Shear walls are added to the building interior to provide extra strength and stiffness to the building when the exterior walls cannot provide sufficient strength and stiffness or when the allowable span-width ratio for the floor or roof diaphragm is exceeded. Shear walls are analyzed to resist two types of forces: shear forces and uplift forces. Shear forces are created throughout the height of the wall between the top and bottom shear wall connections. Uplift forces exist on shear walls because the horizontal forces are applied to the top of the wall. These uplift forces try to lift up one end of the wall and push the other end down. In some cases, the uplift force is large enough to tip the wall over. Shear walls are analyzed to the provide necessary lateral strength to resist horizontal forces. Shear walls are strong enough, to transfer these horizontal forces to the next element in the load path below them. In present work, twenty storey buildings have been modeled using software package ETABS for earthquake zone III in India. This paper aims to study the behavior of reinforced concrete building by conducting dynamic analysis for shear wall with opening conditions. Symmetrical openings are provided in shear walls with proper sizes to ensure least interruption to force flow through walls. Estimation of structural response such as; storey displacements, Torsion ,Bending Moment , storey drift is carried out. Dynamic responses under zone III earthquake as per IS 1893 (part 1) : 2002 have been carried out.

Shear walls are analyzed for two cases

1) With openings
2) Without openings

and the results are compared and tabulated.

Keywords: dynamic analysis, structural response ,shear walls with opening, shear forces , uplift forces

I. INTRODUCTION

Shear walls are a type of structural system that provides lateral resistance to a building or structure. They resist in-plane loads that are applied along its height. The applied load is generally transferred to the wall by a diaphragm or collector or drag member. The efficiency of a structural system is measured in terms of their ability to resist lateral load, which increases with the height of the frame. A building can be considered as tall when the effect of lateral loads is reflected in the design. Lateral deflections of framed buildings should be limited to prevent damage to both structural and nonstructural elements. Reinforced concrete

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(RC) buildings often have vertical plate-like RC walls called Shear Walls in addition to slabs, beams and columns. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings. Shear walls are usually provided along both length and width of buildings. Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation. “We cannot afford to build concrete buildings meant to resist severe earthquakes without shear walls.” Mark Fintel, a noted consulting engineer in USA Shear walls in high seismic regions requires special detailing. However, in past earthquakes, even buildings with sufficient amount of walls that were not specially detailed for seismic performance (but had enough well-distributed reinforcement) were saved from collapse. Shear wall buildings are a popular choice in many earthquake prone countries, like Chile, New Zealand and USA. Shear walls are easy to construct, because reinforcement detailing of walls is relatively straight-forward and therefore easily implemented at site. Shear walls are efficient; both in terms of construction cost properly designed and detailed buildings with Shear walls have shown very good performance in past earthquakes. The overwhelming success of buildings with shear walls in resisting strong earthquakes is summarized in the quote: And effectiveness in minimizing earthquake damage in structural and non- Structural elements (like glass windows and building contents).Shear walls provide large strength and stiffness to buildings in the direction of their orientation, which significantly reduces lateral sway of the building and thereby reduces damage to structure and its contents. Shear walls should be provided along preferably both length and width.Door or window openings can be provided in shear walls, but their size must be small to ensure least interruption to force flow through walls. Moreover, openings should be symmetrically located. Special design checks are required to ensure that the net cross sectional area of a wall at an opening is sufficient to carry the horizontal earthquake force. Shear walls in buildings must be symmetrically located in plan to reduce ill-effects of twist in buildings. They could be placed symmetrically along one or both directions in plan. In modern tall buildings, shear walls are commonly used as a vertical structural element for resisting the lateral loads that may be induced by the effect of wind and earthquakes. Shear walls of varying cross sections i.e. rectangular shapes to more irregular cores such as channel, T, L, barbell shape, box etc. can be used. Provision of walls helps to divide an enclose space, whereas of cores to contain and convey services such as elevator. Wall openings are inevitably required for windows in external walls and for doors or corridors in inner walls or in lift cores. The size and location of openings may vary from architectural and functional point of view.

When a building is subjected to wind or earthquake load, various types of failure must be prevented:
- slipping off the foundation (sliding)
- overturning and uplift (anchorage failure)
- shear distortion (drift or racking deflection)
- collapse (excessive racking deflection)

The first three types of failure are schematically shown in the Figure 1 Clearly, the entire system must be tied together to prevent building collapse or significant deformation.

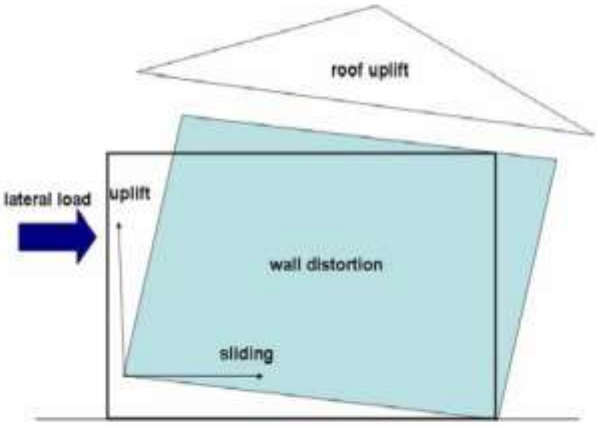
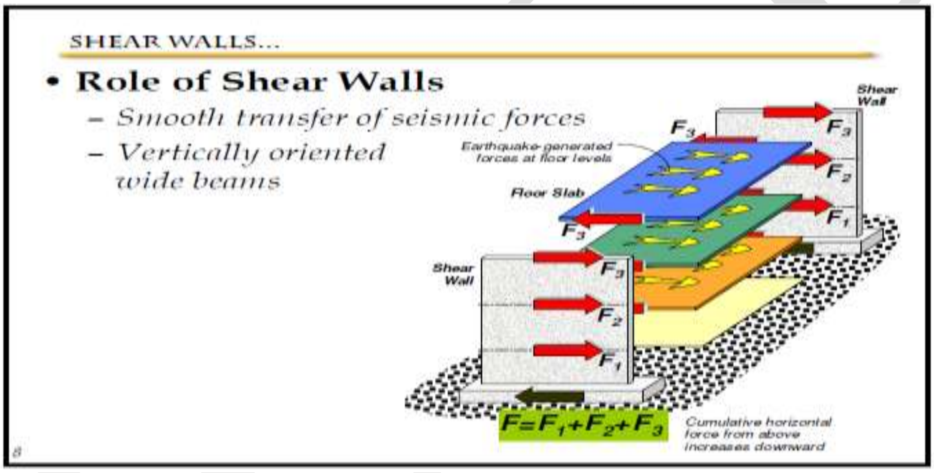
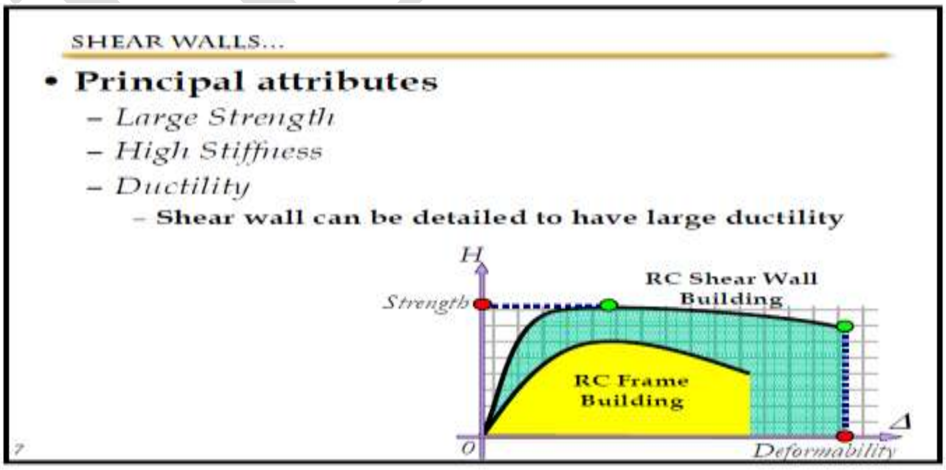


Figure 1: Schematic of the deformations of the structure due to the lateral loads





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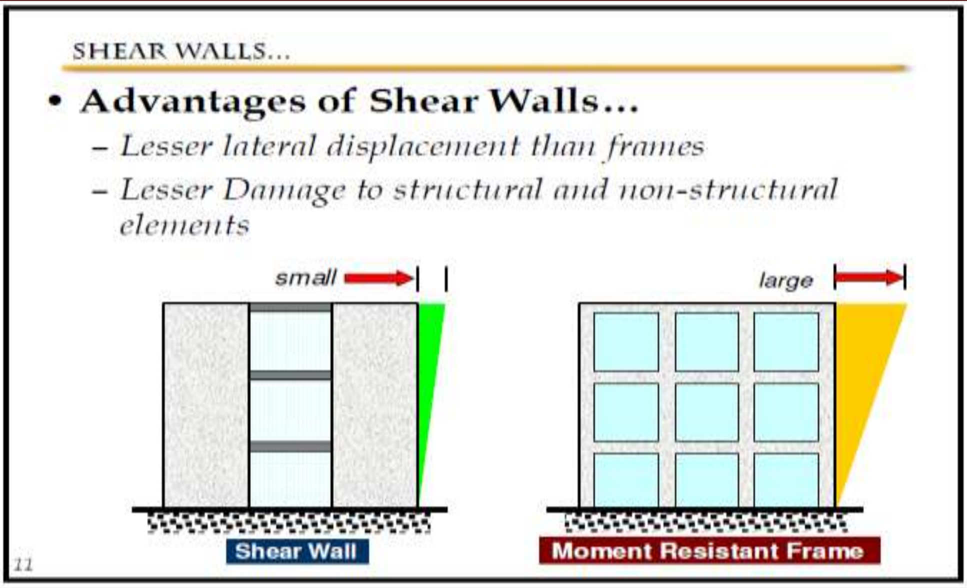

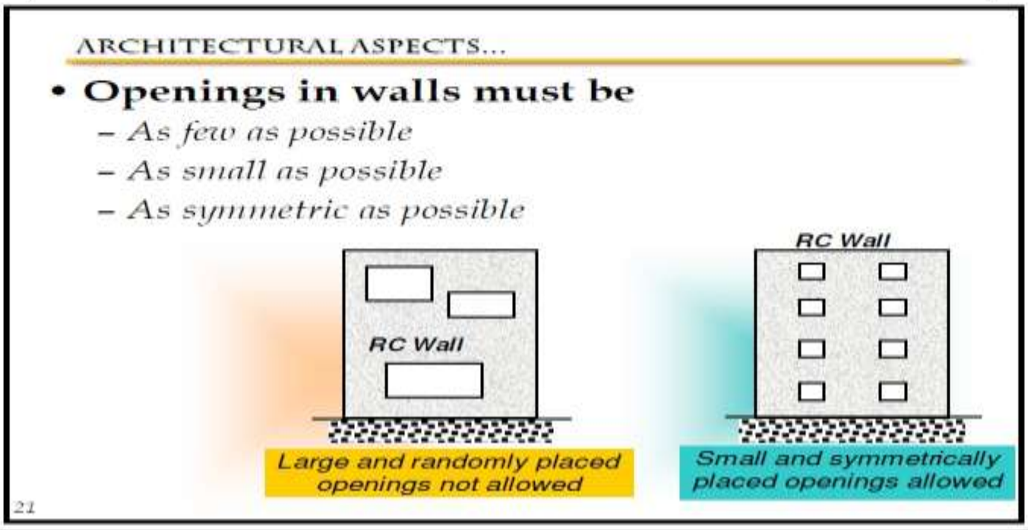

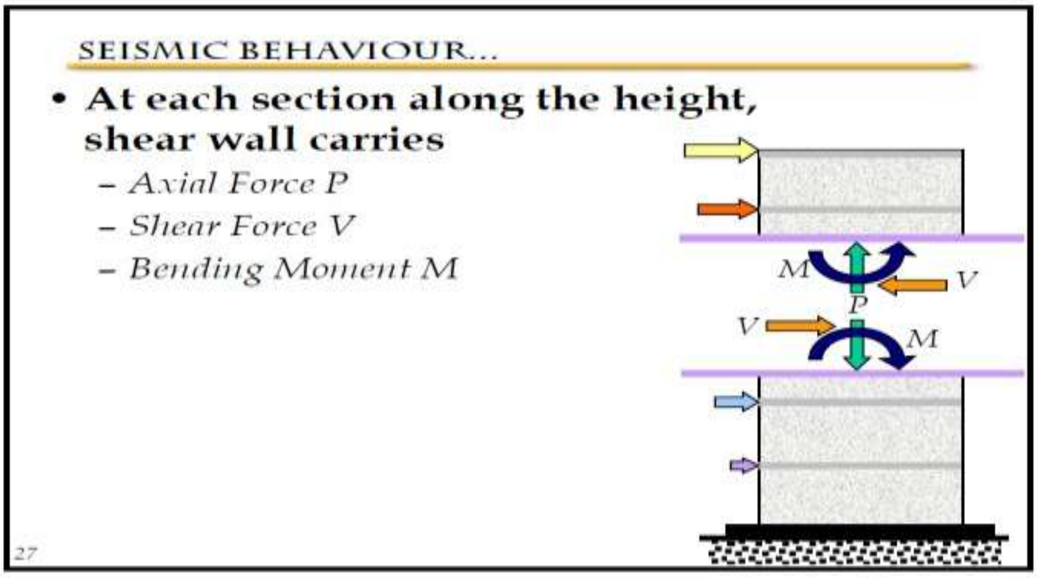

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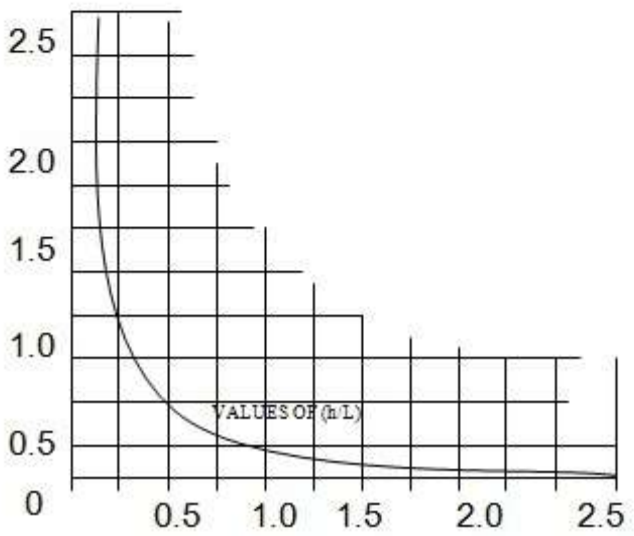
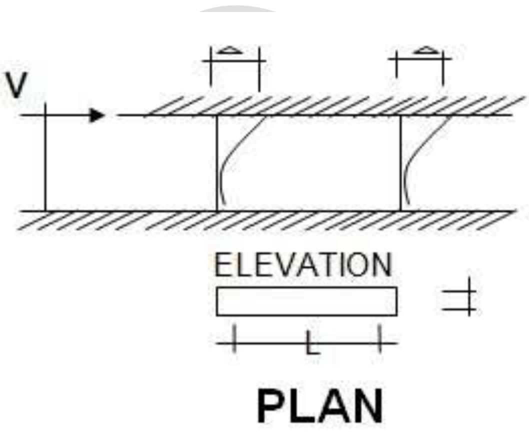
1.1 Shear Walls with Openings

Pipers in a wall formed by openings may be regarded as fixed at both ends, which changes the bending deflection tremh/3EI to h3/12EI in esq. the rigidity of a pier is then given in the direction of its length.

$$R = \frac{E_t}{\left(\frac{h}{L}\right)^3 + 2.64\left(\frac{h}{L}\right)}$$

VALUES OF (h/L)





$$R = \frac{V}{\Delta} = \frac{E_t}{\left(\frac{h}{L}\right)^3 + 2.64\left(\frac{h}{L}\right)}$$

Rigidity of wall element fixed at both ends. It gives a curve for rapid evaluations of the rigidity of piers. The rigidity of a pier in the direction of its thickness in negligibly small.

The rigidity of a wall with openings may be calculated neglecting the effect of the axial shortening of piers by the judicious use of the principles of series and parallels in the same way. It is seen that for normal window or door openings, the rigidity of the wall is not affected to any appreciable extent. The rigidity of a shear wall is due more to its form than it its mass.

In size of the openings should be relatively small and these should be spaced at least a distance equal to the size of the openings in each direction. To restrict the stresses in the shear wall, the width of openings should be limited approximately to 15% of the total length of the connected shear walls and the depth of the connecting beam should be greater than 20% of the storey height.

1.2 Rigidity of a Wall Element

Ryx is defined as the horizontal force necessary to prevent y- distortions of a wall element when Rx is applied in the x-directions producing a unit deflection Rxy is also defined. When the principal axes of the shape of a shear wall are parallel to the x and y axes, Rxy and Ryx vanish.

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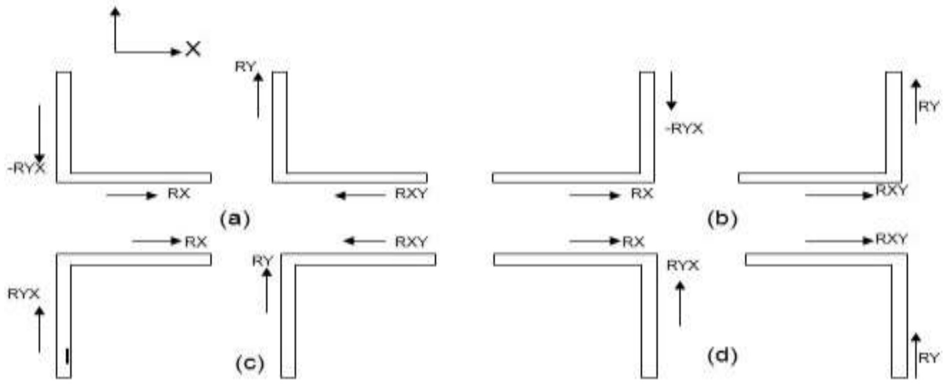

Direction of Rxy and Ryx for various dispositions of the angle wall element. (a) angle in position 1; (b) angle in position 2; (c) angle in position 3; (d) angle in position 4.

II. METHODOLOGY

2.1 Dynamic Analysis

Dynamic analysis shall be performed to obtain to design seismic force, and its distribution to different levels along the height of the building and to various lateral loads resisting elements for the following buildings:

Regular buildings-those greater than 40 m in height in zones 4 and 5, those greater than 90 m in height in zones 2 and 3. The analysis model for dynamic analysis of buildings with unusual configuration should be such that it adequately models the types of irregularities present in the building configuration. Buildings with plan irregularities (as defined in the Table 4 of IS 1893-2002) can not be modeled for dynamic analysis.

Dynamic analysis may be performed either by the time history method or by the response spectrum method. However, in either method, the design base shear $(\bar{V}_B)$ shall be compared with a base shear (V_B) calculated using a fundamental period t. where $(\bar{V}_B)$ is less than (V_B) , all response quantities (for example member forces, displacements, storey forces, storey shears and base reactions) shall be multiplied by $(V_B)/(\bar{V}_B)$. The values of damping for building may be taken as 2 and 5 percent of the critical, for the purposes of dynamic analysis of steel and reinforce concrete buildings, respectively.

a) Time history method- the usage of this method shall be on an appropriate ground motion and shall be performed using accepted principles of dynamics.

b) Response spectrum method- this method shall be performed using the design spectrum specified in code or by a site-specific design spectrum for a structure prepared at a project site.

III. NUMERICAL MODELLING AND ANALYSIS

3.1 Geometrical Properties

1. No. of stories of the Building model = 20
2. Column Sizes: -
a) Outer periphery columns = 600mm x 600mm
3. Beam Size = 400mm x 600mm
4. Slab thickness = 150mm

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3.2 Loads Calculations

1. Live load
   a) Corridor = 3 KN/m2
   b) Floor = 2 KN/m2
2. Dead Load (Floor Finishing) = 1.5 KN/m2
3. Wall load
   a) 9’’ = 12.4 KN/m
   b) 41/2’’ = 7 KN/m
4. Wind load

a) Wind Exposure parameters
Wind direction angle =0Degree
Windward coff. Cp = 0.8
Leeward coff Cp = 0.5
b) Wind coefficients
Wind speed = 50 KN/m
Terrain category = 2
Structure class = B
Risk coefficient (k1) = 1
Topography (k3) = 1

5. Seismic loading
   Seismic zone factor (Z) = 0.16
   Soil Type = Medium (II)
   Response Reduction factor = 5

3.3 Load Combinations

The following Load Combinations have been considered for the design

1. (DL+ LL)
2. (DL ± EQXTP)
3. (DL ± EQYTP)
4. (DL ± EQXTN)
5. (DL ± EQYTN)
6. (DL + LL ± EQXTP)
7. (DL + LL ± EQYTP)
8. (DL + LL ± EQXTN)
9. (DL + LL ± EQYTN)
10. (DL ± WLX)
11. (DL ± WLY)
12. (DL + LL ± WLX)
13. (DL + LL ± WLY)

DL – Dead Load
LL – Live Load
EQTP–Earthquake load
With torsion positive
EQTN–Earthquake load
With torsion negative

14. 1.5(DL+ LL)
15. 1.5(DL ± EQXTP)
16. 1.5(DL ± EQYTP)
17. 1.5(DL ± EQXTN)
18. 1.5(DL ± EQYTN)
19. 1.2(DL + LL ± EQXTP)
20. 1.2(DL + LL ± EQYTP)
21. 1.2(DL + LL ± EQXTN)
22. 1.2(DL + LL ± EQYTN)
23. 1.5(DL ± WLX)
24. 1.5(DL ± WLY)
25. 1.2(DL + LL ± WLX)
26. 1.2(DL + LL ± WLY)

DL – Dead Load
LL – Live Load
EQTP–Earthquake load
With torsion positive
EQTN–Earthquake load

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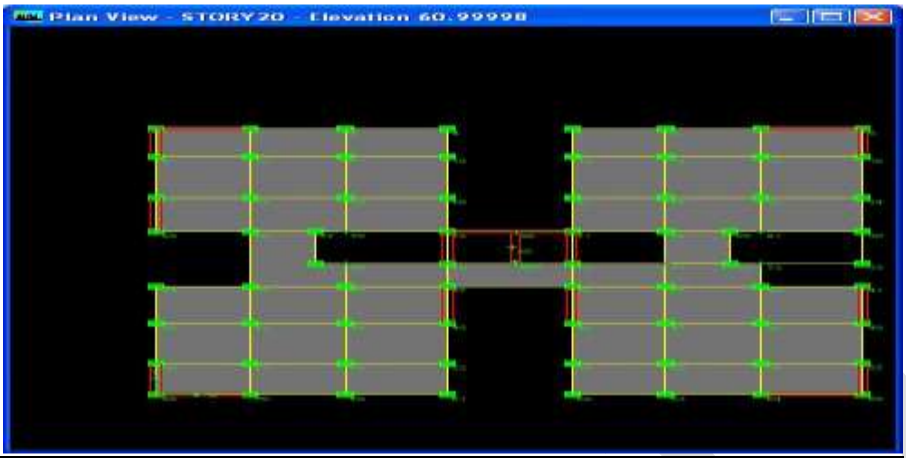

Figure 2: PLAN

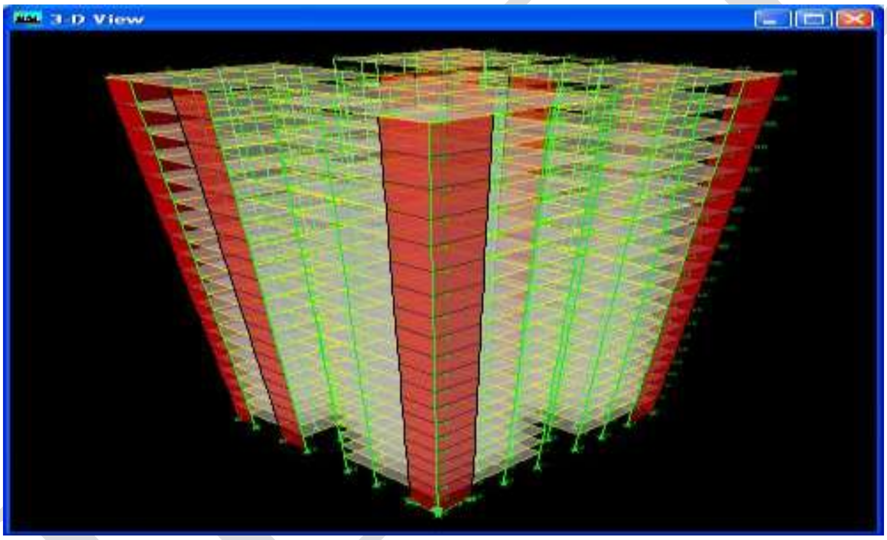

Figure 3: 3-D MODEL OF A BUILDING

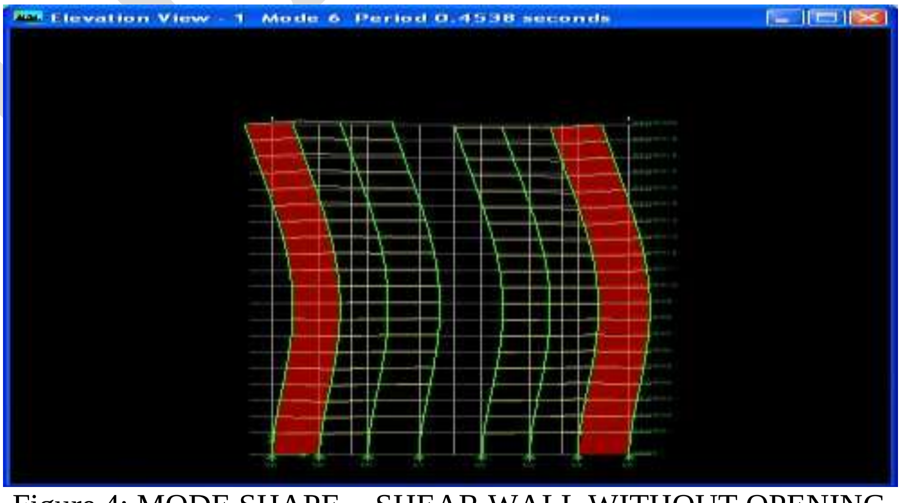

Figure 4: MODE SHAPE - SHEAR WALL WITHOUT OPENING

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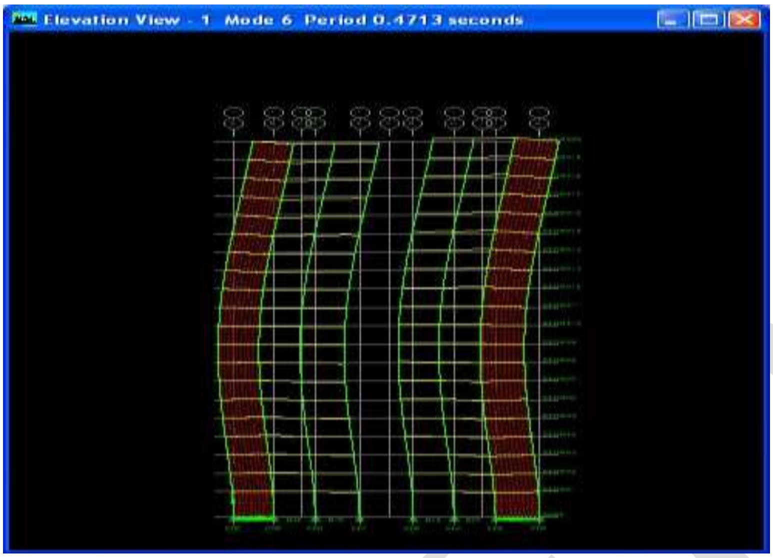


Figure 5: MODE SHAPE - 6 SHEAR WALL WITH OPENING

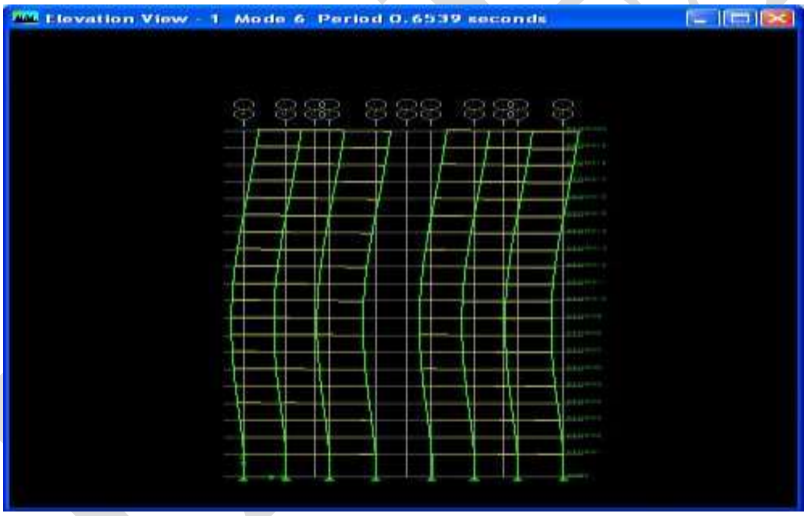


Figure 6: MODE SHAPE – 6 WITHOUT SHEAR WALL

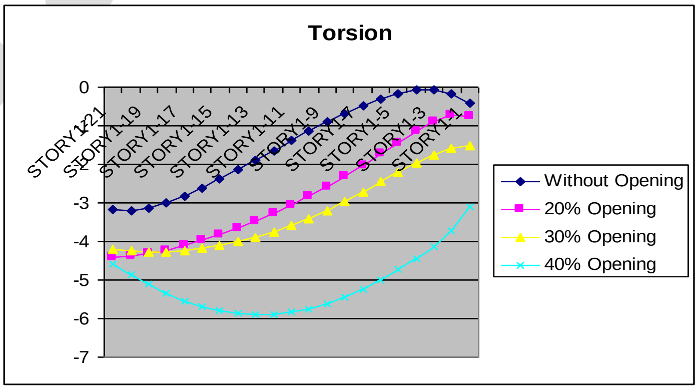
IV. RESULTS AND DISCUSSIONS

% Torsion of shear wall without opening is compared with different % openings and tabulated for column C85, which is nearer to shear wall

% opening	For single opening the % increase in Torsion	For two openings the % increase in Torsion
20%	37.6	14.4
30%	39.5	17.5
40%	39.4	20.43

TABLE 1: Torsion for column C85 which is nearer to shear wall

STORY	without SW	20%	30%	40%
STORY1-21	-3.169	-4.424	-4.198	-4.577
STORY1-20	-3.202	-4.384	-4.235	-4.847
STORY1-19	-3.122	-4.327	-4.271	-5.117
STORY1-18	-2.987	-4.232	-4.271	-5.352
STORY1-17	-2.812	-4.114	-4.239	-5.546
STORY1-16	-2.607	-3.978	-4.184	-5.697
STORY1-15	-2.382	-3.828	-4.107	-5.807
STORY1-14	-2.143	-3.662	-4.01	-5.876
STORY1-13	-1.896	-3.482	-3.891	-5.905
STORY1-12	-1.645	-3.284	-3.751	-5.894
STORY1-11	-1.394	-3.069	-3.588	-5.841
STORY1-10	-1.146	-2.835	-3.403	-5.747
STORY1-9	-0.906	-2.582	-3.194	-5.613
STORY1-8	-0.681	-2.311	-2.965	-5.441
STORY1-7	-0.475	-2.026	-2.718	-5.234
STORY1-6	-0.299	-1.731	-2.459	-4.998
STORY1-5	-0.164	-1.435	-2.2	-4.738
STORY1-4	-0.084	-1.153	-1.952	-4.456
STORY1-3	-0.08	-0.911	-1.744	-4.141
STORY1-2	-0.162	-0.718	-1.57	-3.709
STORY1-1	-0.397	-0.759	-1.534	-3.109
STORY1	-0.762	-0.357	-0.658	-1.135



Graph 1: Torsion for C85 column which is nearer to the shear wall

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% Shear Force of shear wall without opening is compared with different % openings and tabulated for column C85,which is nearer to shear wall

% opening	For single opening the % increase in Shear Force	For two openings the % increase in Shear Force
20%	16.4	17.1
30%	17.24	18.6
40%	18.5	19.3

TABLE 2: Shear Force for column C85 which is nearer to shear wall

STORY	without SW	20%	30%	40%
STORY1-21	-4.95	-12.61	-1.9	12.64
STORY1-20	-49.92	-36.64	-33.49	-21.62
STORY1-19	-50.7	-43.99	-41.99	-35.14
STORY1-18	-62.93	-57.01	-55.85	-51.19
STORY1-17	-73	-69.28	-68.89	-65.66
STORY1-16	-83.18	-81.14	-81.38	-79.14
STORY1-15	-92.74	-92.27	-93.03	-91.49
STORY1-14	-101.59	-102.53	-103.74	-102.71
STORY1-13	-109.58	-111.83	-113.44	-112.8
STORY1-12	-116.6	-120.1	-122.08	-121.79
STORY1-11	-122.57	-127.28	-129.63	-129.71
STORY1-10	-127.4	-133.33	-136.08	-136.58
STORY1-9	-131	-138.18	-141.37	-142.42
STORY1-8	-133.25	-141.76	-145.45	-147.26
STORY1-7	-134.01	-143.94	-148.23	-151.08
STORY1-6	-133.08	-144.51	-149.53	-153.82
STORY1-5	-130.23	-143.32	-149.24	-155.57
STORY1-4	-124.8	-139.46	-146.37	-155.42
STORY1-3	-117.55	-134.6	-143.25	-156.84
STORY1-2	-101.22	-118	-126.3	-143.41
STORY1-1	-90.64	-108.34	-116.88	-134.27
STORY1	-85.55	-106.43	-111.78	-133.24

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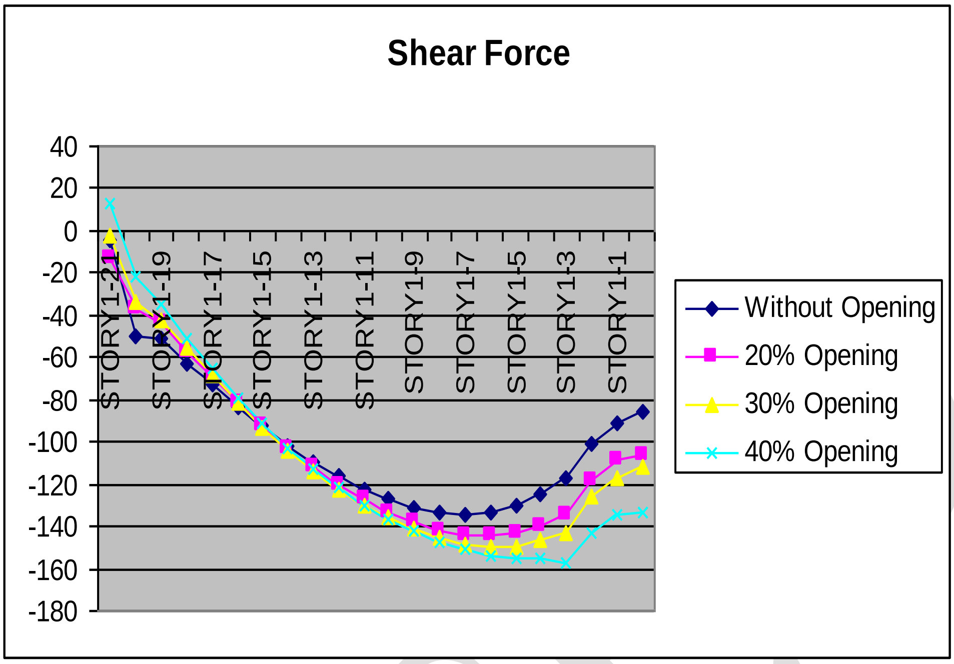

Graph 2: Shear force for C85column which is nearer to the shear wall

% Bending Moment is tabulated when compared with shear wall without opening for column C85, near to Shear wall

% opening	For single opening the % increase in Bending Moment	For two openings the % increase in Bending Moment
20%	1.9	2.46
30%	2.1	2.5
40%	2.17	1.5

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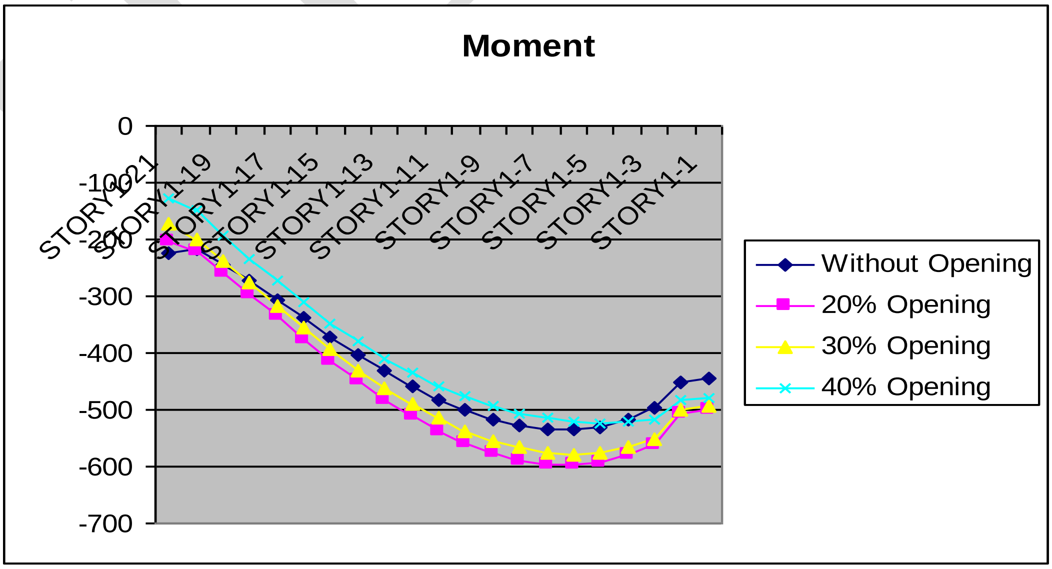
TABLE 3: Moment for column C85 which is nearer to shear wall

STORY	without SW	20%	30%	40%
STORY1-21	-7.934	15.231	31.455	48.322
STORY1-20	-40.58	-14.32	-4.165	17.864
STORY1-19	-44.42	-27.508	-21.154	-4.447
STORY1-18	-58.851	-45.535	-41.633	-29.834
STORY1-17	-74.218	-64.91	-62.857	-54.768
STORY1-16	-91.123	-85.113	-84.478	-79.027
STORY1-15	-108.543	-105.438	-105.903	-102.25
STORY1-14	-126	-125.421	-126.74	-124.268
STORY1-13	-143.094	-144.738	-146.724	-144.984
STORY1-12	-159.545	-163.173	-165.687	-164.361
STORY1-11	-175.154	-180.584	-183.529	-182.401
STORY1-10	-189.779	-196.888	-200.201	-199.135
STORY1-9	-203.328	-212.04	-215.687	-214.614
STORY1-8	-215.736	-226.016	-229.984	-228.894
STORY1-7	-226.965	-238.815	-243.112	-242.06
STORY1-6	-236.949	-250.356	-254.987	-254.093
STORY1-5	-245.795	-260.859	-265.9	-265.489
STORY1-4	-252.79	-269.035	-274.235	-274.584
STORY1-3	-260.993	-279.991	-286.525	-290.446
STORY1-2	-255.003	-270.546	-272.478	-276.794
STORY1-1	-254.655	-269.421	-271.498	-270.105



Graph 3: Bending moment for C85 column which is nearer to the shear wall

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TABLE 4: Displacement

STORY	without SW	20%	30%	40%	20%_2	30%_2	40%_2
STORY1-21	-0.1557	-0.1619	-0.1632	-0.1631	-0.1612	-0.1633	-0.1651
STORY1-20	-0.1501	-0.1566	-0.1582	-0.1585	-0.156	-0.1583	-0.1603
STORY1-19	-0.1442	-0.1509	-0.1526	-0.1534	-0.1503	-0.1527	-0.1549
STORY1-18	-0.138	-0.1446	-0.1465	-0.1477	-0.1442	-0.1467	-0.149
STORY1-17	-0.1313	-0.138	-0.1399	-0.1415	-0.1376	-0.1401	-0.1426
STORY1-16	-0.1242	-0.1308	-0.1328	-0.1347	-0.1305	-0.1331	-0.1356
STORY1-15	-0.1168	-0.1233	-0.1253	-0.1275	-0.123	-0.1256	-0.1281
STORY1-14	-0.1089	-0.1153	-0.1174	-0.1197	-0.1151	-0.1177	-0.1202
STORY1-13	-0.1008	-0.107	-0.1091	-0.1117	-0.1068	-0.1094	-0.112
STORY1-12	-0.0924	-0.0984	-0.1005	-0.1032	-0.0983	-0.1009	-0.1034
STORY1-11	-0.0837	-0.0895	-0.0917	-0.0946	-0.0895	-0.092	-0.0946
STORY1-10	-0.075	-0.0805	-0.0827	-0.0857	-0.0806	-0.083	-0.0856
STORY1-9	-0.0661	-0.0714	-0.0736	-0.0768	-0.0715	-0.0739	-0.0764
STORY1-8	-0.0573	-0.0623	-0.0645	-0.0678	-0.0625	-0.0648	-0.0673
STORY1-7	-0.0487	-0.0533	-0.0555	-0.0588	-0.0535	-0.0557	-0.0582
STORY1-6	-0.0402	-0.0445	-0.0466	-0.0499	-0.0448	-0.0469	-0.0493
STORY1-5	-0.0321	-0.036	-0.038	-0.0413	-0.0363	-0.0382	-0.0405
STORY1-4	-0.0244	-0.028	-0.0298	-0.0329	-0.0283	-0.03	-0.0322
STORY1-3	-0.0175	-0.0205	-0.0222	-0.025	-0.0208	-0.0223	-0.0243
STORY1-2	-0.0113	-0.0138	-0.0152	-0.0176	-0.0141	-0.0154	-0.017
STORY1-1	-0.0061	-0.008	-0.0091	-0.0108	-0.0083	-0.0092	-0.0105
STORY1	-0.0024	-0.0024	-0.0041	-0.005	-0.0037	-0.0042	-0.0049

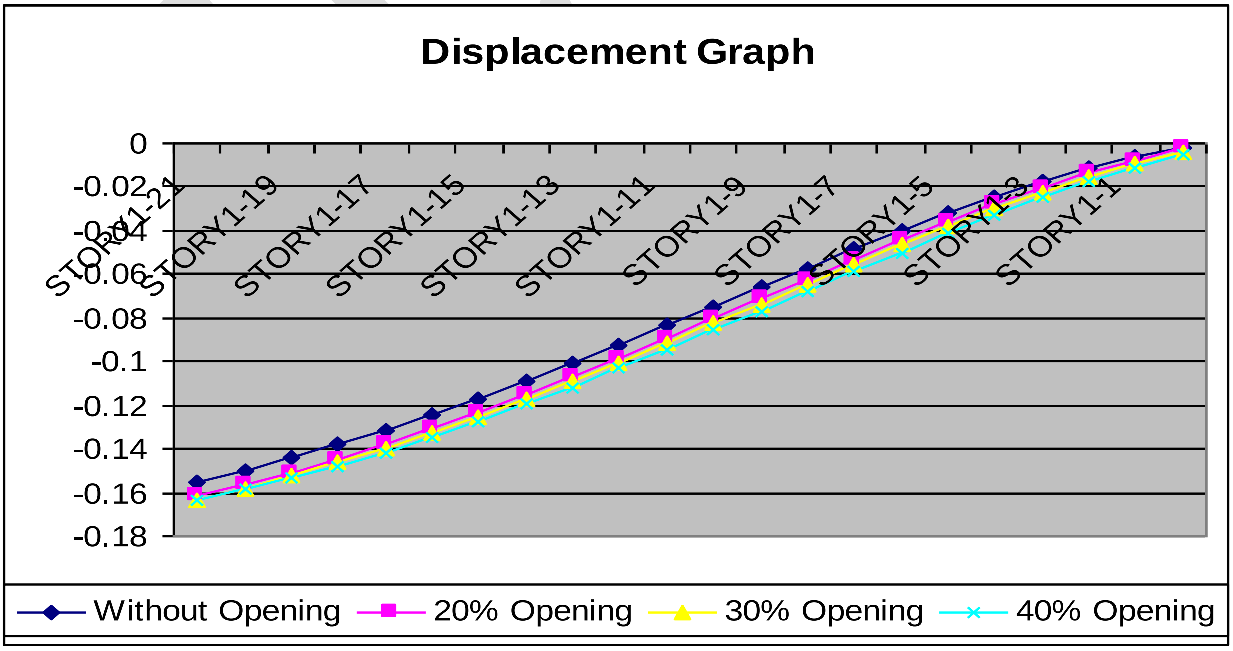

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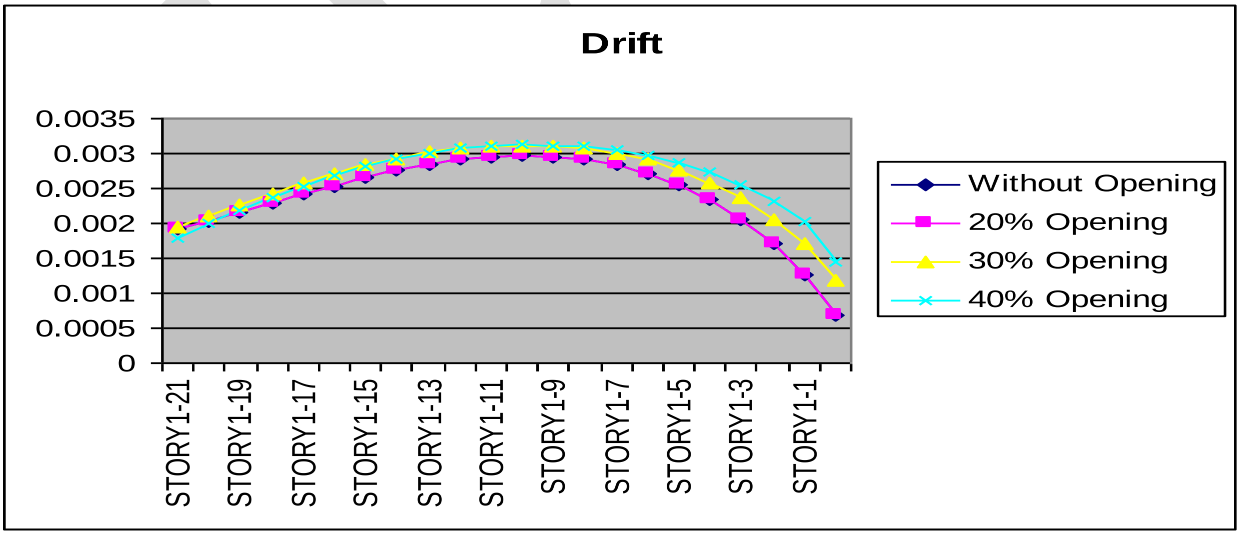
TABLE 5: Drift

STORY	without SW	20%	30%	40%	20%_2	30%_2	40%_2
STORY1-21	0.001929	0.001929	0.001938	0.001801	0.00196	0.001918	0.001857
STORY1-20	0.002037	0.002037	0.002101	0.001995	0.002108	0.002081	0.002041
STORY1-19	0.002153	0.002153	0.002264	0.002186	0.002259	0.002244	0.00222
STORY1-18	0.002281	0.002281	0.002424	0.002366	0.00241	0.002405	0.002392
STORY1-17	0.002411	0.002411	0.002575	0.002533	0.002553	0.002557	0.002552
STORY1-16	0.002538	0.002538	0.002712	0.002681	0.002685	0.002695	0.002697
STORY1-15	0.002655	0.002655	0.002833	0.002811	0.002801	0.002816	0.002824
STORY1-14	0.002758	0.002758	0.002934	0.002919	0.002898	0.002919	0.00293
STORY1-13	0.002844	0.002844	0.003014	0.003006	0.002973	0.002999	0.003014
STORY1-12	0.002909	0.002909	0.00307	0.003068	0.003026	0.003055	0.003074
STORY1-11	0.00295	0.00295	0.003101	0.003107	0.003052	0.003087	0.003111
STORY1-10	0.002966	0.002966	0.003109	0.003121	0.003057	0.003095	0.003124
STORY1-9	0.002953	0.002953	0.0031	0.003114	0.003048	0.003088	0.003116
STORY1-8	0.002908	0.002908	0.00307	0.003098	0.003014	0.00306	0.003094
STORY1-7	0.002829	0.002829	0.003008	0.003054	0.002946	0.002999	0.003043
STORY1-6	0.00271	0.00271	0.002911	0.002981	0.002842	0.002904	0.002959
STORY1-5	0.002548	0.002548	0.002774	0.002877	0.002697	0.002769	0.00284
STORY1-4	0.002334	0.002334	0.002592	0.002739	0.002505	0.002589	0.00268
STORY1-3	0.00206	0.00206	0.002359	0.00256	0.002258	0.002356	0.002475
STORY1-2	0.001713	0.001713	0.002063	0.002326	0.001945	0.002059	0.002213
STORY1-1	0.001271	0.001271	0.001706	0.002024	0.001568	0.001708	0.001909
STORY1	0.000688	0.000688	0.001183	0.00144	0.00109	0.001255	0.001443



For Load Combinations 1.2 (D.L + L.L + EQYNX) following are the values of the drift

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TABLE 6: Without Shear Wall

Story	Item	Load	Point	X	Y	Z	DriftX
STORY20	Max Drift X	DCON25	8	28.94	26.845	61	0.000245
STORY19	Max Drift X	DCON25	8	28.94	26.845	58	0.000268
STORY18	Max Drift X	DCON25	8	28.94	26.845	55	0.00029
STORY17	Max Drift X	DCON25	8	28.94	26.845	52	0.000311
STORY16	Max Drift X	DCON25	8	28.94	26.845	49	0.000328
STORY15	Max Drift X	DCON25	8	28.94	26.845	46	0.000343
STORY14	Max Drift X	DCON25	8	28.94	26.845	43	0.000356
STORY13	Max Drift X	DCON25	8	28.94	26.845	40	0.000365
STORY12	Max Drift X	DCON25	8	28.94	26.845	37	0.000371
STORY11	Max Drift X	DCON25	8	28.94	26.845	34	0.000374
STORY10	Max Drift X	DCON25	8	28.94	26.845	31	0.000373
STORY9	Max Drift X	DCON25	8	28.94	26.845	28	0.00037
STORY8	Max Drift X	DCON25	8	28.94	26.845	25	0.000363
STORY7	Max Drift X	DCON25	8	28.94	26.845	22	0.000353
STORY6	Max Drift X	DCON25	8	28.94	26.845	19	0.000339
STORY5	Max Drift X	DCON25	65	28.94	0	16	0.000328
STORY4	Max Drift X	DCON25	65	28.94	0	13	0.000328
STORY3	Max Drift X	DCON25	65	28.94	0	10	0.000332
STORY2	Max Drift X	DCON25	65	28.94	0	7	0.000375
STORY1	Max Drift X	DCON25	65	28.94	0	4	0.000739

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TABLE 7: Shear Wall Without Opening

Story	Item	Load	Point	X	Y	Z	DriftX
STORY20	Max Drift X	DCON25	8	1139.37	1056.89	2401.574	0.000324
STORY19	Max Drift X	DCON25	8	1139.37	1056.89	2283.464	0.000328
STORY18	Max Drift X	DCON25	65	1139.37	0	2165.354	0.000334
STORY17	Max Drift X	DCON25	65	1139.37	0	2047.244	0.000341
STORY16	Max Drift X	DCON25	65	1139.37	0	1929.133	0.000347
STORY15	Max Drift X	DCON25	65	1139.37	0	1811.023	0.000352
STORY14	Max Drift X	DCON25	65	1139.37	0	1692.913	0.000356
STORY13	Max Drift X	DCON25	65	1139.37	0	1574.803	0.000358
STORY12	Max Drift X	DCON25	65	1139.37	0	1456.693	0.000357
STORY11	Max Drift X	DCON25	65	1139.37	0	1338.582	0.000353
STORY10	Max Drift X	DCON25	65	1139.37	0	1220.472	0.000346
STORY9	Max Drift X	DCON25	65	1139.37	0	1102.362	0.000336
STORY8	Max Drift X	DCON25	65	1139.37	0	984.252	0.000321
STORY7	Max Drift X	DCON25	65	1139.37	0	866.142	0.000302
STORY6	Max Drift X	DCON25	65	1139.37	0	748.031	0.000279
STORY5	Max Drift X	DCON25	65	1139.37	0	629.921	0.000251
STORY4	Max Drift X	DCON25	65	1139.37	0	511.811	0.000216
STORY3	Max Drift X	DCON25	65	1139.37	0	393.701	0.000175
STORY2	Max Drift X	DCON25	65	1139.37	0	275.591	0.000126
STORY1	Max Drift X	DCON25	65	1139.37	0	157.48	0.000059

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TABLE 8: Shear Wall with Opening

Story	Item	Load	Point	X	Y	Z	DriftX
STORY20	Max Drift X	DCON25	14-Jul	975	1056.89	2366.141	0.000305
STORY19	Max Drift X	DCON25	10-Jul	975	1056.89	2177.165	0.000307
STORY18	Max Drift X	DCON25	4-Jul	975	1056.89	2070.866	0.000312
STORY17	Max Drift X	DCON25	11-Jul	975	1056.89	1964.566	0.000316
STORY16	Max Drift X	DCON25	12-Jul	975	1056.89	1858.267	0.00032
STORY15	Max Drift X	DCON25	13-Jul	975	1056.89	1751.968	0.000321
STORY14	Max Drift X	DCON25	7-Jul	975	1056.89	1645.669	0.000321
STORY13	Max Drift X	DCON25	14-Jul	975	1056.89	1539.37	0.00032
STORY12	Max Drift X	DCON25	15-Jul	975	1056.89	1433.07	0.000316
STORY11	Max Drift X	DCON25	574	1090.059	0	1338.582	0.000312
STORY10	Max Drift X	DCON25	602	90.827	0	1220.472	0.000307
STORY9	Max Drift X	DCON25	603	75.689	0	1102.362	0.000299
STORY8	Max Drift X	DCON25	604	60.551	0	984.252	0.000287
STORY7	Max Drift X	DCON25	604	60.551	0	866.142	0.000272
STORY6	Max Drift X	DCON25	605	45.413	0	748.031	0.000252
STORY5	Max Drift X	DCON25	605	45.413	0	629.921	0.000227
STORY4	Max Drift X	DCON25	605	45.413	0	511.811	0.000197
STORY3	Max Drift X	DCON25	606	30.276	0	393.701	0.00016
STORY2	Max Drift X	DCON25	576	1057.185	0	275.591	0.000116
STORY1	Max Drift X	DCON25	604	60.551	0	157.48	0.000053

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The following are the values of the Center Of Rigidity and Center Of Mass

TABLE 9: With Out Shear Wall

Story	MassX	MassY	XCM	YCM	XCCM	YCCM	XCR	YCR
STORY20	1730.674	1730.674	14.683	13.481	14.683	13.481	14.684	15.016
STORY19	1960.744	1960.744	14.672	13.526	14.677	13.505	14.676	15.075
STORY18	1960.744	1960.744	14.672	13.526	14.675	13.512	14.668	15.136
STORY17	1960.744	1960.744	14.672	13.526	14.674	13.516	14.66	15.192
STORY16	1960.744	1960.744	14.672	13.526	14.674	13.518	14.652	15.245
STORY15	1960.744	1960.744	14.672	13.526	14.673	13.519	14.645	15.299
STORY14	1960.744	1960.744	14.672	13.526	14.673	13.52	14.637	15.355
STORY13	1960.744	1960.744	14.672	13.526	14.673	13.521	14.63	15.416
STORY12	1960.744	1960.744	14.672	13.526	14.673	13.522	14.622	15.483
STORY11	1960.744	1960.744	14.672	13.526	14.673	13.522	14.614	15.556
STORY10	1960.744	1960.744	14.672	13.526	14.672	13.522	14.606	15.637
STORY9	1960.744	1960.744	14.672	13.526	14.672	13.523	14.598	15.727
STORY8	1960.744	1960.744	14.672	13.526	14.672	13.523	14.59	15.825
STORY7	1960.744	1960.744	14.672	13.526	14.672	13.523	14.582	15.931
STORY6	1960.744	1960.744	14.672	13.526	14.672	13.523	14.573	16.045
STORY5	1960.744	1960.744	14.672	13.526	14.672	13.523	14.565	16.164
STORY4	1960.744	1960.744	14.672	13.526	14.672	13.524	14.556	16.282
STORY3	1960.744	1960.744	14.672	13.526	14.672	13.524	14.548	16.388
STORY2	1960.744	1960.744	14.672	13.526	14.672	13.524	14.542	16.451
STORY1	2034.611	2034.611	14.668	13.539	14.672	13.525	14.543	16.397

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TABLE 10: Shear Wall With Out Opening

Story	MassX	MassY	XCM	YCM	XCCM	YCCM	XCR	YCR
STORY20	1853.364	1853.364	14.686	13.417	14.686	13.417	14.742	14.466
STORY19	2206.123	2206.123	14.678	13.413	14.682	13.415	14.742	14.47
STORY18	2206.123	2206.123	14.678	13.413	14.681	13.414	14.743	14.476
STORY17	2206.123	2206.123	14.678	13.413	14.68	13.414	14.744	14.483
STORY16	2206.123	2206.123	14.678	13.413	14.68	13.414	14.745	14.49
STORY15	2206.123	2206.123	14.678	13.413	14.679	13.414	14.746	14.499
STORY14	2206.123	2206.123	14.678	13.413	14.679	13.414	14.748	14.508
STORY13	2206.123	2206.123	14.678	13.413	14.679	13.414	14.749	14.517
STORY12	2206.123	2206.123	14.678	13.413	14.679	13.414	14.751	14.526
STORY11	2206.123	2206.123	14.678	13.413	14.679	13.414	14.752	14.535
STORY10	2206.123	2206.123	14.678	13.413	14.679	13.414	14.754	14.542
STORY9	2206.123	2206.123	14.678	13.413	14.679	13.414	14.756	14.549
STORY8	2206.123	2206.123	14.678	13.413	14.679	13.414	14.759	14.553
STORY7	2206.123	2206.123	14.678	13.413	14.679	13.414	14.76	14.554
STORY6	2206.123	2206.123	14.678	13.413	14.679	13.414	14.761	14.551
STORY5	2206.123	2206.123	14.678	13.413	14.679	13.414	14.76	14.54
STORY4	2206.123	2206.123	14.678	13.413	14.679	13.414	14.755	14.517
STORY3	2206.123	2206.123	14.678	13.413	14.678	13.414	14.741	14.475
STORY2	2206.123	2206.123	14.678	13.413	14.678	13.414	14.711	14.399
STORY1	2320.887	2320.887	14.676	13.413	14.678	13.414	14.651	14.272

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TABLE 11: Shear Wall With Opening

Story	MassX	MassY	XCM	YCM	XCCM	YCCM	XCR	YCR
STORY20	1743.045	1743.045	14.683	13.475	14.683	13.475	14.734	14.494
STORY19	1985.384	1985.384	14.672	13.514	14.677	13.496	14.734	14.5
STORY18	1985.384	1985.384	14.672	13.514	14.676	13.502	14.735	14.507
STORY17	1985.384	1985.384	14.672	13.514	14.675	13.505	14.735	14.516
STORY16	1985.384	1985.384	14.672	13.514	14.674	13.507	14.736	14.526
STORY15	1985.384	1985.384	14.672	13.514	14.674	13.508	14.736	14.536
STORY14	1985.384	1985.384	14.672	13.514	14.674	13.509	14.737	14.547
STORY13	1985.384	1985.384	14.672	13.514	14.673	13.51	14.737	14.558
STORY12	1985.384	1985.384	14.672	13.514	14.673	13.51	14.738	14.57
STORY11	1985.384	1985.384	14.672	13.514	14.673	13.511	14.739	14.581
STORY10	1985.384	1985.384	14.672	13.514	14.673	13.511	14.739	14.592
STORY9	1985.384	1985.384	14.672	13.514	14.673	13.511	14.74	14.602
STORY8	1985.384	1985.384	14.672	13.514	14.673	13.511	14.741	14.61
STORY7	1985.384	1985.384	14.672	13.514	14.673	13.512	14.741	14.616
STORY6	1985.384	1985.384	14.672	13.514	14.673	13.512	14.74	14.618
STORY5	1985.384	1985.384	14.672	13.514	14.673	13.512	14.736	14.612
STORY4	1985.384	1985.384	14.672	13.514	14.673	13.512	14.729	14.592
STORY3	1985.384	1985.384	14.672	13.514	14.673	13.512	14.714	14.549
STORY2	1985.384	1985.384	14.672	13.514	14.673	13.512	14.692	14.466
STORY1	2063.341	2063.341	14.669	13.526	14.673	13.513	14.658	14.342

The following are the values of the Model Mass Contributions

TABLE 12: With Out Shear Wall

Mode	Period	UX	UY	UZ	SumUX	SumUY
1	2.813121	13.2781	0.005	0	13.2781	0.005
2	2.326692	0.1383	75.9988	0	13.4164	76.0038
3	2.204959	62.6667	0.1973	0	76.0831	76.2011
4	0.923186	1.6732	0.0004	0	77.7563	76.2015
5	0.704249	0.0047	12.6577	0	77.761	88.8591
6	0.653931	12.2647	0.0051	0	90.0257	88.8642
7	0.505037	0.5488	0.0004	0	90.5745	88.8647
8	0.364535	0	4.5899	0	90.5745	93.4545
9	0.346039	0.2477	0.0017	0	90.8223	93.4563
10	0.332068	4.3894	0	0	95.2117	93.4563
11	0.256092	0.0234	0	0	95.235	93.4563
12	0.232316	0	2.4896	0	95.235	95.9459

TABLE 13: Shear Wall Without Opening

Mode	Period	UX	UY	UZ	SumUX	SumUY
1	2.008698	65.6283	0.5892	0	65.6283	0.5892
2	1.895758	0.6233	72.4332	0	66.2516	73.0224
3	1.75645	6.369	0.0291	0	72.6205	73.0515
4	0.554075	13.8419	0.1119	0	86.4625	73.1634
5	0.53466	0.1138	13.5512	0	86.5763	86.7146
6	0.453777	0.5506	0.0041	0	87.1268	86.7187
7	0.263488	5.5609	0.0142	0	92.6877	86.7329
8	0.256385	0.0148	5.2883	0	92.7025	92.0211
9	0.203708	0.1221	0.0013	0	92.8246	92.0224
10	0.160475	2.9063	0.0006	0	95.7309	92.023
11	0.153942	0.0006	2.9382	0	95.7315	94.9612
12	0.119972	0.0556	0.0006	0	95.7871	95.2659

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TABLE 14: Shear Wall With Opening

Mode	Period	UX	UY	UZ	SumUX	SumUY
1	2.037052	64.4361	0.3771	0	64.4361	0.3771
2	1.933803	0.412	72.9029	0	64.8481	73.2801
3	1.794027	7.6779	0.033	0	72.5261	73.3131
4	0.564611	13.6862	0.1278	0	86.2123	73.4409
5	0.551598	0.1336	13.4243	0	86.3459	86.8653
6	0.47132	0.7877	0.003	0	87.1336	86.8682
7	0.269714	1.8097	3.4556	0	88.9433	90.3238
8	0.269188	3.7129	1.6846	0	92.6563	92.0084
9	0.216015	0.2079	0.0007	0	92.8642	92.0091
10	0.165567	0.005	2.7647	0	92.8692	94.7738
11	0.164697	2.8754	0.0048	0	95.7446	94.7786
12	0.129794	0.0964	0.0002	0	95.8409	95.2785

Shear Force, Bend Motion and Torsion

TABLE 15: Without Shear Wall

Story	Column	Load	Loc	P	V2	V3	T	M2	M3
STORY20	C23	DCON25	0	-297.11	14.82	87.26	-2.348	111.457	19.706
STORY19	C23	DCON25	0	-571.87	12.79	77.45	-2.725	111.017	18.904
STORY18	C23	DCON25	0	-847.37	14.1	93.04	-3.112	131.185	20.77
STORY17	C23	DCON25	0	-1118.36	15.15	106.63	-3.471	151.669	22.405
STORY16	C23	DCON25	0	-1385.85	16.12	120.7	-3.793	173.085	23.95
STORY15	C23	DCON25	0	-1650.26	17.01	134.05	-4.074	193.812	25.376
STORY14	C23	DCON25	0	-1912.27	17.78	146.33	-4.313	213.132	26.625
STORY13	C23	DCON25	0	-2172.61	18.41	157.24	-4.509	230.534	27.659
STORY12	C23	DCON25	0	-2431.99	18.87	166.61	-4.663	245.694	28.442
STORY11	C23	DCON25	0	-2691.11	19.14	174.29	-4.775	258.387	28.935
STORY10	C23	DCON25	0	-2950.64	19.19	180.19	-4.845	268.437	29.103
STORY9	C23	DCON25	0	-3211.27	19	184.15	-4.875	275.668	28.907
STORY8	C23	DCON25	0	-3473.68	18.54	186.02	-4.866	279.867	28.305
STORY7	C23	DCON25	0	-3738.66	17.78	185.52	-4.817	280.72	27.256
STORY6	C23	DCON25	0	-4007.14	16.69	182.25	-4.731	277.768	25.7
STORY5	C23	DCON25	0	-4280.35	15.24	175.48	-4.609	270.134	23.609
STORY4	C23	DCON25	0	-4560	13.31	164.49	-4.465	257.474	20.749
STORY3	C23	DCON25	0	-4848.9	11.07	144.99	-4.351	232.329	17.579
STORY2	C23	DCON25	0	-5150.04	6.97	134.27	-4.621	241.03	9.722
STORY1	C23	DCON25	0	-5495.36	3.77	-5.24	0	0	0

TABLE 16: Shear Wall Without Opening

Story	Column	Load	Loc	P	V2	V3	T	M2	M3
STORY20	C23	DCON25	0	-56.81	16.36	43.49	-40.438	2255.88	863.422
STORY19	C23	DCON25	0	-105.04	12.32	34.35	-41.052	2023.412	740.051
STORY18	C23	DCON25	0	-154.29	12.88	37.79	-41.763	2172.238	757.518
STORY17	C23	DCON25	0	-202.78	12.8	39.65	-42.477	2285.75	754.993
STORY16	C23	DCON25	0	-250.78	12.77	41.76	-43.11	2409.628	752.896
STORY15	C23	DCON25	0	-298.35	12.68	43.69	-43.588	2526.694	747.768
STORY14	C23	DCON25	0	-345.65	12.53	45.38	-43.852	2631.679	739.149
STORY13	C23	DCON25	0	-392.85	12.32	46.76	-43.852	2719.368	726.35
STORY12	C23	DCON25	0	-440.14	12.02	47.76	-43.547	2785.854	708.738
STORY11	C23	DCON25	0	-487.75	11.63	48.33	-42.897	2827.883	685.721
STORY10	C23	DCON25	0	-535.94	11.14	48.42	-41.868	2842.567	656.726
STORY9	C23	DCON25	0	-584.96	10.54	47.97	-40.425	2827.075	621.195
STORY8	C23	DCON25	0	-635.12	9.83	46.94	-38.534	2778.343	578.572
STORY7	C23	DCON25	0	-686.76	8.98	45.25	-36.153	2692.708	528.313
STORY6	C23	DCON25	0	-740.29	7.99	42.82	-33.238	2565.768	469.779
STORY5	C23	DCON25	0	-796.17	6.86	39.51	-29.735	2390.55	402.718
STORY4	C23	DCON25	0	-854.97	5.56	35.24	-25.575	2165.749	325.282
STORY3	C23	DCON25	0	-917.45	4.11	29.28	-20.679	1836.26	241.029
STORY2	C23	DCON25	0	-984.16	2.47	24.84	-14.896	1700.931	143.214
STORY1	C23	DCON25	0	-1061.06	0.06	0.51	0	0	0

TABLE 17: Shear Wall With Opening

Story	Column	Load	Loc	P	V2	V3	T	M2	M3
STORY20	C23	DCON25	0	-58.05	14.78	41.42	-35.714	2142.233	780.131
STORY19	C23	DCON25	0	-107.72	11.16	33.3	-36.409	1952.634	669.768
STORY18	C23	DCON25	0	-158.24	11.67	36.78	-37.163	2109.614	686.42
STORY17	C23	DCON25	0	-207.93	11.62	38.82	-37.922	2233.694	684.96
STORY16	C23	DCON25	0	-257.08	11.6	41.05	-38.612	2365.897	683.9
STORY15	C23	DCON25	0	-305.76	11.53	43.1	-39.16	2490.336	680.069
STORY14	C23	DCON25	0	-354.13	11.41	44.9	-39.513	2601.966	673.043
STORY13	C23	DCON25	0	-402.36	11.23	46.38	-39.625	2695.856	662.172
STORY12	C23	DCON25	0	-450.65	10.97	47.47	-39.455	2768.288	646.864
STORY11	C23	DCON25	0	-499.22	10.62	48.14	-38.968	2816.161	626.554
STORY10	C23	DCON25	0	-548.3	10.19	48.32	-38.131	2836.724	600.697
STORY9	C23	DCON25	0	-598.15	9.65	47.98	-36.911	2827.286	568.756
STORY8	C23	DCON25	0	-649.07	9	47.06	-35.274	2784.95	530.192
STORY7	C23	DCON25	0	-701.39	8.23	45.5	-33.18	2706.281	484.478
STORY6	C23	DCON25	0	-755.47	7.32	43.2	-30.583	2587.163	430.986
STORY5	C23	DCON25	0	-811.76	6.28	40.06	-27.429	2421.141	369.474
STORY4	C23	DCON25	0	-870.81	5.08	35.99	-23.645	2207.253	298.057
STORY3	C23	DCON25	0	-933.32	3.75	30.28	-19.15	1891.258	220.525
STORY2	C23	DCON25	0	-999.81	2.22	26.45	-13.773	1811.38	128.735
STORY1	C23	DCON25	0	-1076.58	0.03	0.32	0	0	0

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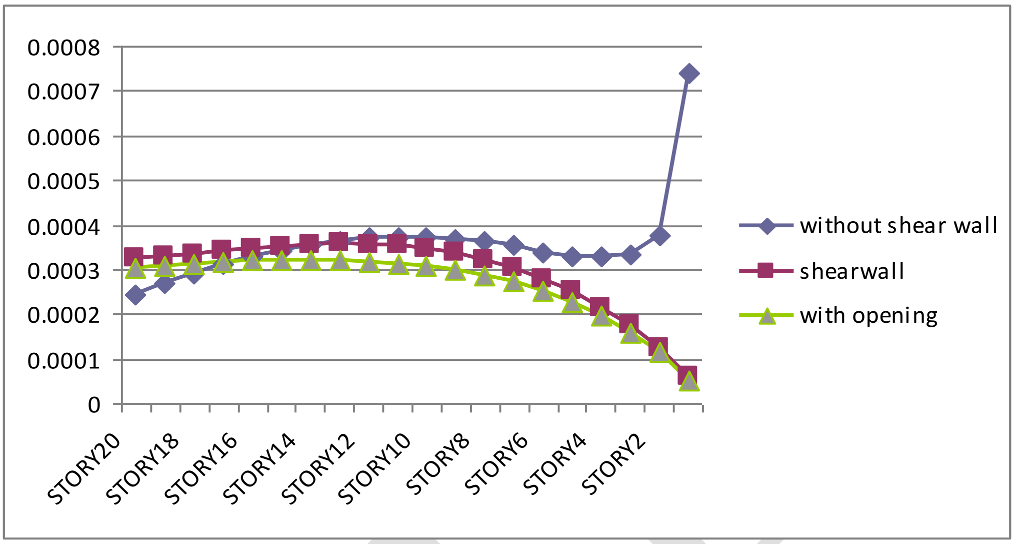
GRAPHS

Comparison of Story Drift for C23

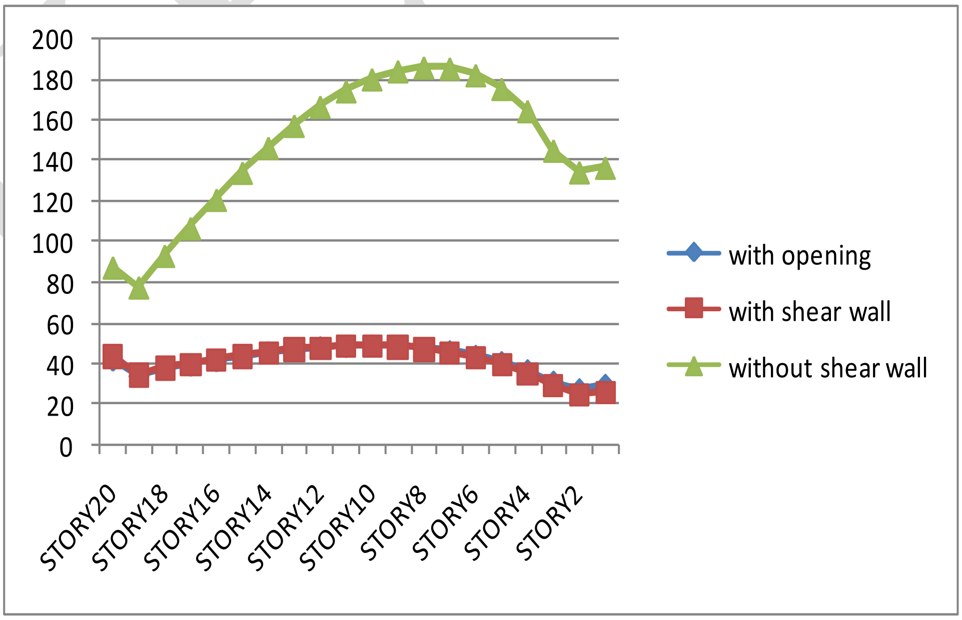
1) Without Shear Wall
2) Shear Wall Without Opening
3) Shear Wall With Opening



Graph 4: Load Combinations 1.2 (D.L + L.L + EQYNX)

Comparison of Shear Force for C23

4) Without Shear Wall
5) Shear Wall Without Opening
6) Shear Wall With Opening



Graph 5: Load Combinations 1.2 (D.L + L.L + EQYNX)

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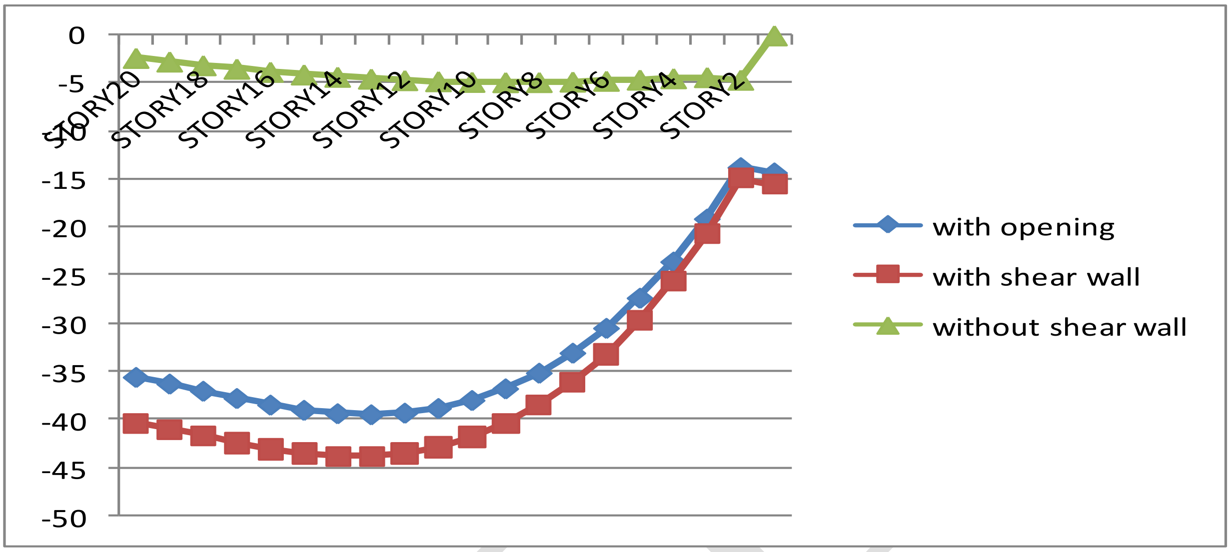
Comparison of Torsion for C23

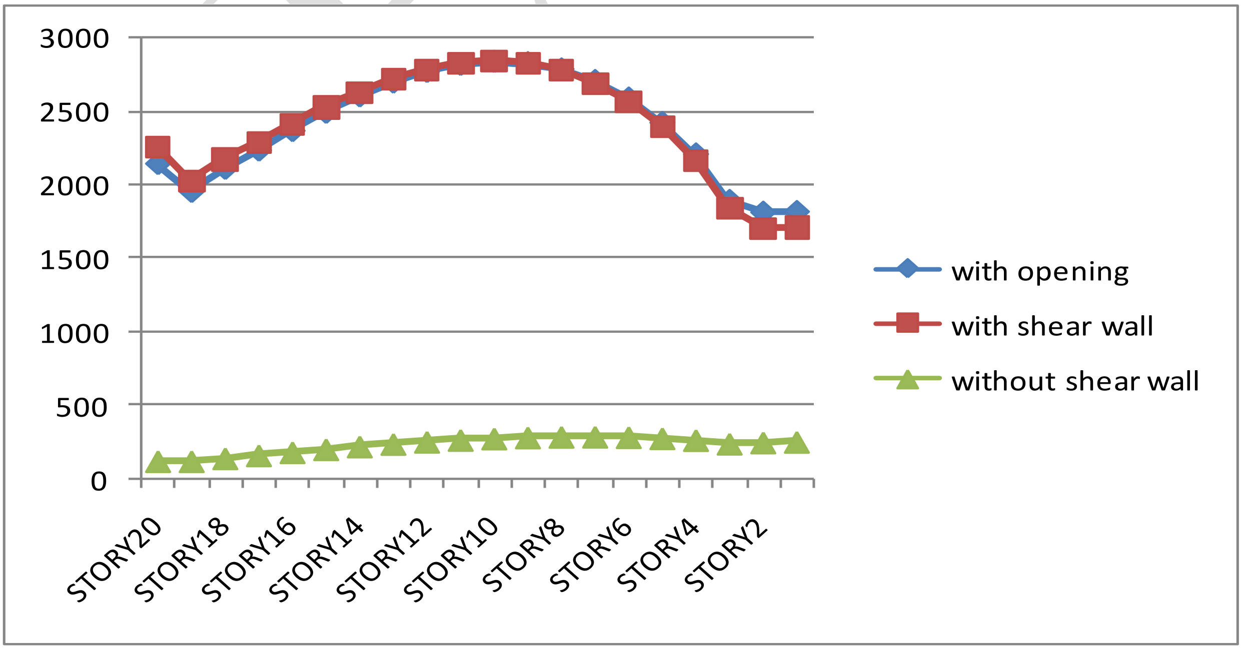
7) Without Shear Wall
8) Shear Wall Without Opening
9) Shear Wall With Opening



Graph 6: Load Combinations 1.2 (D.L + L.L + EQYNX)

Comparison of Bending Moment for C23

10) Without Shear Wall
11) Shear Wall Without Opening
12) Shear Wall With Opening



Graph 7: Load Combinations 1.2 (D.L + L.L + EQYNX)

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Check for Drift and Displacement

From IS 1893 (Part – I) – 2002

Allowable drift = 0.004h = 0.004 x 3 =0.012m

Allowable displacement =H / 500 = 0.122m

Case 1:- Shear Wall with Openings

For Load Combination EQXNY

Drift = 0 .0021522m

Displacement = 0.11m

Case 2:- Shear Wall without Openings

For Load Combination EQXNY

Drift = 0.00213m

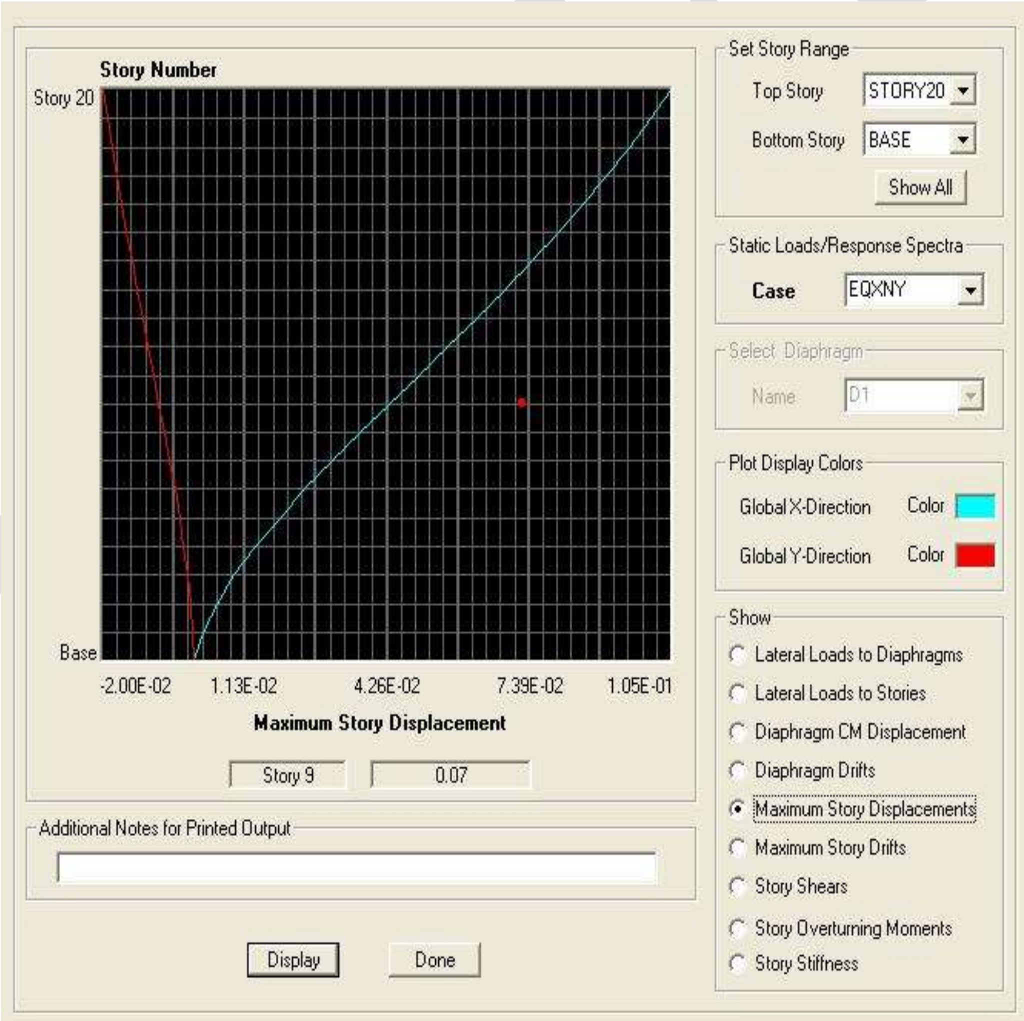
Displacement = 0.1m

Case 3:- Without Shear Wall

For Load Combination EQXNY

Drift = 0 .0021522m

Displacement = 0.15m



Graph 8: Displacement Shear Wall

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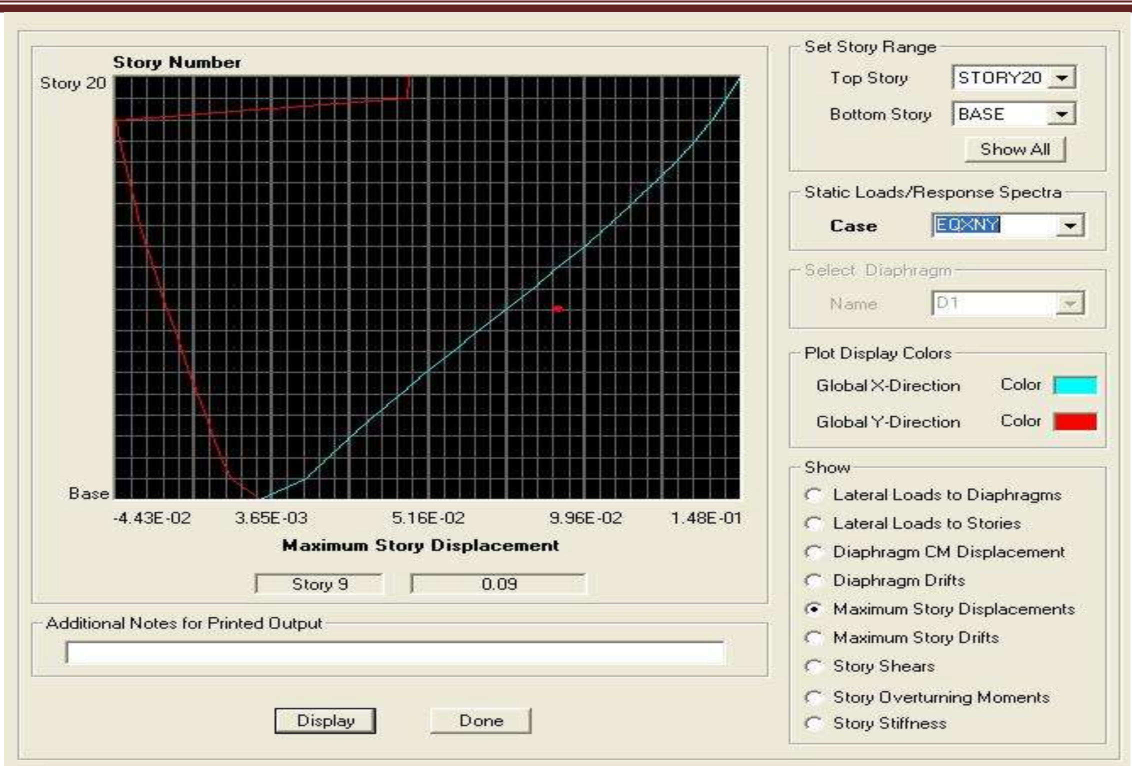
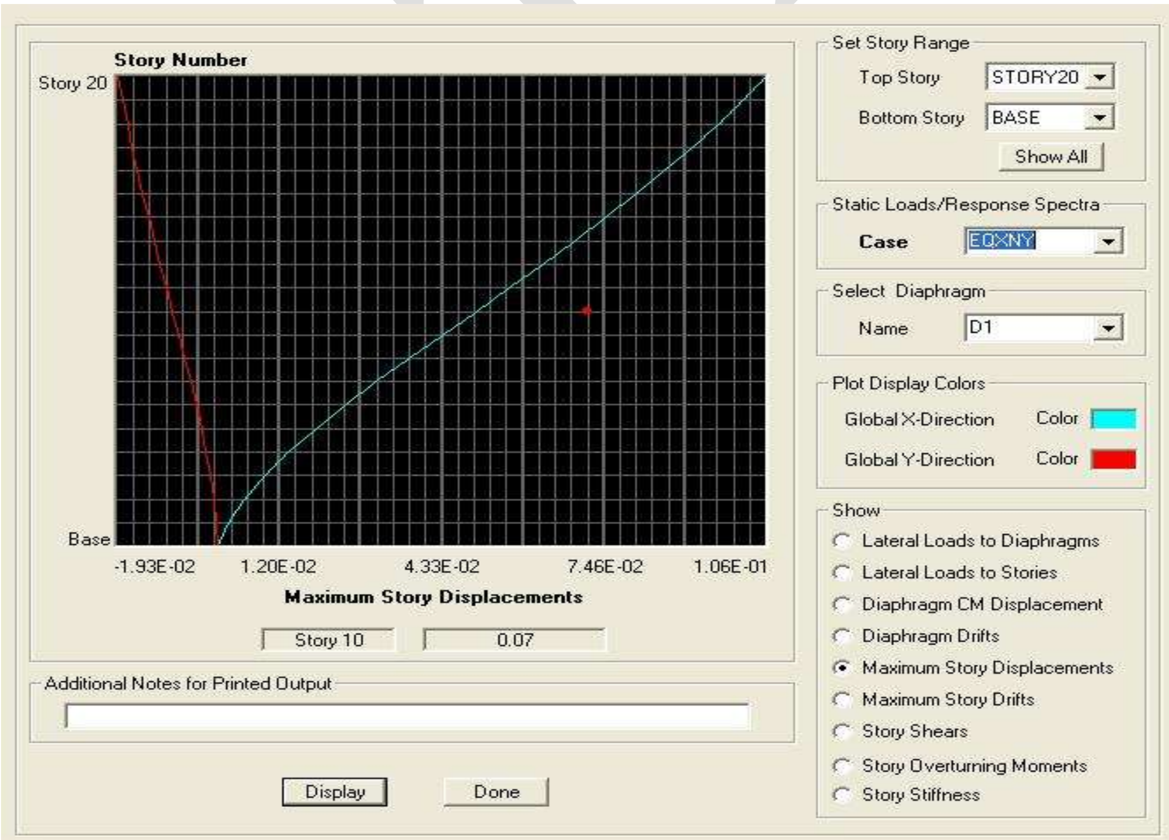


Graph 9: Displacement With Out Shear Wall



Graph 10: Displacement Opening

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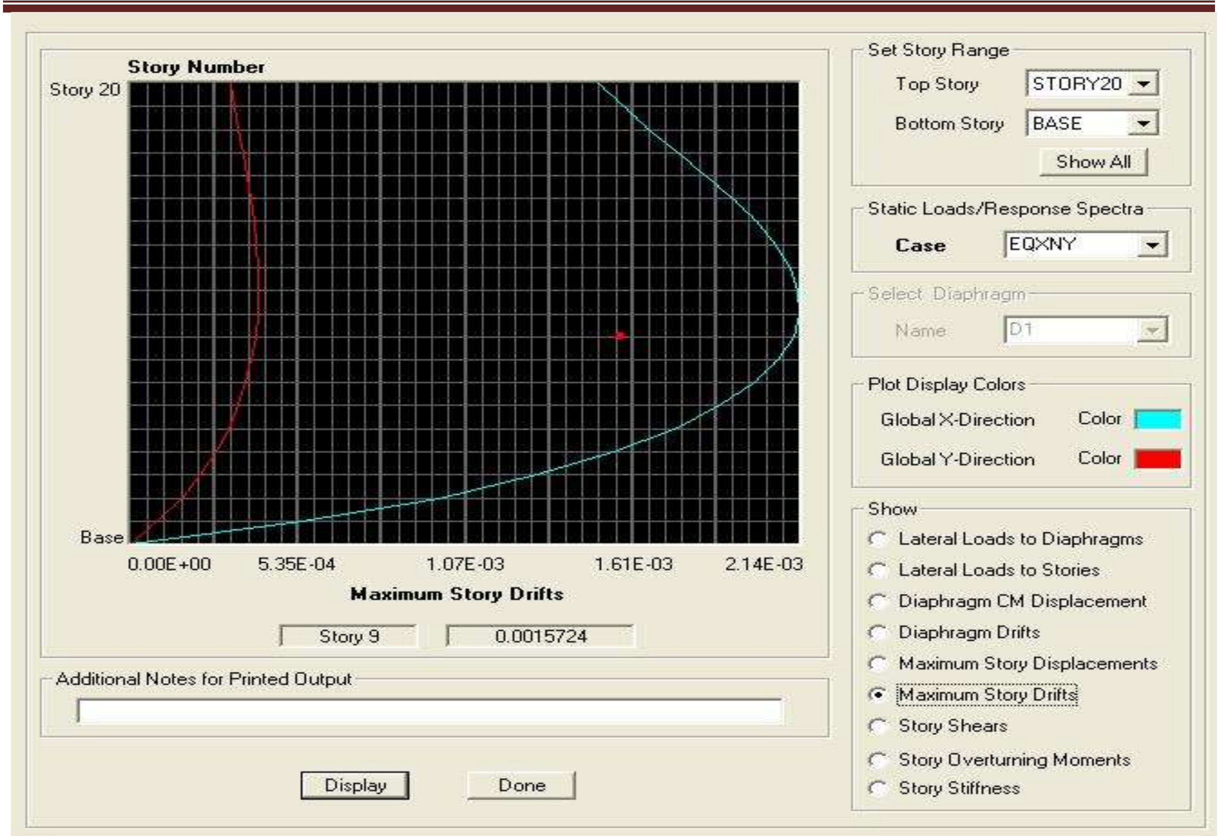
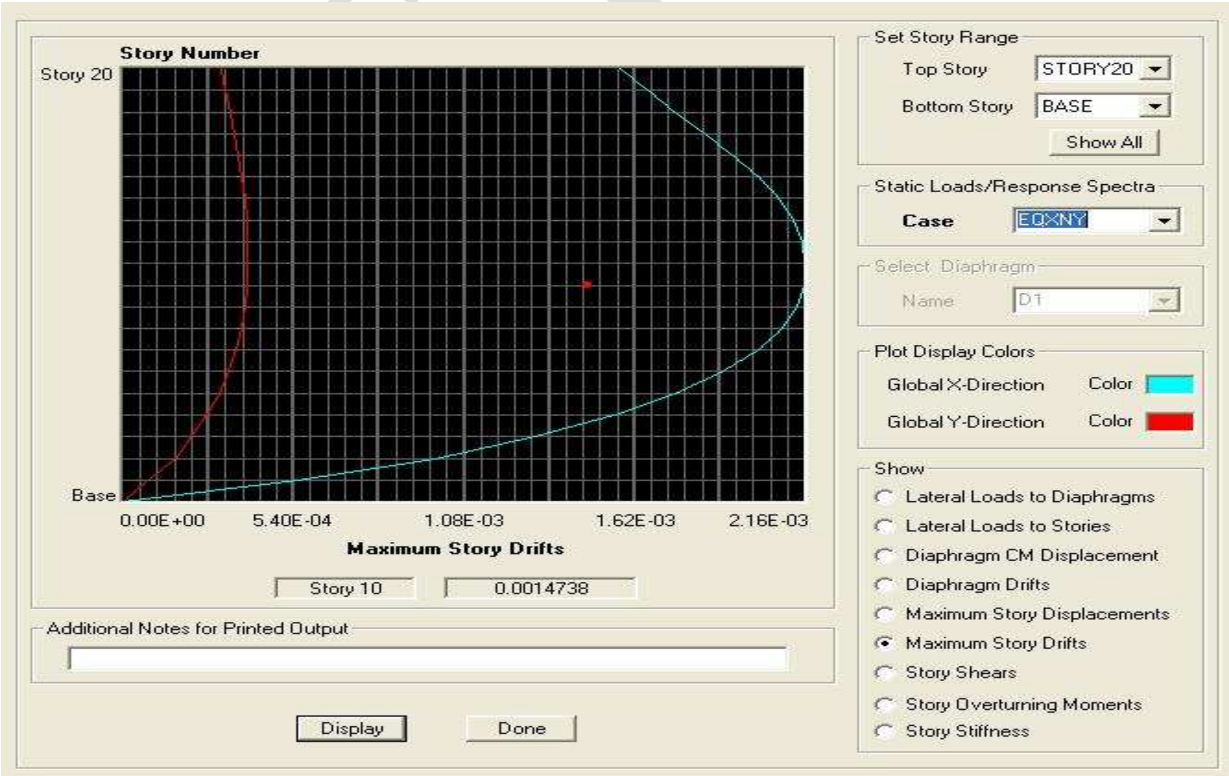


Graph 11: Drift Shear Wall



Graph 12: Drift With Opening

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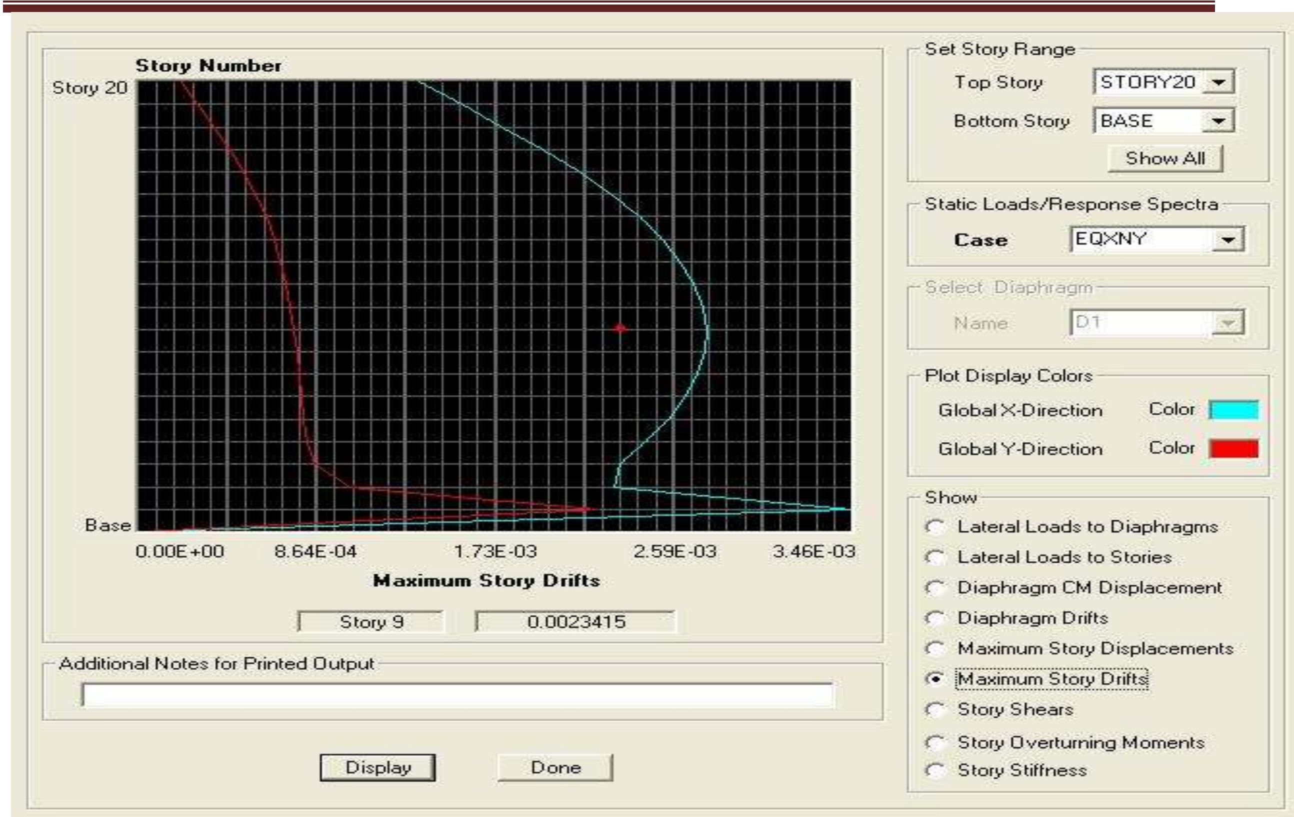

Graph 13: Drift With Out Shear Wall

V. CONCLUSIONS

- With the provision of shear wall the shear force in the columns, decreased.
- With the provision of shear wall the moment in the columns, increased.
- No significant difference in shear force and moment provision of 20 % opening in the shear wall.
- With the provision of the shear walls drift and displacement is decreasing.
- With the provision of the shear wall the drift and displacement is increasing.

VI. SCOPE FOR FURTHUR STUDY

The size of opening and placement of the openings can be changed and a study can be made.

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