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Comparative Study of Shear Walls and Bracings for A Multistoried Structure Under Seismic Loading

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***Abstract*:- Earthquake is the natural calamity, it produce strong ground motions which affect the structure. Small or weak motions that can or cannot be felt by the humans. Provision of shear walls and bracings are installed to enhance the lateral stiffness, ductility, minimum lateral displacements and safety of the structure. Storey drift and lateral displacements are the critical issues in seismic design of buildings.**

Three types of frame models are developed and evaluated by static analysis by ETABS . In the present work G+15 multi Storey building is analysed by using shear wall and braced frame at outer most of the structure and Comparison with multistoried structure . Main purpose of this study is to compare the seismic response of the structure.

BACK GROUND:

Lateral forces on buildings such as wind, earthquake and blast forces can be produced critical stresses in the buildings that it cause excessive lateral sway of the buildings and undesirable stresses and vibrations in the buildings. Design and structural evaluation of the building systems subjected to lateral loads form the important task of the present generation and the designers are faced with problems of providing adequate strength and stability of buildings against lateral loads. Different lateral loads resisting systems are used in high-rise building as the lateral loads due to earthquakes are a matter of concern. Steel plate shear walls system and steel bracings system are used in steel structures buildings and their effect shows unequal variations and behaviour against seismic loads. Recently, laminated composite plate shear walls are used as a lateral loads resisting system where the laminated composite plates are used as infill plate in shear walls. The laminated composite plates are created by constructing plates of two or more thin bonded layers of materials and it can be either cross-ply laminates or angle-ply laminates.

The major criteria now-a-days in designing RCC structures in seismic zones is control of lateral displacement resulting from lateral forces. In this thesis effort has been made to investigate the effect of Shear Wall position on lateral displacement in RCC Frames. Eight models of various shapes of shear walls with varying thickness are arranged at different locations of eleven(11) storeyed framed building and performed linear static analysis, obtained displacements is compared with the corresponding frame without shear wall.

In this project shear wall systems are taken consideration and executed for lateral forces like wind and earthquake.

DEFINITION OF SHEAR WALL:

Shear walls are vertical elements of the horizontal force resisting system. Shear walls are constructed to counter the effects of lateral load acting on a structure. In residential construction, shear walls are straight external walls that typically form a box which provides all of the lateral support for the building. When shear walls are designed and constructed properly, and they will have the strength and stiffness to resist the horizontal forces.

SCOPE OF THE WORK

The scope is to analyse the constructed shear wall that is to be constructed. Firstly the different thickness of shear wall is placed at different locations are implemented into known computer software and then it is analysed based on the investigation of strength based on design codes. The strength of shear walls tested are compared with the strength of frame correspondingly of without shear wall.

- Only multi-storey frames are considered.
- Plan irregularities are not considered.
- Shear walls are considered for the frame at different position for the study of linear static analysis.
- Linear static analysis is used to predict the actual performance of the RC Frames under lateral loadings.

OBJECTIVE

The walls are structurally integrated with roofs / floors (diaphragms) and other lateral walls running across at right angles, thereby giving the three dimensional stability for the building structures. Shear wall structural systems are more stable.

Walls have to resist the uplift forces caused by the pull of the wind. Walls have to resist the shear forces that try to push the walls over. Walls have to resist the lateral force of the wind that tries to push the walls in and pull them away from the building.

PROJECT OBJECTIVES:

- To determine the effective location of shear wall and bracings on the basis of storey displacement under lateral loading.
- To determine percentage reduction in storey displacement with different places of shear wall and Bracings at different locations on different models when compared to without shear wall.

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METHODOLOGY

For the purpose of study a plan of eleven storeyed frame were considered. For linear elastic study, RC plane frames with and without shear wall were analysed and designed for gravity loads as per IS 456:2000 and lateral loads (earthquake loads) as per IS 1893 (part-1):2002.

SHEAR WALLS

Shear walls are vertical elements of the horizontal force resisting system. Shear walls are constructed to counter the effects of lateral load acting on a structure. In residential construction, shear walls are straight external walls that typically form a box which provides all of the lateral support for the building. When shear walls are designed and constructed properly, and they will have the strength and stiffness to resist the horizontal forces. In building construction, a rigid vertical diaphragm capable of transferring lateral forces from exterior walls, floors, and roofs to the ground foundation in a direction parallel to their planes. Examples are the reinforced-concrete wall or vertical truss. Lateral forces caused by wind, earthquake, and uneven settlement loads, in addition to the weight of structure and occupants; create powerful twisting (torsion) forces. These forces can literally tear (shear) a building apart. Reinforcing a frame by attaching or placing a rigid wall inside it maintains the shape of the frame and prevents rotation at the joints. Shear walls are especially important in high-rise buildings subjected to lateral wind and seismic forces. In the last two decades, shear walls became an important part of mid and high-rise residential buildings. As part of an earthquake resistant building design, these walls are placed in building plans reducing lateral displacements under earthquake loads. So shear-wall frame structures are obtained.

Shear wall buildings are usually regular in plan and in elevation. However, in some buildings, lower floors are used for commercial purposes and the buildings are characterized with larger plan dimensions at those floors. In other cases, there are setbacks at higher floor levels. Shear wall buildings are commonly used for residential purposes and can house from 100 to 500 inhabitants per building.

PURPOSE OF CONSTRUCTING SHEAR WALLS

Shear walls are not only designed to resist gravity / vertical loads (due to its self-weight and other living / moving loads), but they are also designed for lateral loads of earthquakes / wind. The walls are structurally integrated with roofs / floors (diaphragms) and other lateral walls running across at right angles, thereby giving the three dimensional stability for the building structures. Shear wall structural systems are more stable. Because, their supporting area (total cross-sectional area of all shear walls) with reference to total plans area of building, is comparatively more, unlike in the case of RCC framed structures. Walls have to resist the uplift forces caused by the pull of the wind. Walls have to resist the shear forces that try to push the walls over. Walls have to resist the lateral force of the wind that tries to push the walls in and pull them away from the building.

Shear walls are quick in construction, as the method adopted to construct is concreting the members using formwork.
Shear walls doesn't need any extra plastering or finishing as the wall itself gives such a high level of precision, that it doesn't require plastering.

BRACINGS

INTRO

Bracing is a highly efficient and economical method to laterally stiffen the frame structures against wind loads. A braced bent consists of usual columns and girders whose primary purpose is to support the gravity loading, and diagonal bracing members that are connected so that total set of members forms a vertical cantilever truss to resist the horizontal forces. Bracing is efficient because the diagonals work in axial stress

Tall Buildings and Structural Form

Tallness is considered as relative term which cannot be defined in terms of height. From structural engineer's point of view, tall building is defined as the building whose structural design is governed by the lateral forces induced due to wind and earthquake.
The structural form of a tall building depends on a number of factors, some are given below;

- Internal planning
- Material and method of construction
- External architectural treatment
- Location and routing of service system
- Nature and magnitude of horizontal loading
- Height and proportion of building

Following are some structural forms of the tall buildings:

E-TABS SOFTWARE

History of E-Tabs

A well-known and established across the world a structural & earthquake engineering Software Company, Computers and Structures, Inc. (CSI) established in 1975 and located in Walnut Creek, California with further office position in New York. The structural analysis and design software CSI is a developer a lots of software including CSiBridge, SAFE, and CSiCOL, ETABS and SAP2000. The most useful structural analysis and design software developed by Computers and Structures, Inc, is ETABS which at firs utilized to develop the mathematical complete model of the Burj Khalifa, right now the highest building of the world that has been developed and designed by Chicago, Illinois-based Skidmore, Owings & Merrill LLP (SOM). Taking position of the Design and Construction of the world's highest building in their Structural Engineering magazine article on December 2009 in the Structural analysis part: The Burj Dubai next time renamed as Burj Khalifa, William F. Baker, S.E. and James J. Pawlikowski, S.E. mentioned that the gravity as well a wind and seismic behaviour were everything considered using ETABS. Further, ETABS' geometric nonlinear capability provided for P-Delta Effect consideration. Since the launches of this program, now is being used across the world by the Civil Engineering profession who are practicing structural analysis and design.

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About ETABS

It is an engineering software product that caters to multi-story building analysis and design. Modelling tools and templates, code-based load prescriptions, analysis methods and solution techniques, all coordinate with the grid-like geometry unique to this class of structure. Basic or advanced systems under static or dynamic conditions may be evaluated using ETABS. For a sophisticated assessment of seismic performance, modal and direct-integration time-history analyses may couple with P-Delta and Large Displacement effects. Nonlinear links and concentrated PMM or fibre hinges may capture material nonlinearity under monotonic or hysteretic behaviour. Intuitive and integrated features make applications of any complexity practical to implement. Interoperability with a series of design and documentation platforms makes ETABS a coordinated and productive tool for designs which range from simple 2D frames to elaborate modern high-rises.

Use of E-TABS

Generally, ETABS is used for the analysis of concrete shear walls and concrete moment frames. Once we are able to limit the drift, we can output the forces from ETABS into a spreadsheet for design. We design the piers of the shears walls for flexure and axial loads using PCA Column. We design the moment frames using PCA Slab. For the gravity design of the concrete floor system, we use RAM Advance and SAFE. ETABS is also very useful in designing complex steel braced frame and moment frame lateral system. It is especially useful in seismic applications. However, RAM is more suitable for the gravity design of steel floor systems, in my opinion. Often we have two models; a RAM gravity model and an ETABS lateral model.

EQUIVALENT STATIC ANALYSIS (LINEAR STATIC)

This method is also called linear static method. The equivalent static lateral force method is a simplified technique to substitute the effect of dynamic loading of an expected earthquake by a static force distributed laterally on a structure for design purposes. The total applied seismic force *V* is generally evaluated in two horizontal directions parallel to the main axes of the building (Fig. 8). It assumes that the building responds in its fundamental lateral mode. For this to be true, the building must be low rise and must be fairly symmetric to avoid torsional movement underground motions. The structure must be able to resist effects caused by seismic forces in either direction, but not in both directions simultaneously.

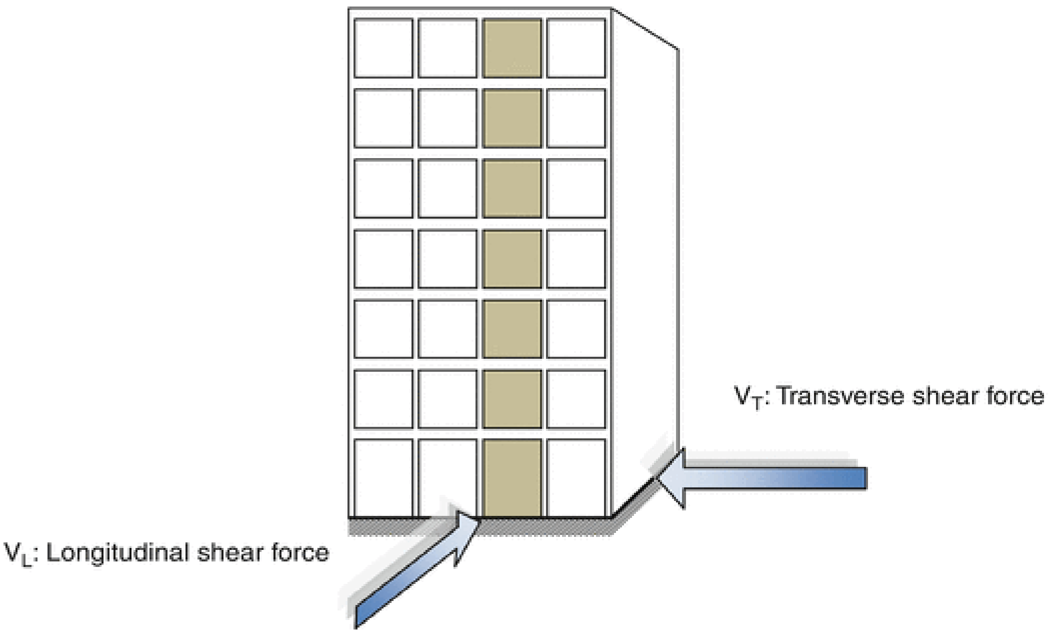

Fig. Lateral force on two axis

Linear elastic seismic analysis of structures is dependent on many assumptions. First assumption is, all the buildings will behave more or less the same under a particular sets of rules. For example, all shear wall buildings will have similar amount of ductility demand, all moment frame buildings will also have similar behaviour. Which in reality is not true. There are some building codes which understand this scenario. They assign additional factors to be incorporated on the building forces, which amplifies the seismic demands. There are some limitations to this method as well but it is still better in predicting the seismic demands.

The seismic demands on the structure is estimated by different methods. Elastic method and inelastic method. In elastic method, we consider that the structure remains elastic and the seismic demands on the structure is reduced using response reduction factor which assumes that the structure has the capacity to go beyond elastic limit but the performance is never checked. While in inelastic method, unreduced seismic demands are tested against the force resisting capacity and inelastic deformation capacity of the structure. In this scenario a true performance of the structure is tested and made sure it meets all the criteria of collapse prevention under maximum considered earthquake.

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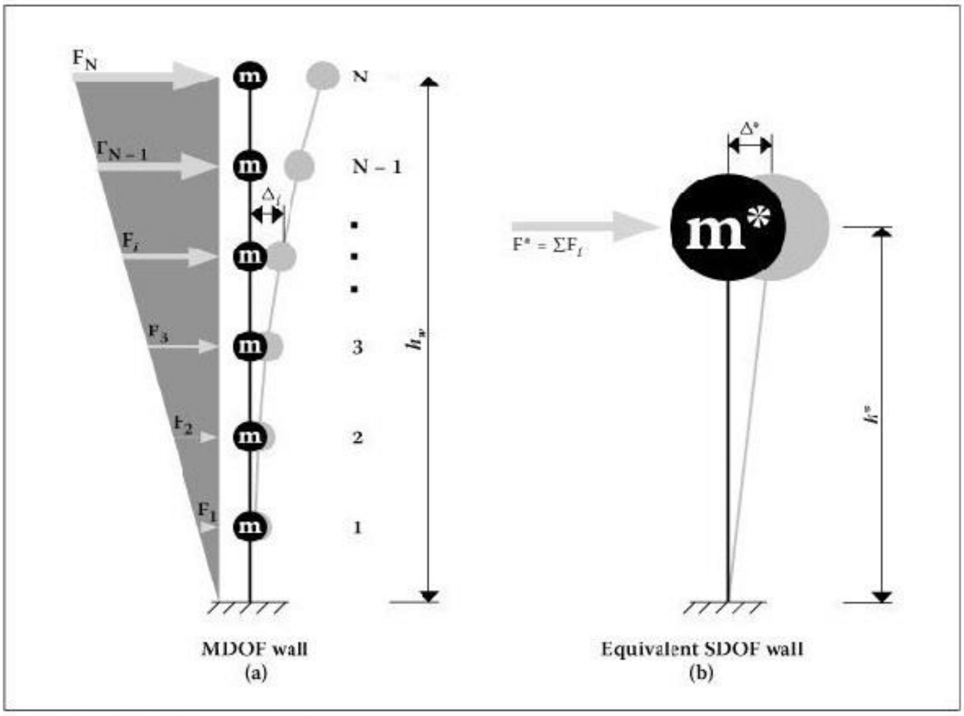

Fig.Equivalent SDOF

ELF analysis is based on an assumption of static cantilever beam. There is a slight effect of second mode of the structure taken into consideration in the story shear distribution but nothing more than that. The amount of seismic base shear consider for designing the building is on the basis of approximate period of the building, site specific ground acceleration and response spectrum curve, site class of the site and type of building system used to resist the lateral forces. This type of analysis should only be used when the building is symmetric, torsion is minimal, no vertical or horizontal irregularities and no discontinuities in the system and where the primary mode of the structure governs the structural dynamics. This means that ELF analysis leads to a fairly accurate results for short and very symmetric and regular buildings.

ELF analysis, story force is generated as per the height at which the story is located from the seismic base. Higher the story up in the building, more loads will be generated by that story. But the drawback of this method is, the if there is a significantly heavier story near the base of the building, let us say Level 2 or 3, the contribution from this heavier story present close to the bottom of the building is significantly less. The only reason is because the equations are developed in such a way that it gives more weight to the height of the story from the base as compared to the story weight itself. This was just an example of drawback of ELF analysis. And so, it is always recommended that ELF analysis should be carried out on structures that are very regular and symmetric and have do not exhibit any complex behaviour.

MODELLING OF MULTI-STOREY FRAME USING E-TABS

For this study, 11-story building with a 3.5 meters bottom storey height and 3 meters typical for each storey, regular in plan is modelled. These buildings were designed in compliance to the Indian Code of Practice for Seismic Resistant Design of Buildings. The buildings are assumed to be fixed at the base. The sections of structural elements are square and rectangular. Storey heights of buildings are assumed to be constant except the ground storey. The buildings are modelled using software ETABS linear v 9.6.0-2015.

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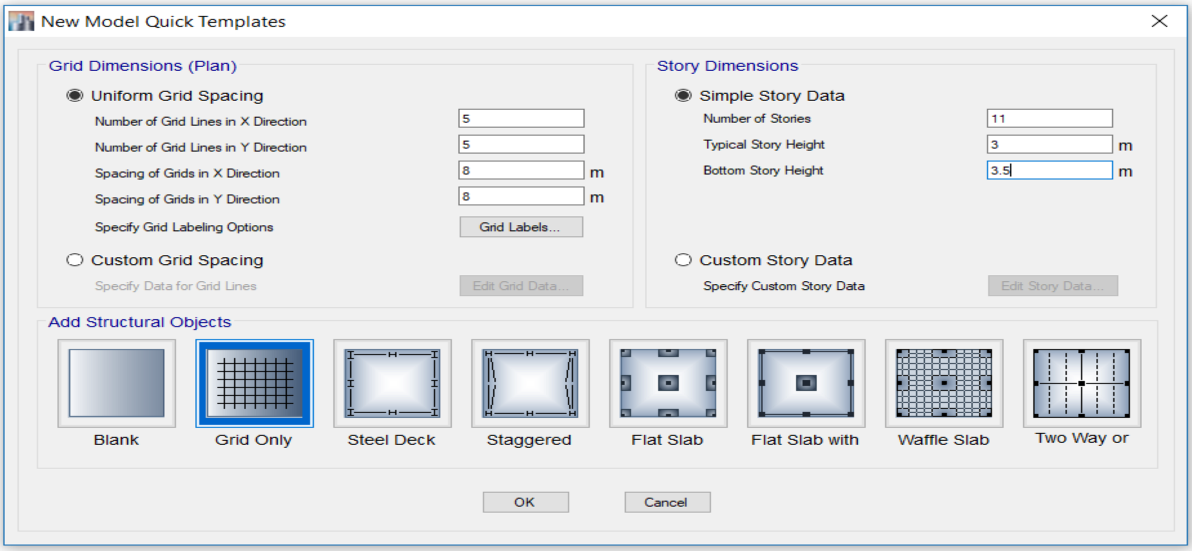

Fig. Dimensional details of model-1

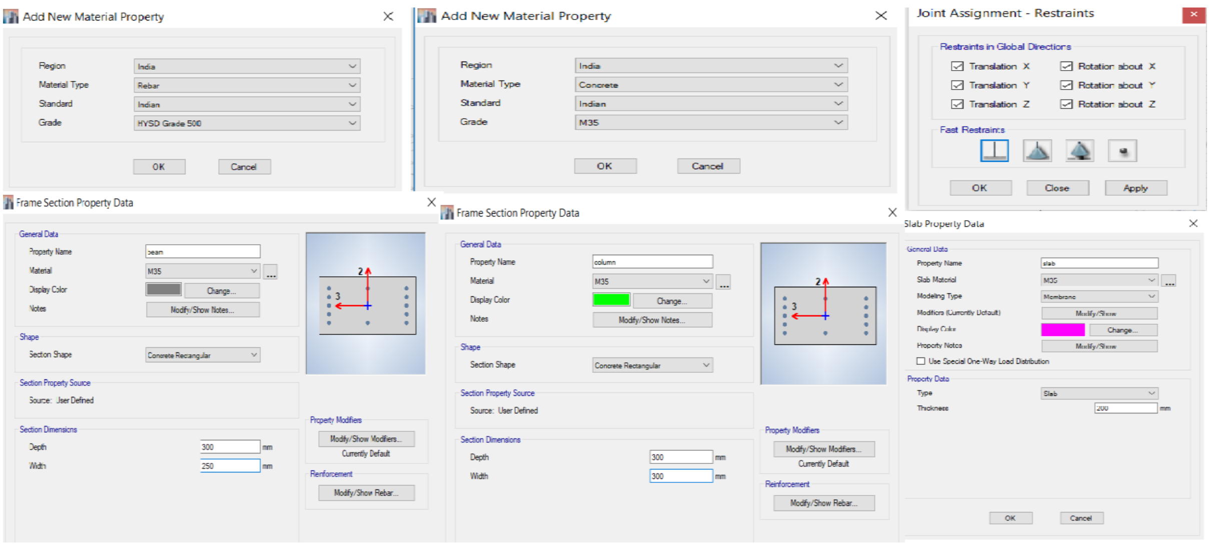

Fig. Defining materials, beams, columns, slab sections and base joint restraints.

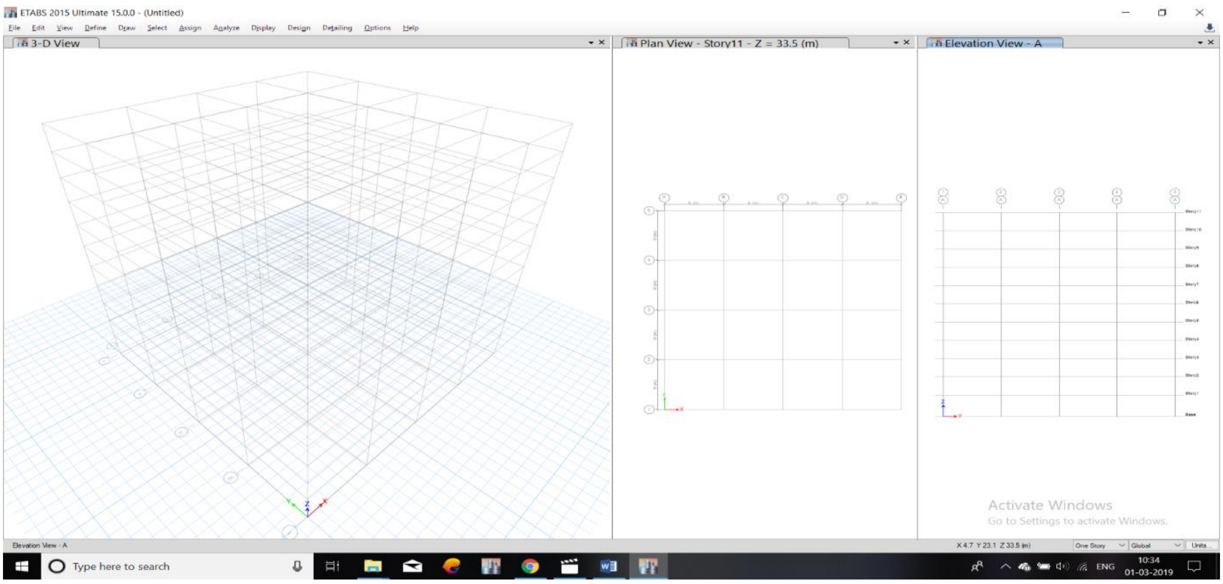

Fig. Model-1 before assigning beams, column and slab

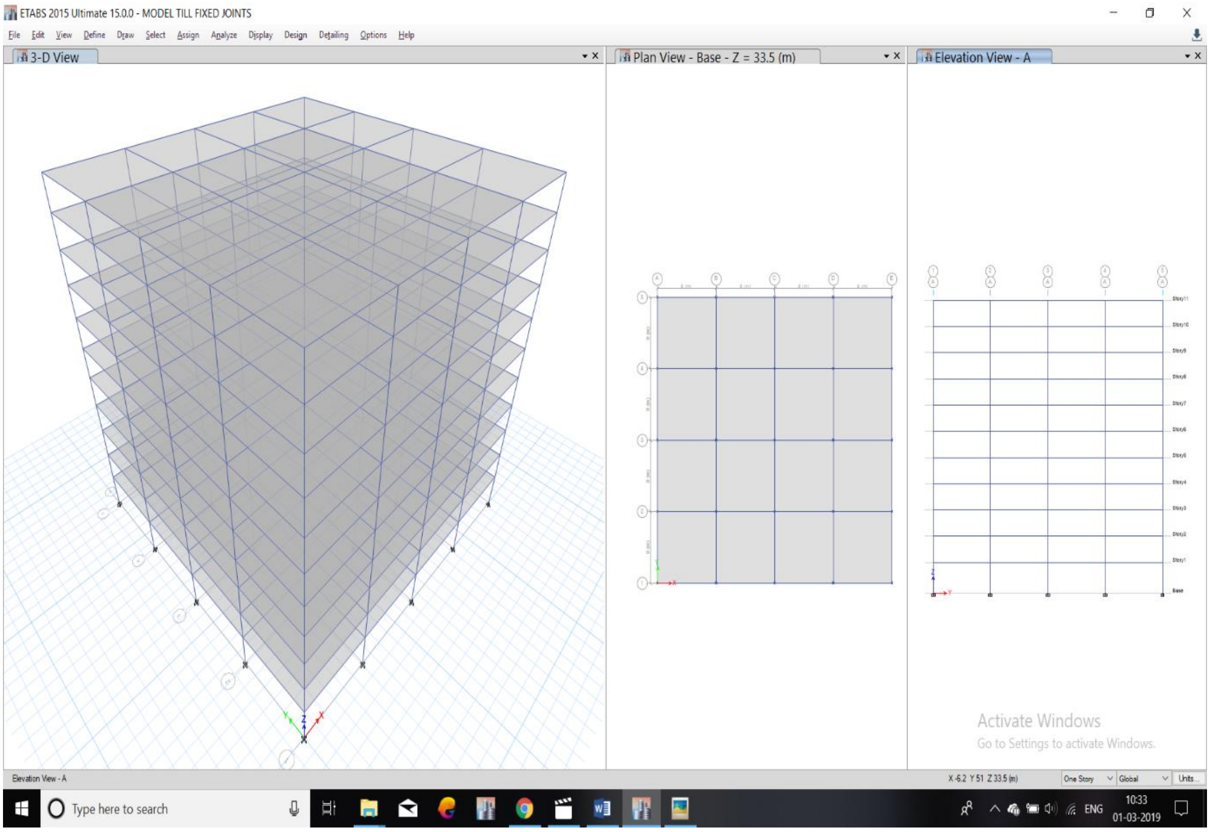

Fig.Model-1 after assigning beams, column and slab

6.1 MATERIALS

The modulus of elasticity of reinforced concrete as per IS 456:2000 is given by

$$E_c = 5000\sqrt{f_{ck}}$$

For the steel rebar, the necessary information is yield stress, modulus of elasticity and ultimate strength. High yield strength deformed bars (HYSD) having yield strength 500 N/mm^2 is widely used in design practice and is adopted for the present study. Cement used is of grade M35.

6.2 STRUCTURAL ELEMENTS

In this section, the details of the modelling adopted for various elements of the frame are given below.

6.2.1 Beams and Columns

Beams and columns were modelled as frame elements. The elements represent the strength, stiffness and deformation capacity of the members. While modelling the beams and columns, the properties to be assigned are cross sectional dimensions, reinforcement details and the type of material used.

All the Beams in the frame were sized to 250mm*300mm

All the columns in the frame were sized to 300mm*300mm

6.2.2 Beam-Column Joints

The beam-column joints are assumed to be rigid.

6.2.3 Wall

A periphery of 300mm wall is taken into consideration.

6.2.4 Slab

A slab of 150mm is considered as per IS 456:2000.

6.2.5 Foundation Modelling

Fixed supports were provided at the ends of supporting columns.

6.3 Loads

Loads that are considered for the frame analysis are follows

1. Dead Load
2. Live Load
3. Lateral Load due to Earthquake and
4. . Lateral Load due to wind

6.3.1 Load cases

As dead load and wall load are permanent loads on building so we take self weight multiplier as one for those cases.

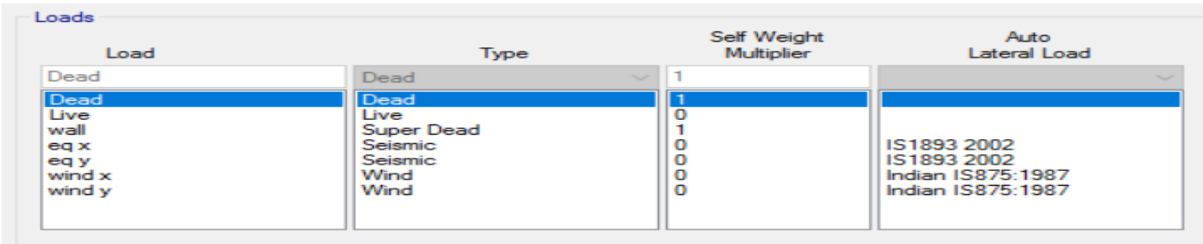

Fig.14 Load Cases

6.3.2 Load patterns

6.3.2.1 Seismic pattern

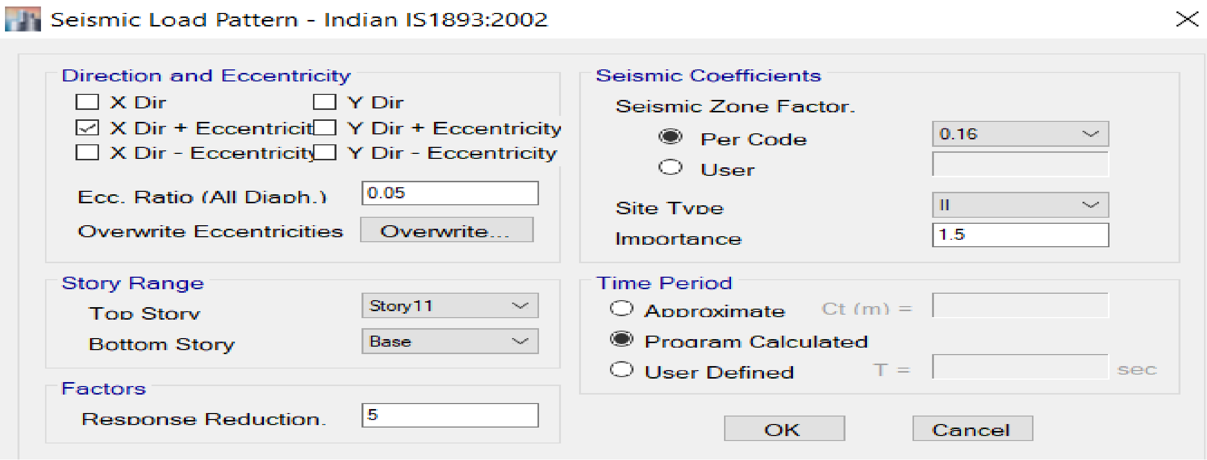

Fig.15 Seismic load pattern

6.3.2.2 Wind pattern

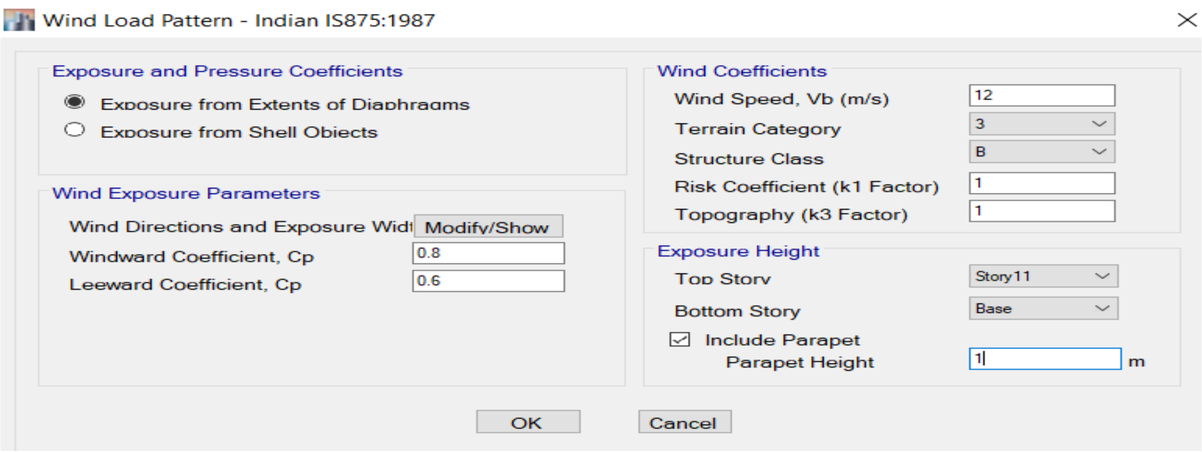

Fig.16 Wind load pattern

Note:

Terrain category I Open sea; free lakes with at least 5 km surface wind direction; smooth, flat land without barriers.

Terrain category II Terrain with hedges, individual farmsteads, houses or trees, for example agricultural areas

Terrain category III Suburbs, industrial or commercial areas, forests

Terrain category IV Urban areas in which at least 15% of the surface is built with buildings whose average height exceeds 15 m

Site type **I** Hard soil

Site type II Medium soil

Site type III Soft soil

We assumed Vijayawada as location of framed building. It is under seismic zone **III** with zone factor **0.16** and taking importance factor as **1.5** and with SMRF (Steel Building with Special Moment resisting Frame) with response reduction factor as **5**.

6.3.3 Member Loading

All the members were assigned the following loadings.

- Dead Load = 3 KN/m^2
- Wall load = 12 KN/m
- Live Load = 4 KN/m^2
- Earthquake Loading------ as per IS-code:1983-2002
- Wind Loading------ as per IS875:1987

6.4 LOAD COMBINATIONS

The load combinations considered in the analysis according to IS 1893:2002 are given below.

COMB1 = 1.2(DL+LL) + EQx + Wx + 0.3(EQy + Wy)

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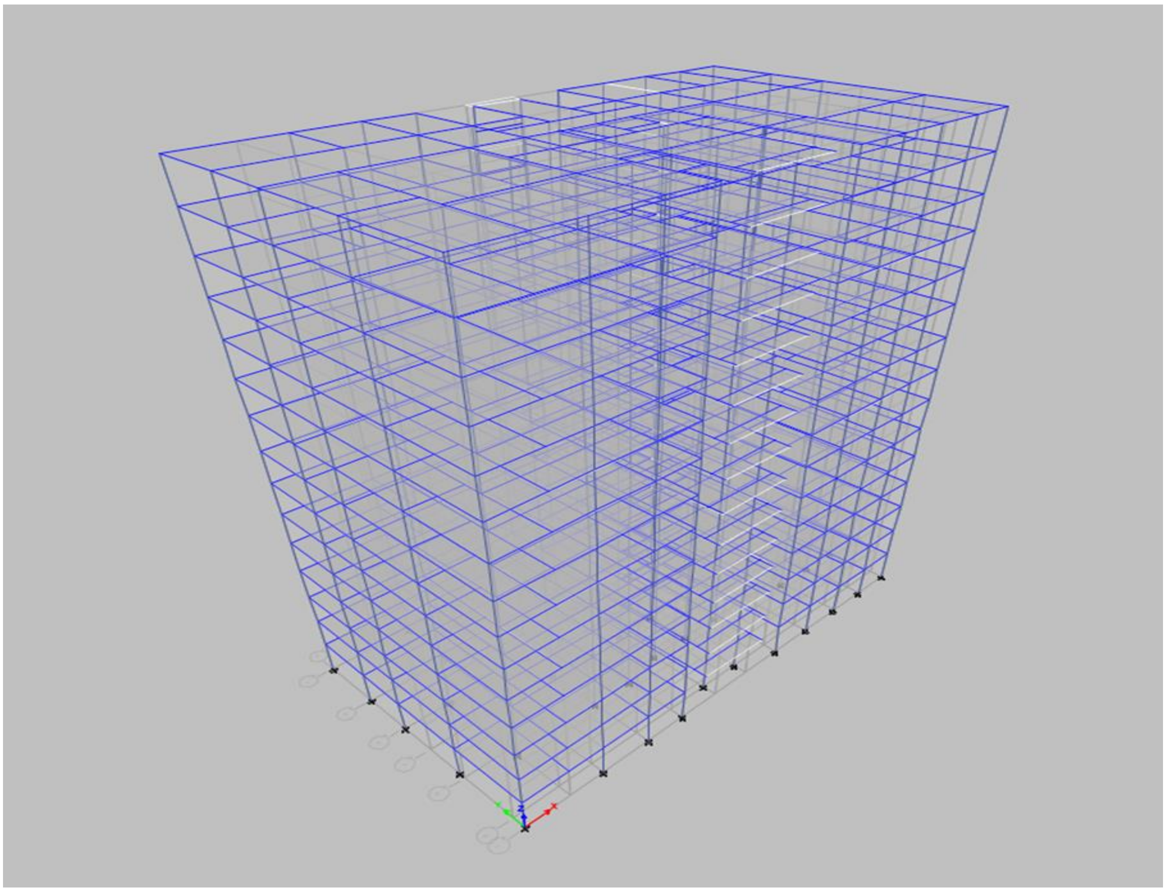
MODEL 1-(G+15) STRUCTURAL MODEL



Structure Data

This chapter provides model geometry information, including items such as story levels, point coordinates, and element connectivity.

Story Data

Table - Story Data

Name	**Height mm**	**Elevation mm**	**Master Story**	**Similar To**	**Splice Story**
Story15	3300	49500	Yes	None	No
Story14	3300	46200	No	Story2	No
Story13	3000	42900	No	Story2	No
Story12	3300	39900	No	Story2	No
Story11	3300	36600	No	Story2	No
Story10	3300	33300	No	Story2	No
Story9	3300	30000	No	Story2	No
Story8	3300	26700	No	Story2	No
Story7	3300	23400	No	Story2	No
Story6	3300	20100	No	Story2	No
Story5	3300	16800	No	Story2	No
Story4	3300	13500	No	Story2	No
Story3	3300	10200	No	Story2	No
Story2	3300	6900	Yes	None	No
Story1	3600	3600	Yes	None	No
Base	0	0	No	None	No

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Loads

This chapter provides loading information as applied to the model.

Load Patterns

Table - Load Patterns

Name	Type	Self Weight Multiplier	Auto Load
Dead	Dead	1	
Live	Live	0	
EQ X	Seismic	0	IS1893 2002
EQ Y	Seismic	0	IS1893 2002
WIND	Wind	0	Indian IS875:1987
WIND Y	Wind	0	Indian IS875:1987

Load Cases

Table - Load Cases – Summary

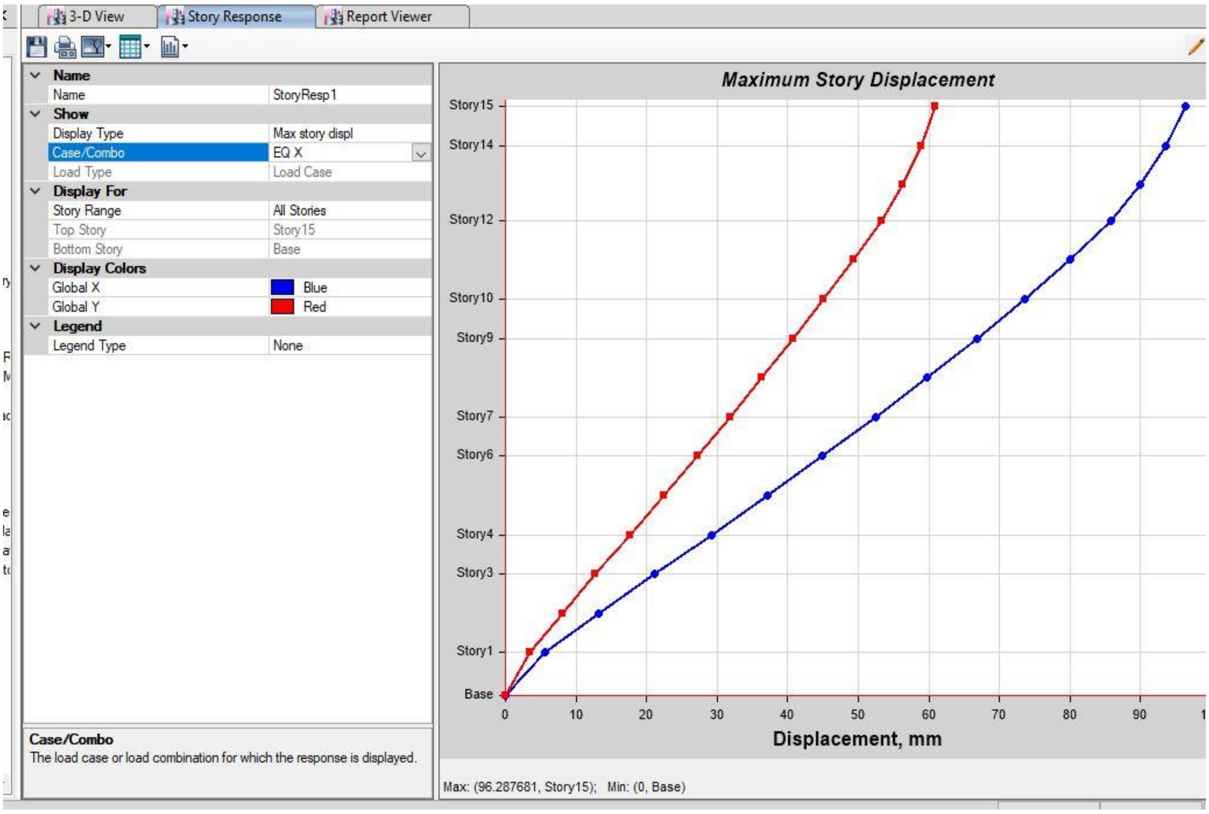
Name	Type
Dead	Linear Static
Live	Linear Static
EQ X	Linear Static
EQ Y	Linear Static
WIND	Linear Static
WIND Y	Linear Static

RESULTS

- Story Stiffness

Story	Load Case	Shear X Kn	Drift X mm	Stiffness X Kn/m	Shear Y Kn	Drift Y mm	Stiffness Y Kn/m
Story15	EQ X	1519.5298	1.59	955506.489	15.057	1.056	0
Story14	EQ X	3419.9334	2.23	1533445.845	12.8207	1.313	0
Story13	EQ X	5217.2232	2.392	2181040.086	49.2239	1.54	0
Story12	EQ X	6581.2751	3.606	1825099.105	37.4888	2.024	0
Story11	EQ X	7866.8226	4.145	1898112.363	50.2088	2.209	0
Story10	EQ X	8912.5661	4.423	2014858.032	45.1156	2.243	0
Story9	EQ X	9761.405	4.658	2095429.094	38.4736	2.246	0
Story8	EQ X	10439.0477	4.871	2142890.788	43.4945	2.324	0
Story7	EQ X	10966.9842	5.022	2183636.272	47.4929	2.391	0
Story6	EQ X	11356.111	5.126	2215462.524	40.0582	2.403	0
Story5	EQ X	11619.538	5.253	2211850.787	47.3702	2.457	0
Story4	EQ X	11789.1984	5.332	2211048.315	60.7418	2.504	0
Story3	EQ X	11878.2201	5.24	2266819.044	38.4742	2.39	0
Story2	EQ X	11928.4979	4.989	2391056.413	52.8668	2.325	0
Story1	EQ X	11915.5832	3.775	3156773.889	87.1229	1.854	0
Story15	EQ Y	8.9001	0.236	0	1335.1288	0.523	2552101.293

Story	Load Case	Shear X Kn	Drift X mm	Stiffness X Kn/m	Shear Y Kn	Drift Y mm	Stiffness Y Kn/m
Story14	EQ Y	5.1023	0.315	0	3045.1409	0.872	3493485.162
Story13	EQ Y	14.0235	0.376	0	4614.8874	0.885	5217319.7
Story12	EQ Y	6.7212	0.468	0	5861.1896	1.684	3481365.015
Story11	EQ Y	8.6758	0.518	0	6996.2517	2.069	3380901.026
Story10	EQ Y	10.1348	0.539	0	7925.3288	2.295	3453266.73
Story9	EQ Y	11.3607	0.555	0	8684.6441	2.475	3508787.451
Story8	EQ Y	11.6809	0.581	0	9290.2518	2.62	3546427.333
Story7	EQ Y	10.06	0.626	0	9757.4977	2.75	3547808.139
Story6	EQ Y	6.1309	0.674	0	10097.8332	2.889	3495092.937
Story5	EQ Y	4.6318	0.72	0	10330.9364	3.007	3435106.395
Story4	EQ Y	5.1164	0.751	0	10484.2825	3.065	3420762.796
Story3	EQ Y	0.7116	0.762	0	10579.292	3.115	3396036.089
Story2	EQ Y	0.3227	0.696	0	10599.9764	3.423	3096649.187
Story1	EQ Y	2.8248	0.457	0	10548.9853	3.002	3513802.231



MAXIMUM STORY DISPLACEMENT EQX

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TABLE- MAXIMUM STORY DISPLACEMENT EQX

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story15	49.5	Top	96.288	60.936
Story14	46.2	Top	93.55	58.865
Story13	42.9	Top	89.876	56.273
Story12	39.9	Top	85.811	53.252
Story11	36.6	Top	80.066	49.334
Story10	33.3	Top	73.583	45.054
Story9	30	Top	66.78	40.705
Story8	26.7	Top	59.746	36.355
Story7	23.4	Top	52.427	31.865
Story6	20.1	Top	44.862	27.224
Story5	16.8	Top	37.133	22.516
Story4	13.5	Top	29.182	17.671
Story3	10.2	Top	21.094	12.73
Story2	6.9	Top	13.223	8.059
Story1	3.6	Top	5.675	3.475
Base	0	Top	0	0

MAXIMUM STORY DISPLACEMENT EQY

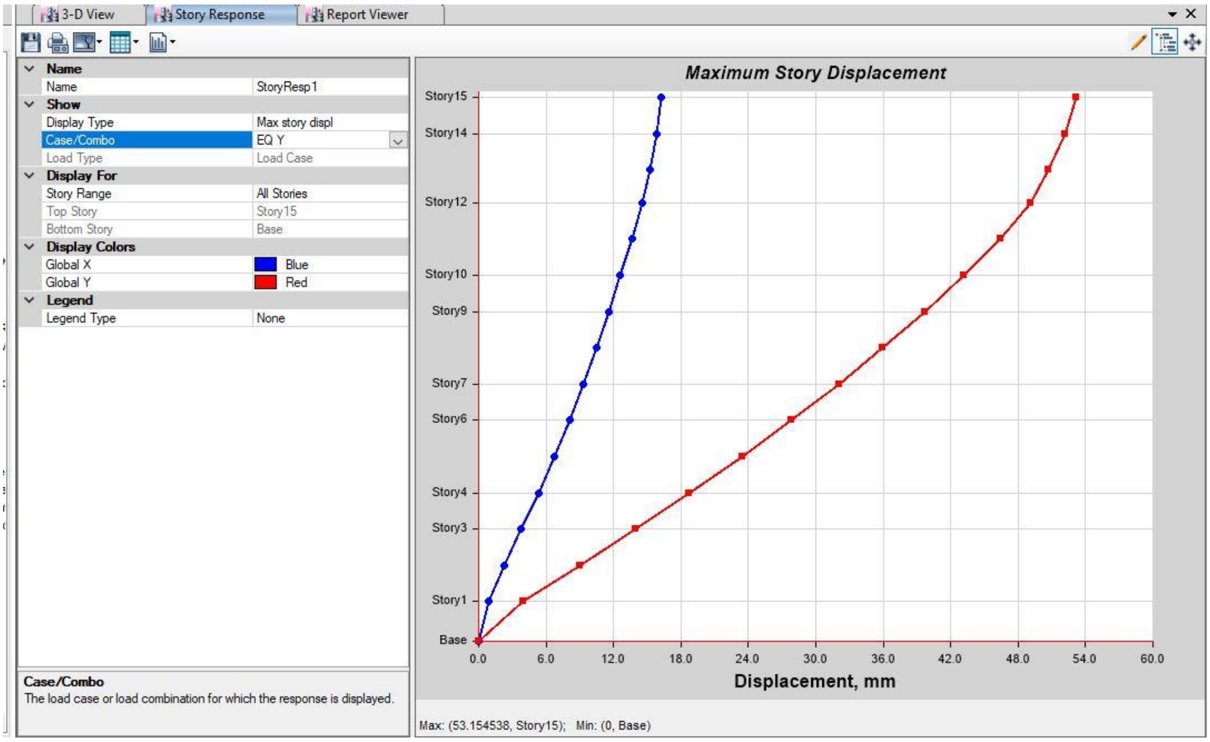

TABLE- MAXIMUM STORY DISPLACEMENT EQY

Story Response

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story15	49.5	Top	16.225	53.155
Story14	46.2	Top	15.795	52.179
Story13	42.9	Top	15.214	50.689
Story12	39.9	Top	14.524	49.078
Story11	36.6	Top	13.631	46.407
Story10	33.3	Top	12.621	43.196
Story9	30	Top	11.561	39.694
Story8	26.7	Top	10.469	35.972
Story7	23.4	Top	9.325	32.045
Story6	20.1	Top	8.086	27.871
Story5	16.8	Top	6.738	23.417
Story4	13.5	Top	5.299	18.738
Story3	10.2	Top	3.799	13.935
Story2	6.9	Top	2.281	9.049
Story1	3.6	Top	0.89	4.007

MAXIMUM STORY DISPLACEMENT WIND1 CASE

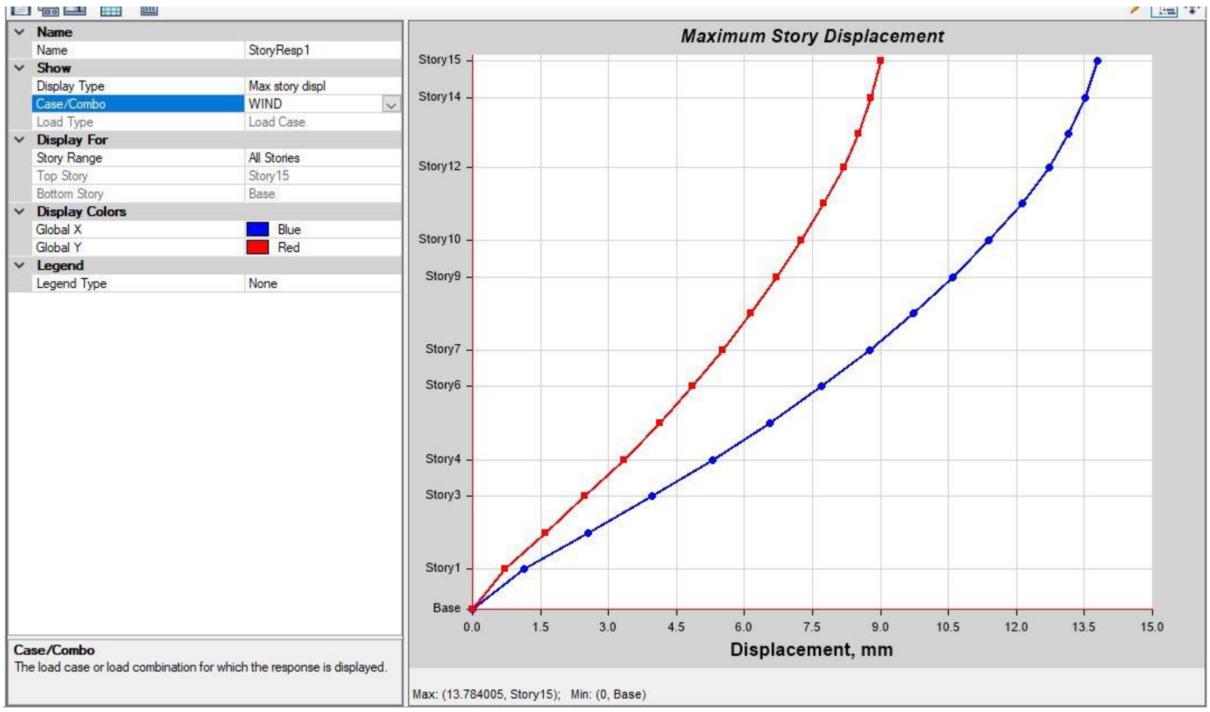

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TABLE-MAXIMUM STORY DISPLACEMENT WIND1 CASE

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story15	49.5	Top	13.784	9.003
Story14	46.2	Top	13.512	8.786
Story13	42.9	Top	13.146	8.515
Story12	39.9	Top	12.729	8.192
Story11	36.6	Top	12.119	7.755
Story10	33.3	Top	11.398	7.255
Story9	30	Top	10.598	6.718
Story8	26.7	Top	9.722	6.149
Story7	23.4	Top	8.758	5.529
Story6	20.1	Top	7.702	4.852
Story5	16.8	Top	6.556	4.126
Story4	13.5	Top	5.305	3.333
Story3	10.2	Top	3.951	2.475
Story2	6.9	Top	2.552	1.612
Story1	3.6	Top	1.128	0.713
Base	0	Top	0	0

MAXIMUM STORY DISPLACEMENT WIND2 CASE

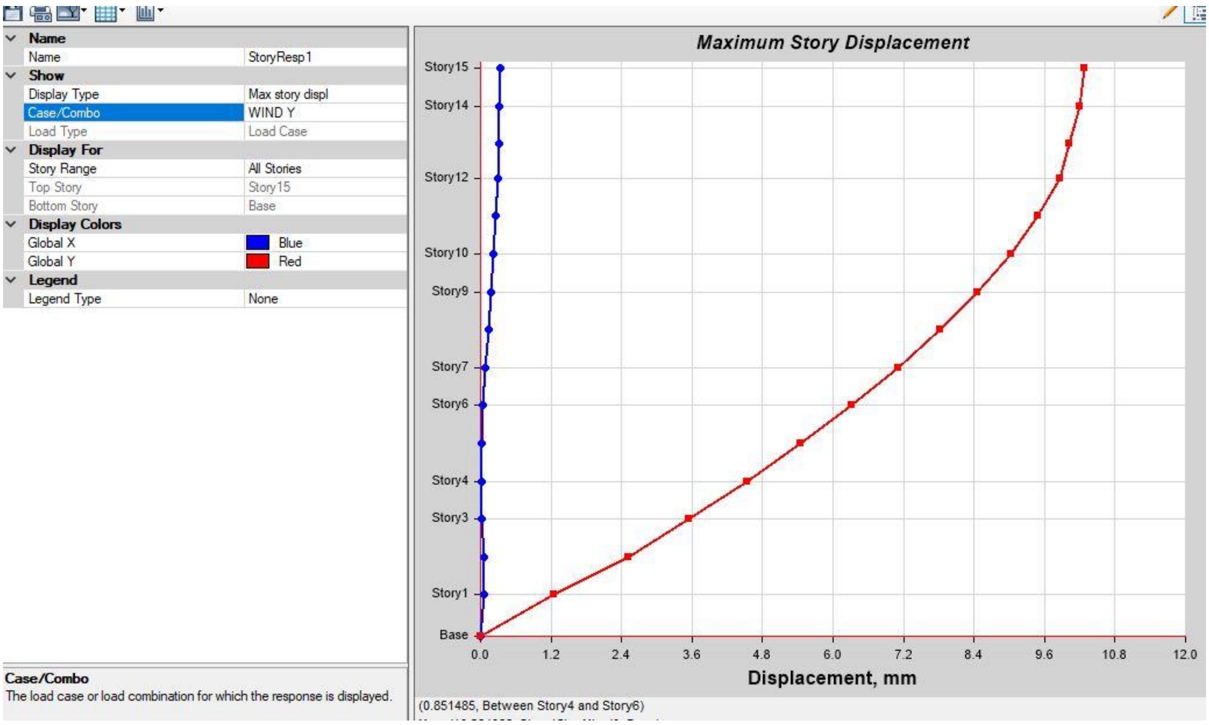

TABLE-MAXIMUM STORY DISPLACEMENT WIND CASE

Story Response

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story15	49.5	Top	0.338	10.284
Story14	46.2	Top	0.324	10.192
Story13	42.9	Top	0.308	10.029
Story12	39.9	Top	0.293	9.855
Story11	36.6	Top	0.261	9.493
Story10	33.3	Top	0.222	9.021
Story9	30	Top	0.178	8.462
Story8	26.7	Top	0.133	7.821
Story7	23.4	Top	0.086	7.1
Story6	20.1	Top	0.047	6.31
Story5	16.8	Top	0.026	5.455
Story4	13.5	Top	0.02	4.529
Story3	10.2	Top	0.026	3.54
Story2	6.9	Top	0.056	2.506
Story1	3.6	Top	0.055	1.243
Base	0	Top	0	0

MAXIMUM STORY DRIFT EQX CASE

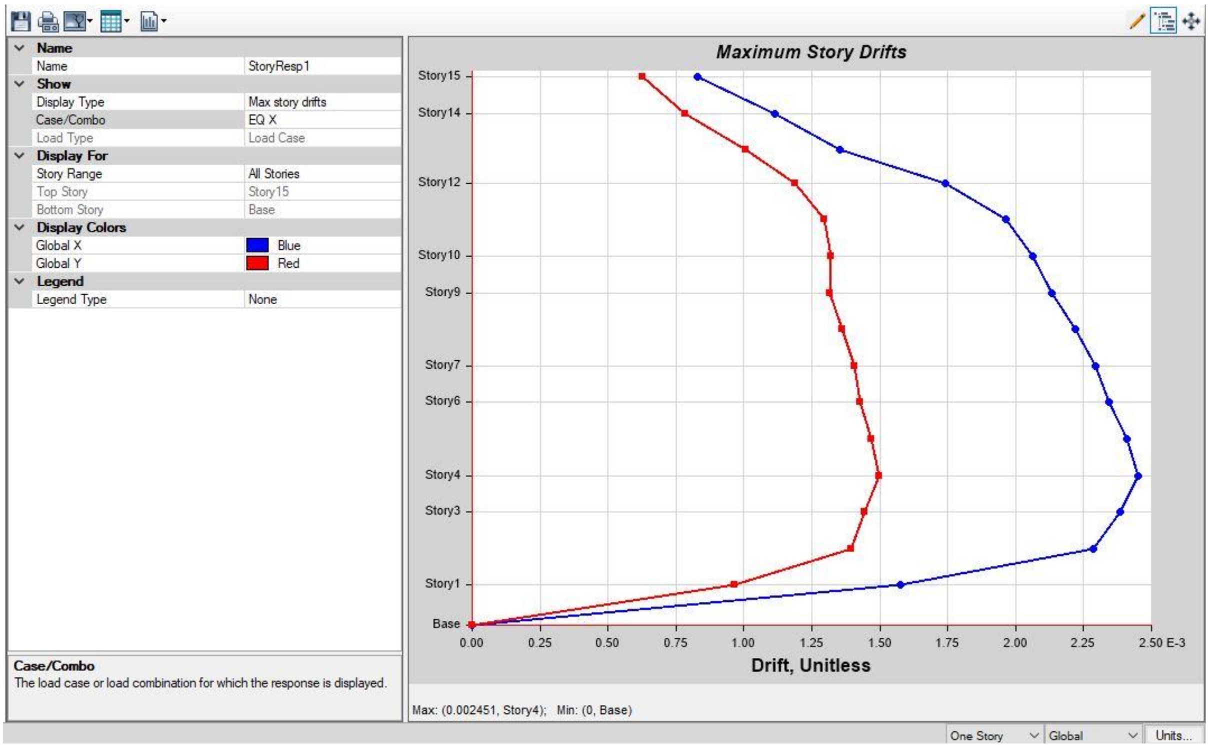

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TABLE-MAXIMUM STORY DRIFT EQX

Story	Elevation m	Location	X-Dir	Y-Dir
Story15	49.5	Top	0.000829	0.000628
Story14	46.2	Top	0.001114	0.000785
Story13	42.9	Top	0.001355	0.001007
Story12	39.9	Top	0.001741	0.001187
Story11	36.6	Top	0.001965	0.001297
Story10	33.3	Top	0.002062	0.001318
Story9	30	Top	0.002131	0.001318
Story8	26.7	Top	0.002218	0.001361
Story7	23.4	Top	0.002292	0.001406
Story6	20.1	Top	0.002342	0.001427
Story5	16.8	Top	0.002409	0.001468
Story4	13.5	Top	0.002451	0.001499
Story3	10.2	Top	0.002385	0.001444
Story2	6.9	Top	0.002287	0.001393
Story1	3.6	Top	0.001577	0.000965
Base	0	Top	0	0

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MAXIMUM STORY DRIFT EQY

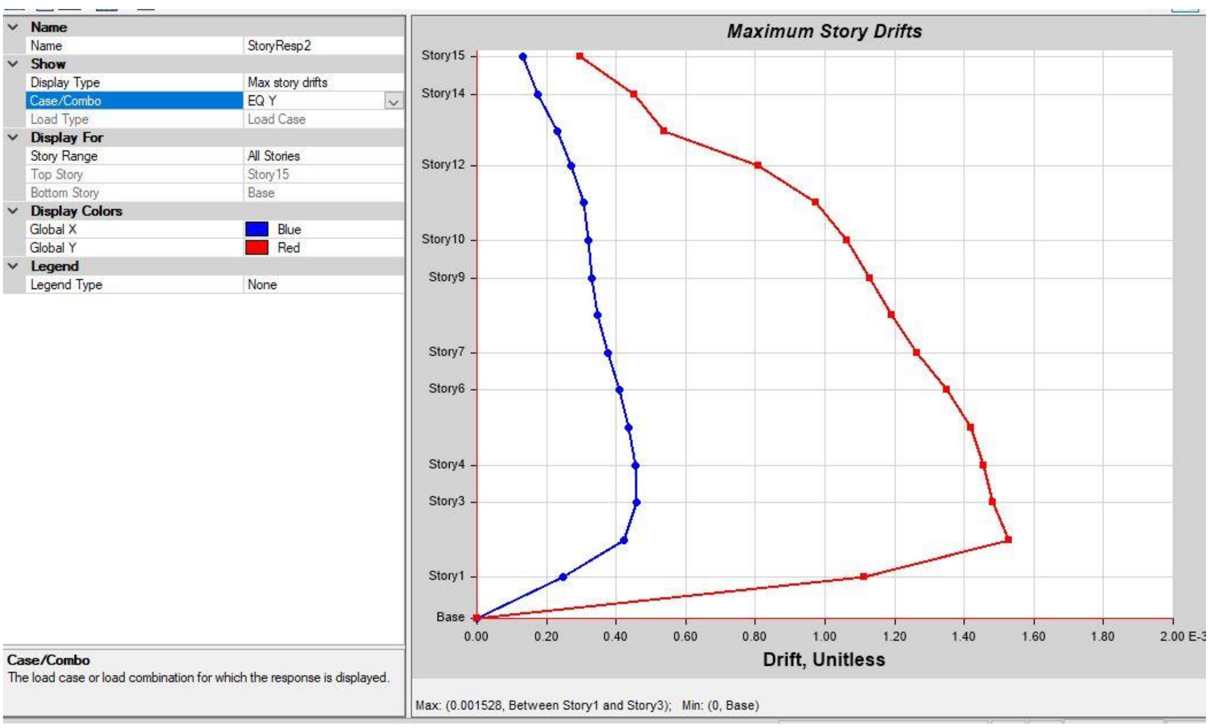

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TABLE- MAXIMUM STORY DRIFT EQY

Story	Elevation m	Location	X-Dir	Y-Dir
Story15	49.5	Top	0.000131	0.000296
Story14	46.2	Top	0.000176	0.000451
Story13	42.9	Top	0.00023	0.000537
Story12	39.9	Top	0.000271	0.000809
Story11	36.6	Top	0.000306	0.000973
Story10	33.3	Top	0.000321	0.001061
Story9	30	Top	0.000331	0.001128
Story8	26.7	Top	0.000347	0.00119
Story7	23.4	Top	0.000376	0.001265
Story6	20.1	Top	0.000409	0.00135
Story5	16.8	Top	0.000436	0.001418
Story4	13.5	Top	0.000455	0.001455
Story3	10.2	Top	0.00046	0.001481
Story2	6.9	Top	0.000421	0.001528
Story1	3.6	Top	0.000247	0.001113
Base	0	Top	0	0

1 of 16

MAXIMUM STORY DRIFT WIND1

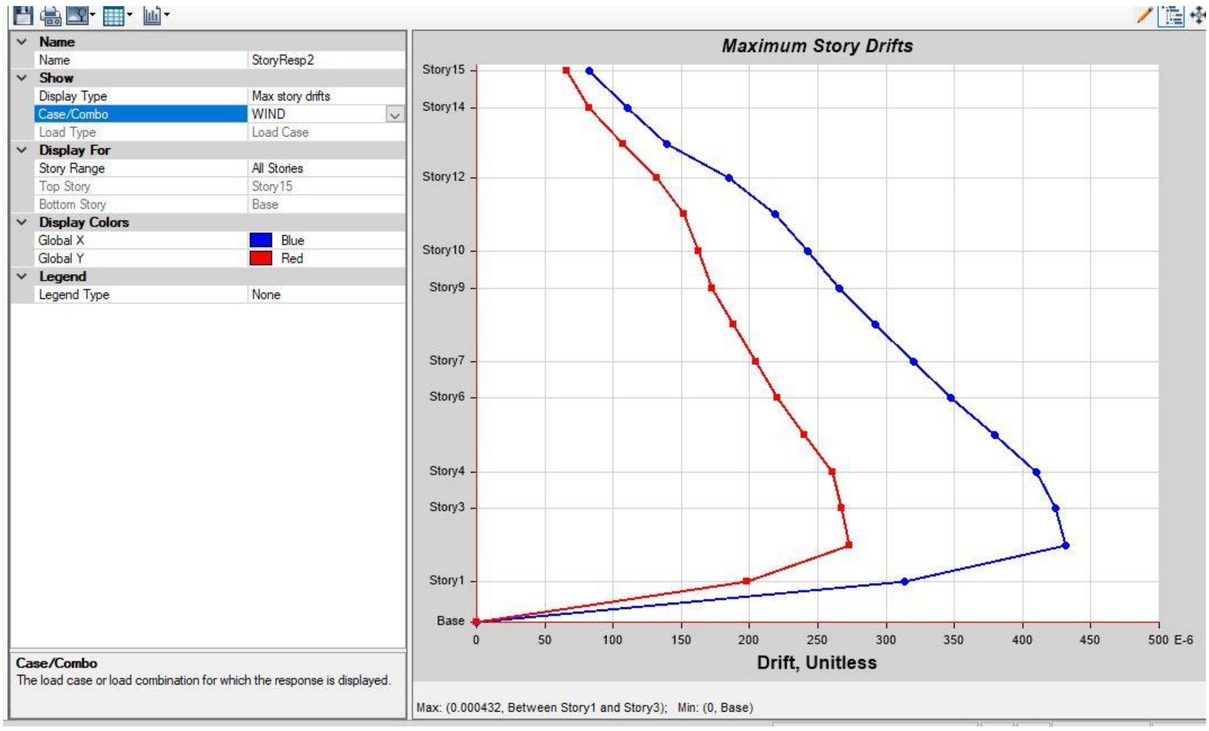

TABLE- MAXIMUM STORY DRIFT WIND1

Story	Elevation m	Location	X-Dir	Y-Dir
Story15	49.5	Top	8.2E-05	6.6E-05
Story14	46.2	Top	0.000111	8.2E-05
Story13	42.9	Top	0.000139	0.000107
Story12	39.9	Top	0.000185	0.000132
Story11	36.6	Top	0.000219	0.000152
Story10	33.3	Top	0.000242	0.000163
Story9	30	Top	0.000265	0.000172
Story8	26.7	Top	0.000292	0.000188
Story7	23.4	Top	0.00032	0.000205
Story6	20.1	Top	0.000347	0.00022
Story5	16.8	Top	0.000379	0.00024
Story4	13.5	Top	0.00041	0.000261
Story3	10.2	Top	0.000424	0.000267
Story2	6.9	Top	0.000432	0.000273
Story1	3.6	Top	0.000313	0.000198
Base	0	Top	0	0

MAXIMUM STORY DRIFT WIND2

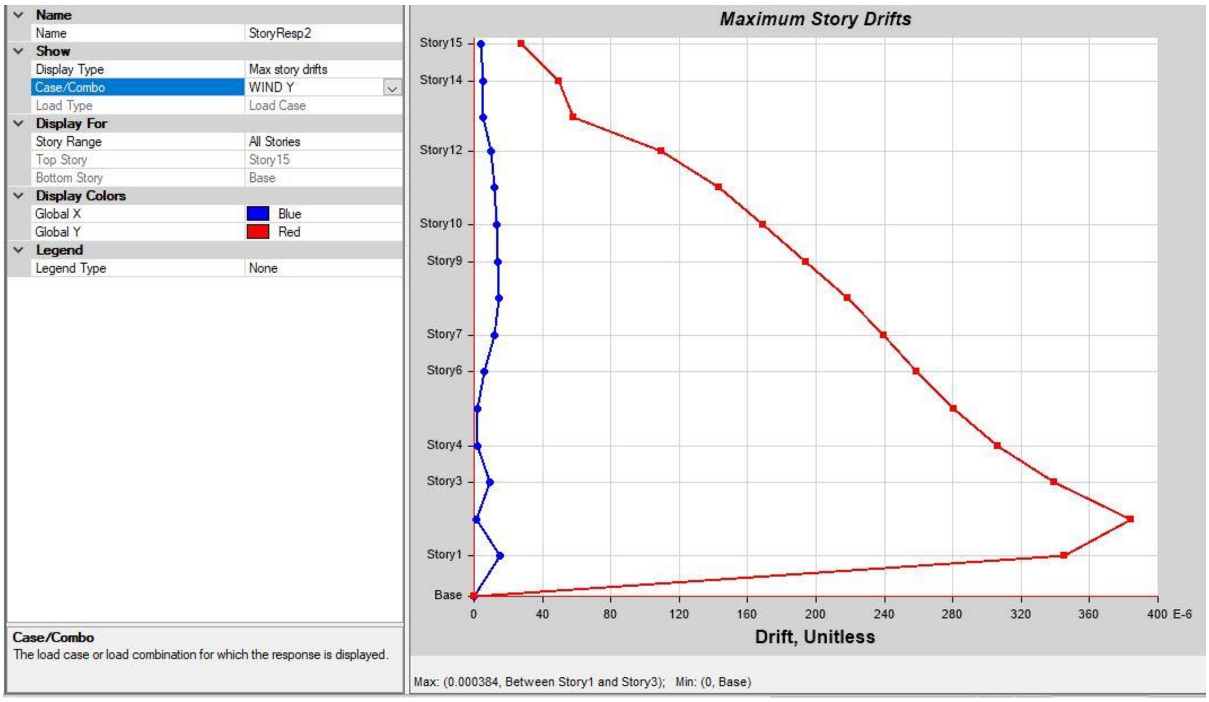

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TABLE- MAXIMUM STORY DRIFT WIND2

Story	Elevation m	Location	X-Dir	Y-Dir
Story15	49.5	Top	4E-06	2.8E-05
Story14	46.2	Top	5E-06	4.9E-05
Story13	42.9	Top	5E-06	5.8E-05
Story12	39.9	Top	1E-05	0.00011
Story11	36.6	Top	1.2E-05	0.000143
Story10	33.3	Top	1.3E-05	0.000169
Story9	30	Top	1.4E-05	0.000194
Story8	26.7	Top	1.4E-05	0.000219
Story7	23.4	Top	1.2E-05	0.000239
Story6	20.1	Top	6E-06	0.000259
Story5	16.8	Top	2E-06	0.000281
Story4	13.5	Top	2E-06	0.000306
Story3	10.2	Top	9E-06	0.000339
Story2	6.9	Top	1E-06	0.000384
Story1	3.6	Top	1.5E-05	0.000345
Base	0	Top	0	0

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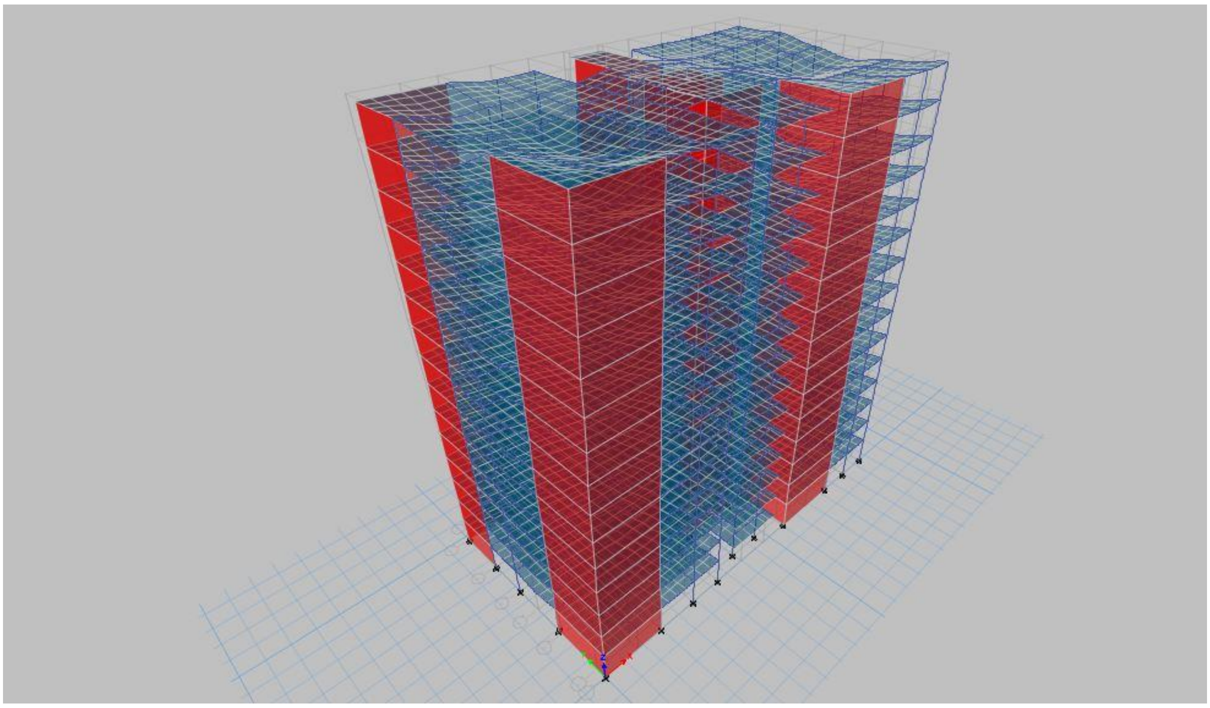
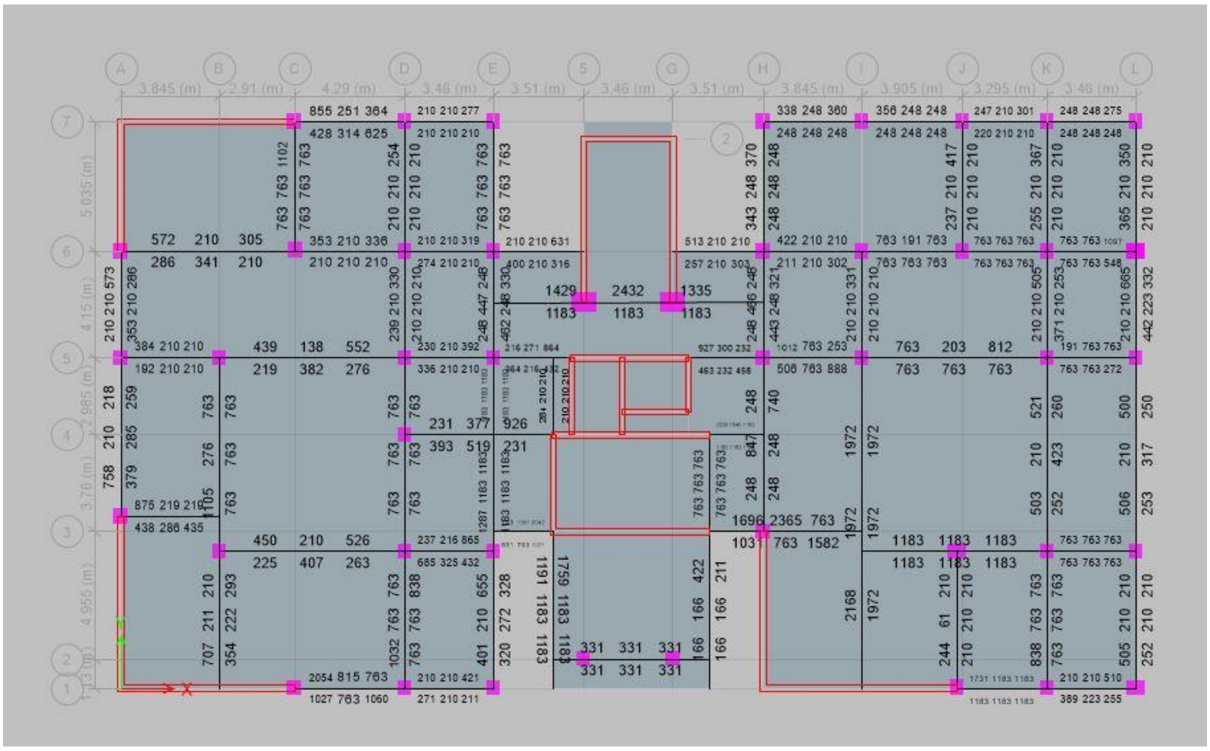
MODEL2 STRUCTURAL MODAL WITH SHEAR WALL





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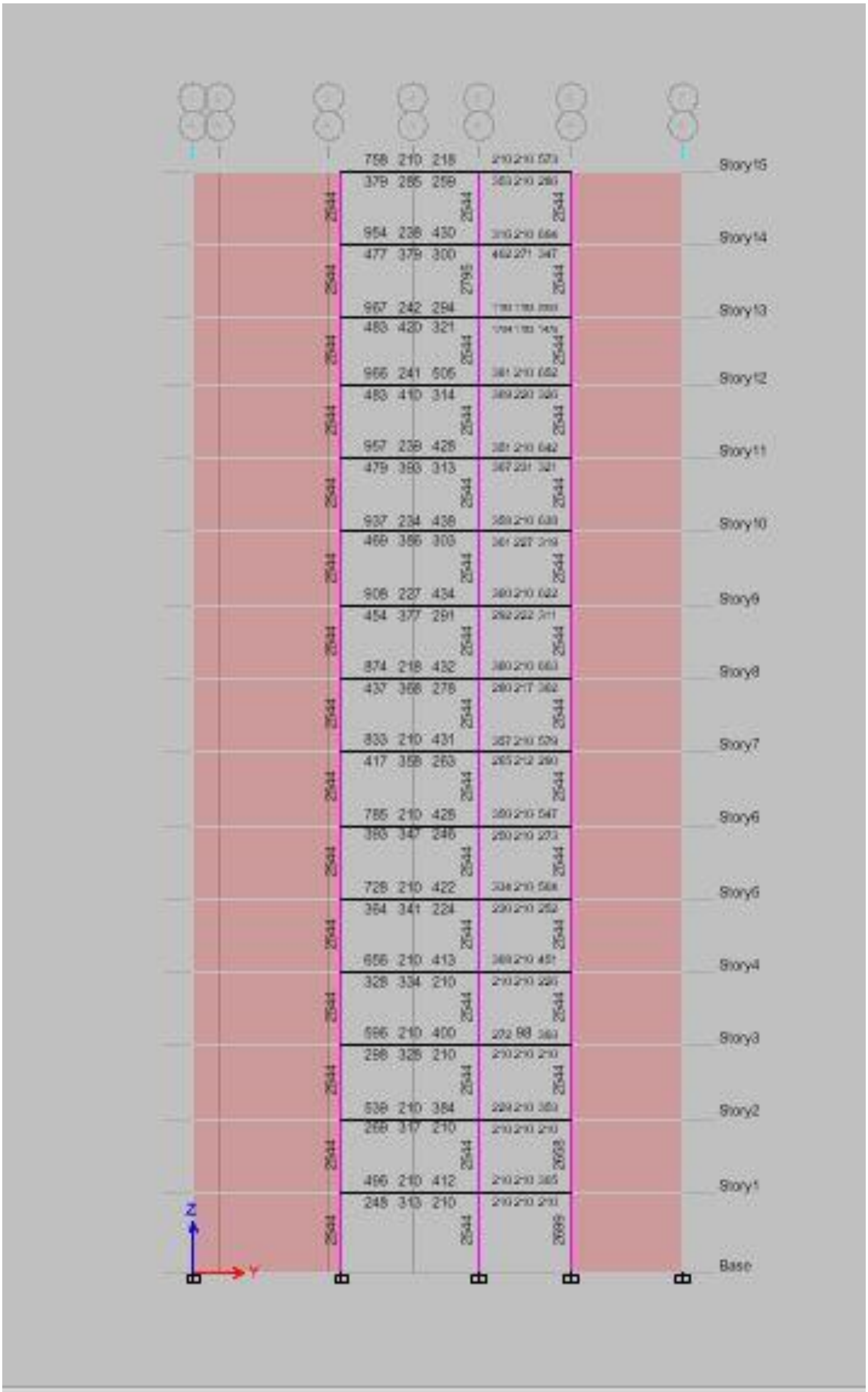

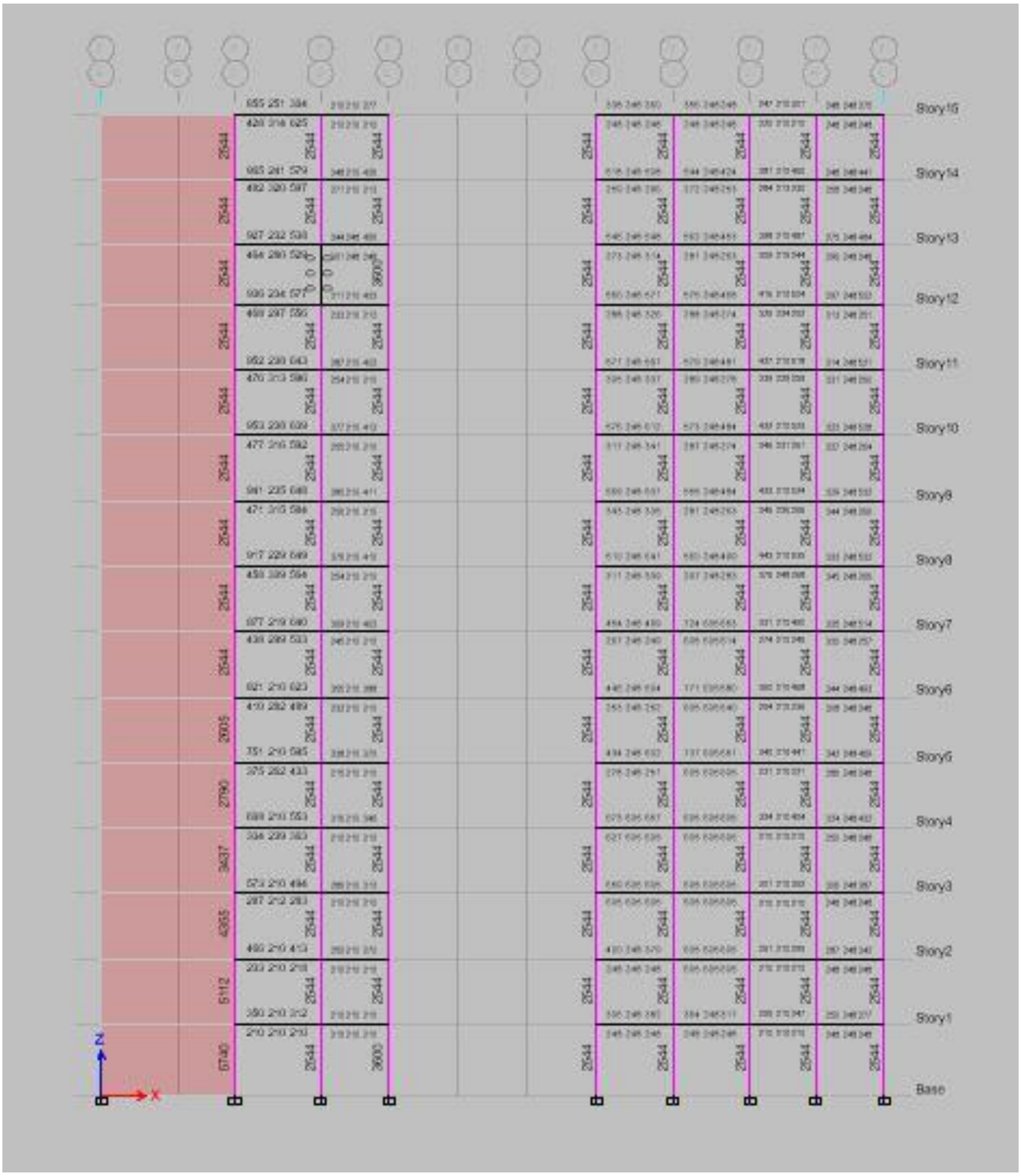
Story15
Story14
Story13
Story12
Story11
Story10
Story9
Story8
Story7
Story6
Story5
Story4
Story3
Story2
Story1
Base
Z
X

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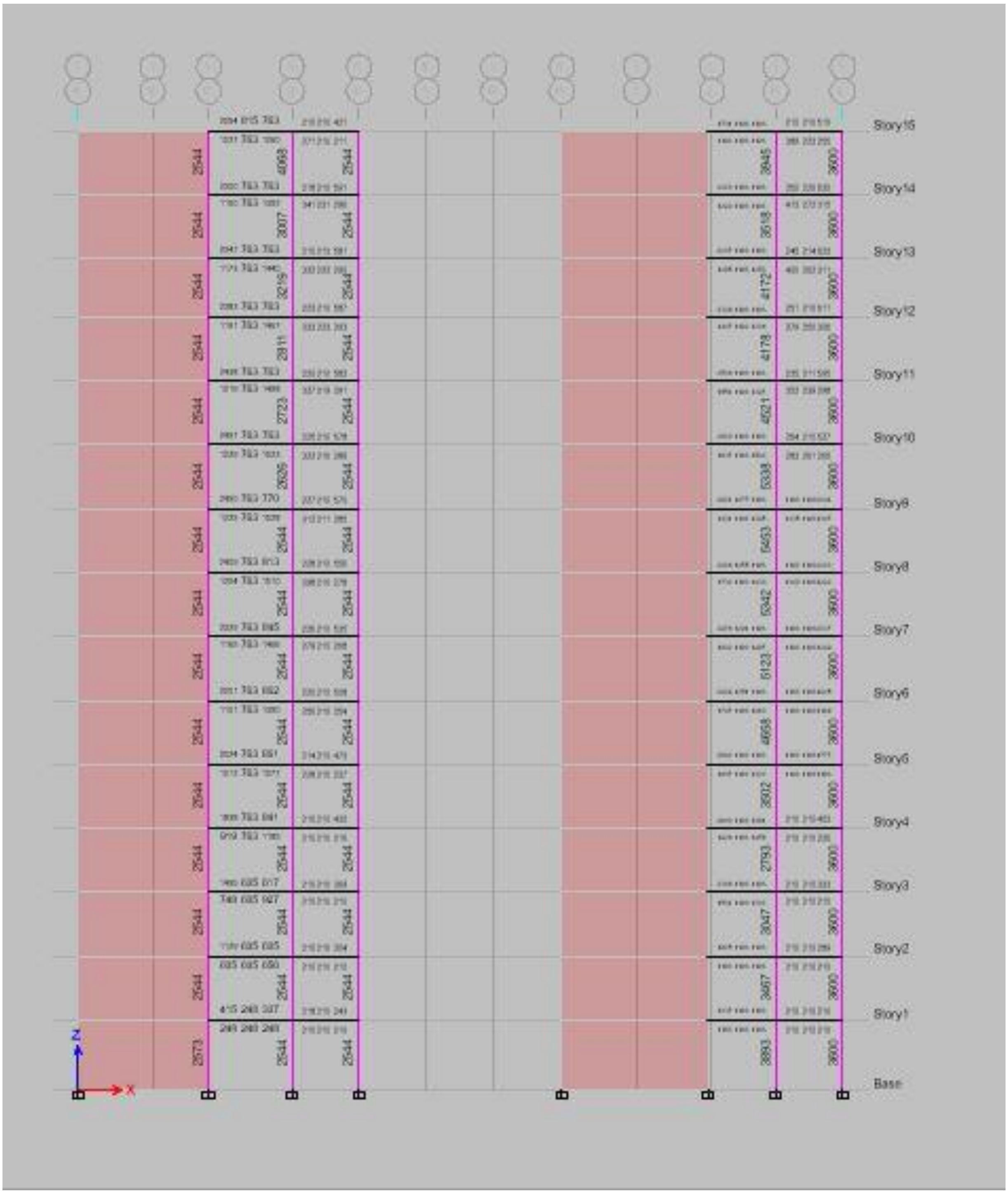

MAXIMUM STORY DISPLACEMENT EQX

TABLE- MAXIMUM STORY DISPLACEMENT EQX

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story15	49.5	Top	43.036	19.108
Story14	46.2	Top	39.947	17.514
Story13	42.9	Top	36.739	15.905
Story12	39.9	Top	33.734	14.43
Story11	36.6	Top	30.322	12.781
Story10	33.3	Top	26.845	11.131
Story9	30	Top	23.347	9.496
Story8	26.7	Top	19.861	7.899
Story7	23.4	Top	16.442	6.37
Story6	20.1	Top	13.149	4.937
Story5	16.8	Top	10.035	3.628
Story4	13.5	Top	7.159	2.479
Story3	10.2	Top	4.606	1.517
Story2	6.9	Top	2.476	0.763
Story1	3.6	Top	0.888	0.247
Base	0	Top	0	0

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MAXIMUM STORY DISPLACEMENT EQY

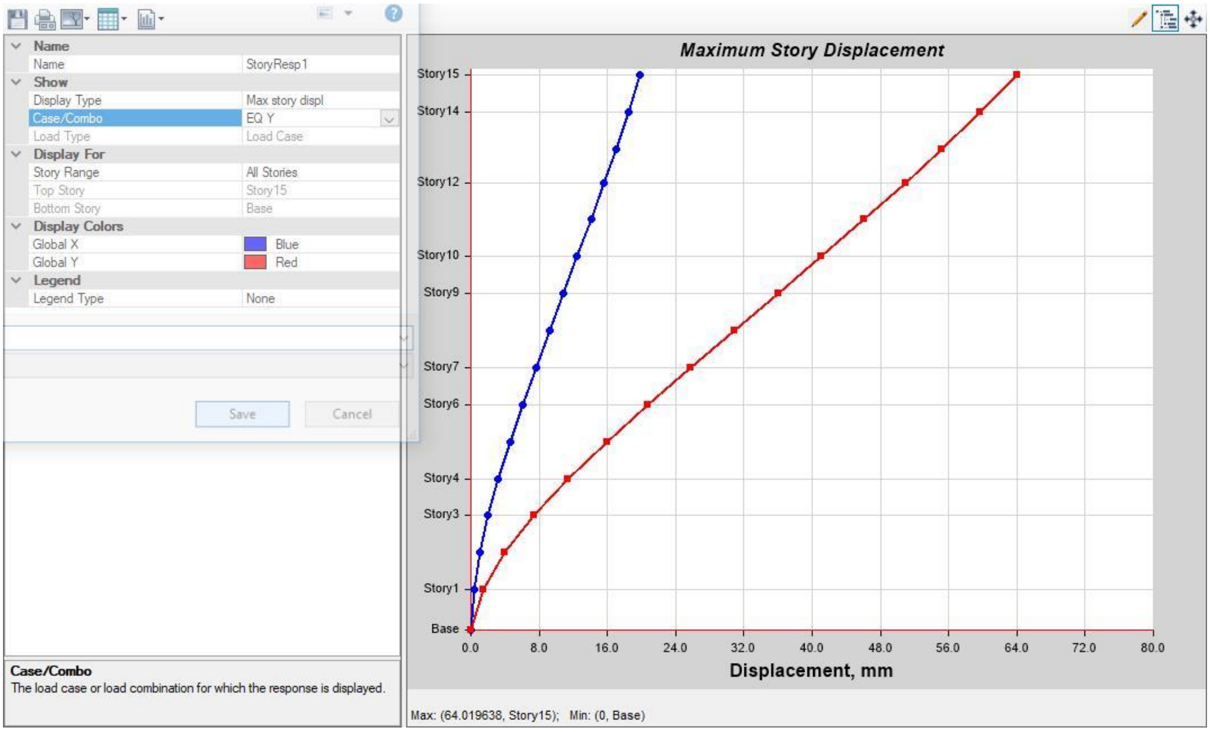

TABLE-MAXIMUM STORY DISPLACEMENT EQY

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story15	49.5	Top	19.863	64.02
Story14	46.2	Top	18.461	59.733
Story13	42.9	Top	17.004	55.233
Story12	39.9	Top	15.638	50.989
Story11	36.6	Top	14.079	46.123
Story10	33.3	Top	12.473	41.102
Story9	30	Top	10.844	35.993
Story8	26.7	Top	9.216	30.852
Story7	23.4	Top	7.608	25.742
Story6	20.1	Top	6.044	20.734
Story5	16.8	Top	4.56	15.91
Story4	13.5	Top	3.201	11.395
Story3	10.2	Top	2.013	7.346
Story2	6.9	Top	1.047	3.946
Story1	3.6	Top	0.353	1.401
Base	0	Top	0	0

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MAXIMUM STORY DISPLACEMENT WIND 1

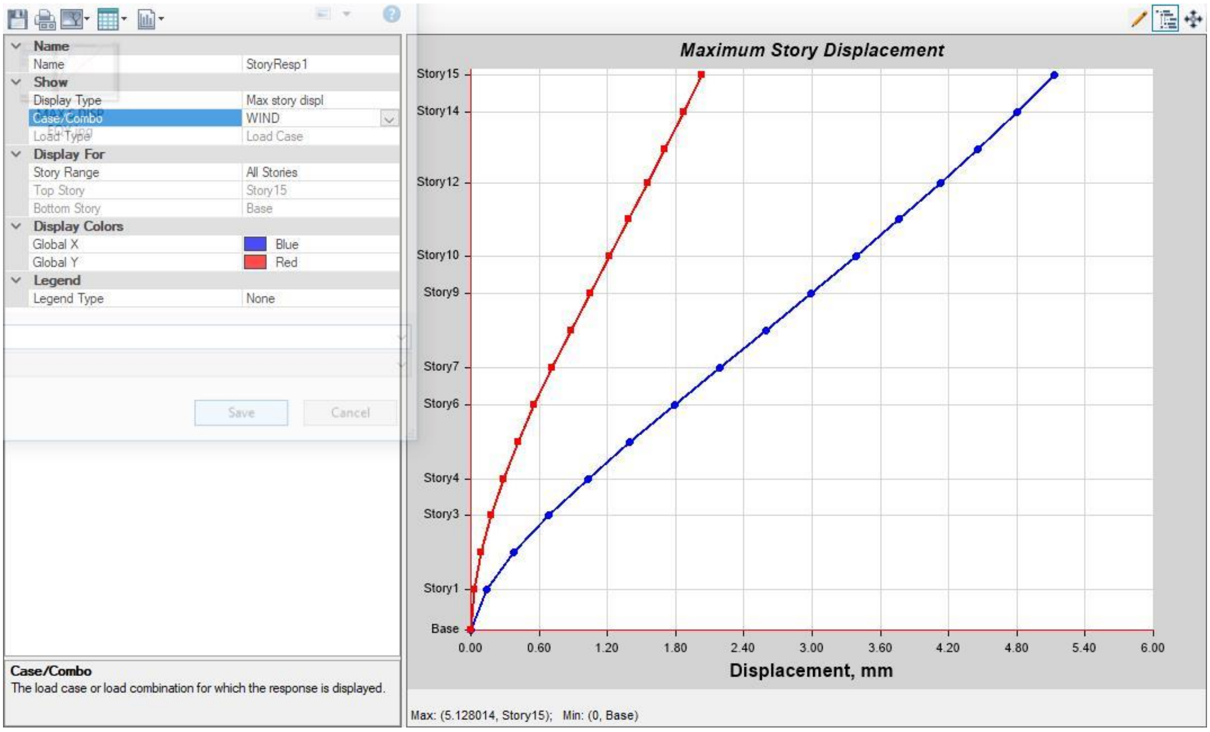

TABLE- MAXIMUM STORY DISPLACEMENT WIND 1

Story Response

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story15	49.5	Top	5.128	2.034
Story14	46.2	Top	4.797	1.871
Story13	42.9	Top	4.455	1.706
Story12	39.9	Top	4.133	1.555
Story11	36.6	Top	3.764	1.386
Story10	33.3	Top	3.383	1.215
Story9	30	Top	2.992	1.045
Story8	26.7	Top	2.593	0.877
Story7	23.4	Top	2.19	0.713
Story6	20.1	Top	1.79	0.558
Story5	16.8	Top	1.4	0.414
Story4	13.5	Top	1.025	0.286
Story3	10.2	Top	0.68	0.177
Story2	6.9	Top	0.379	0.09
Story1	3.6	Top	0.143	0.03
Base	0	Top	0	0

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MAXIMUM STORY DISPLACEMENT WIND 2

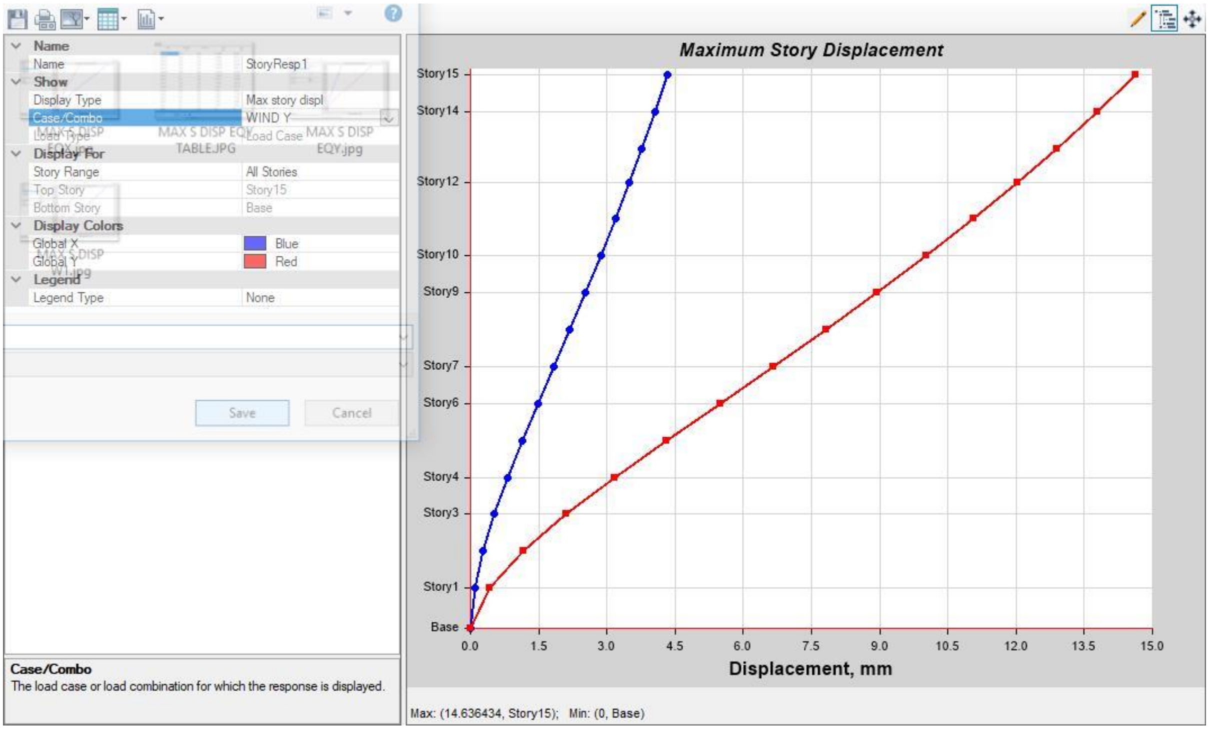

TABLE-MAXIMUM STORY DISPLACEMENT WIND 2

Story Response

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story15	49.5	Top	4.335	14.636
Story14	46.2	Top	4.059	13.784
Story13	42.9	Top	3.772	12.888
Story12	39.9	Top	3.502	12.039
Story11	36.6	Top	3.19	11.053
Story10	33.3	Top	2.864	10.016
Story9	30	Top	2.526	8.933
Story8	26.7	Top	2.18	7.81
Story7	23.4	Top	1.828	6.656
Story6	20.1	Top	1.477	5.484
Story5	16.8	Top	1.133	4.311
Story4	13.5	Top	0.809	3.169
Story3	10.2	Top	0.518	2.102
Story2	6.9	Top	0.274	1.167
Story1	3.6	Top	0.094	0.432
Base	0	Top	0	0

MAXIMUM STORY DRIFT EQX

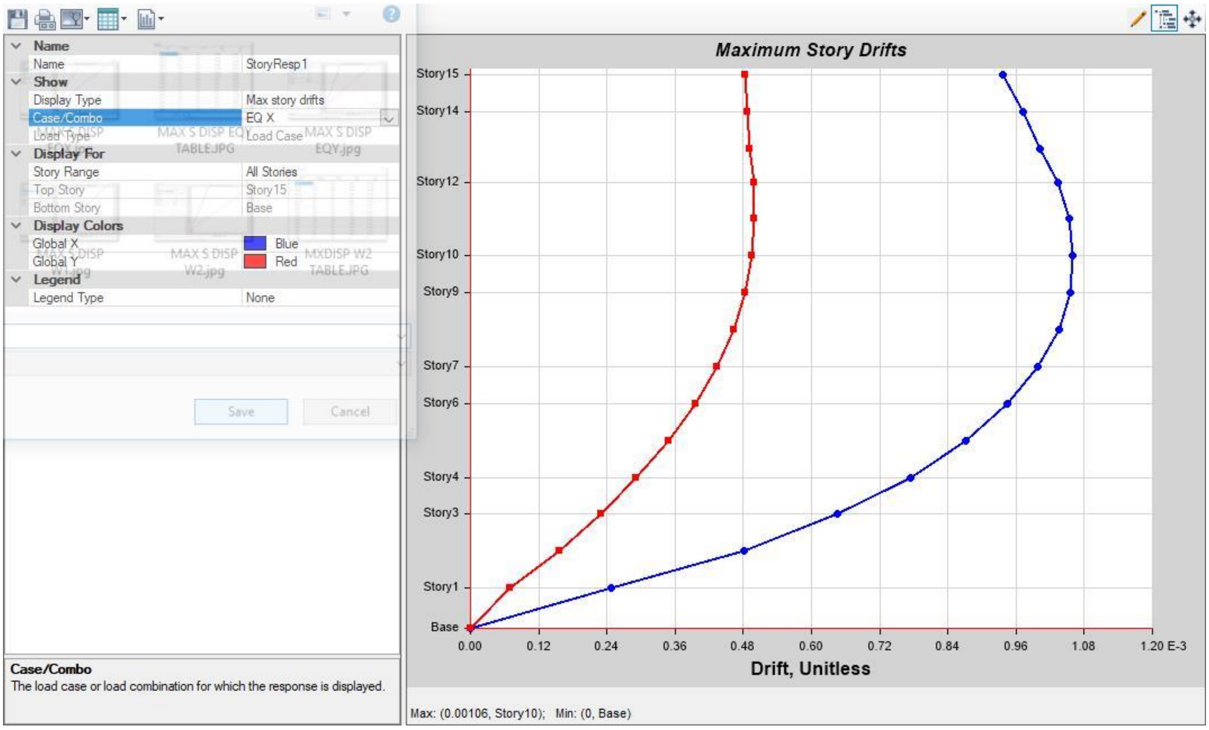

TABLE- MAXIMUM STORY DRIFT EQX

Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story15	49.5	Top	0.000936	0.000483
Story14	46.2	Top	0.000972	0.000487
Story13	42.9	Top	0.001002	0.000492
Story12	39.9	Top	0.001034	0.0005
Story11	36.6	Top	0.001053	0.0005
Story10	33.3	Top	0.00106	0.000495
Story9	30	Top	0.001056	0.000484
Story8	26.7	Top	0.001036	0.000463
Story7	23.4	Top	0.000998	0.000434
Story6	20.1	Top	0.000944	0.000397
Story5	16.8	Top	0.000871	0.000348
Story4	13.5	Top	0.000774	0.000291
Story3	10.2	Top	0.000646	0.000229
Story2	6.9	Top	0.000481	0.000156
Story1	3.6	Top	0.000247	6.8E-05
Base	0	Top	0	0

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MAXIMUM STORY DRIFT EQY

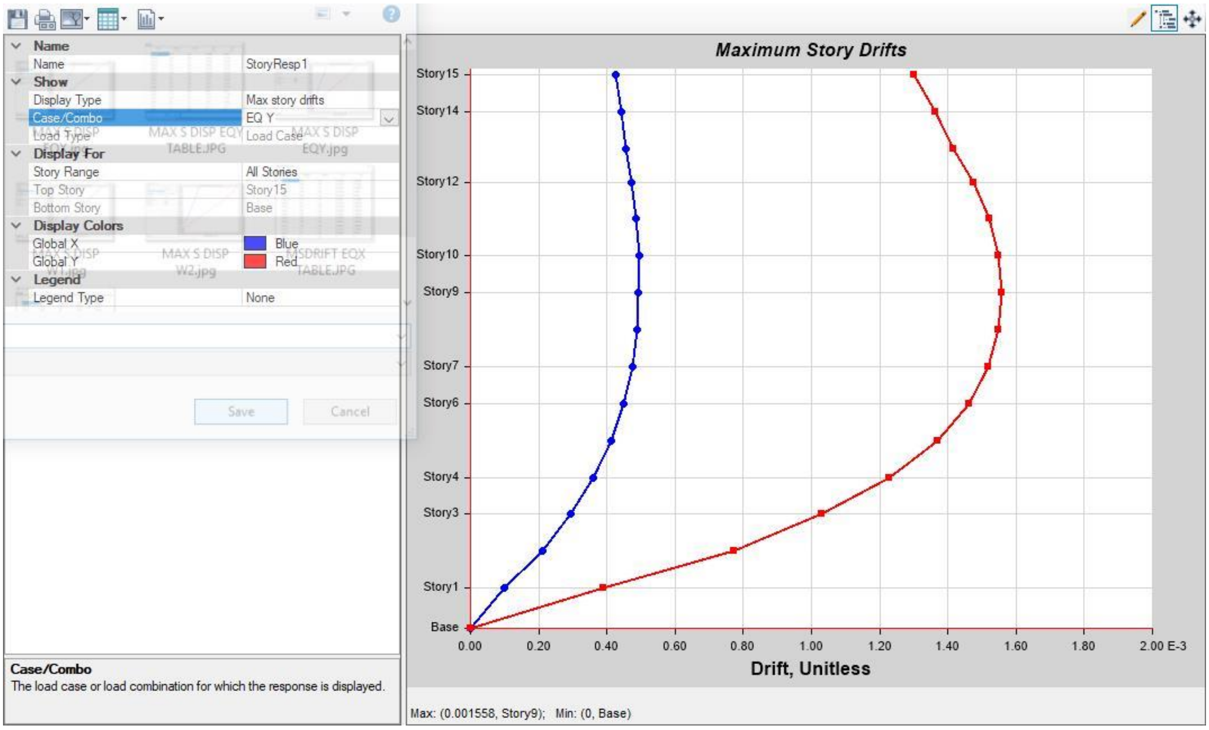

TABLE-MAXIMUM STORY DRIFT EQY

Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story15	49.5	Top	0.000425	0.001299
Story14	46.2	Top	0.000441	0.001364
Story13	42.9	Top	0.000455	0.001415
Story12	39.9	Top	0.000473	0.001475
Story11	36.6	Top	0.000487	0.001522
Story10	33.3	Top	0.000493	0.001548
Story9	30	Top	0.000493	0.001558
Story8	26.7	Top	0.000487	0.001548
Story7	23.4	Top	0.000474	0.001518
Story6	20.1	Top	0.00045	0.001462
Story5	16.8	Top	0.000412	0.001368
Story4	13.5	Top	0.00036	0.001227
Story3	10.2	Top	0.000293	0.00103
Story2	6.9	Top	0.00021	0.000771
Story1	3.6	Top	9.8E-05	0.000389
Base	0	Top	0	0

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MAXIMUM STORY DRIFT WIND1

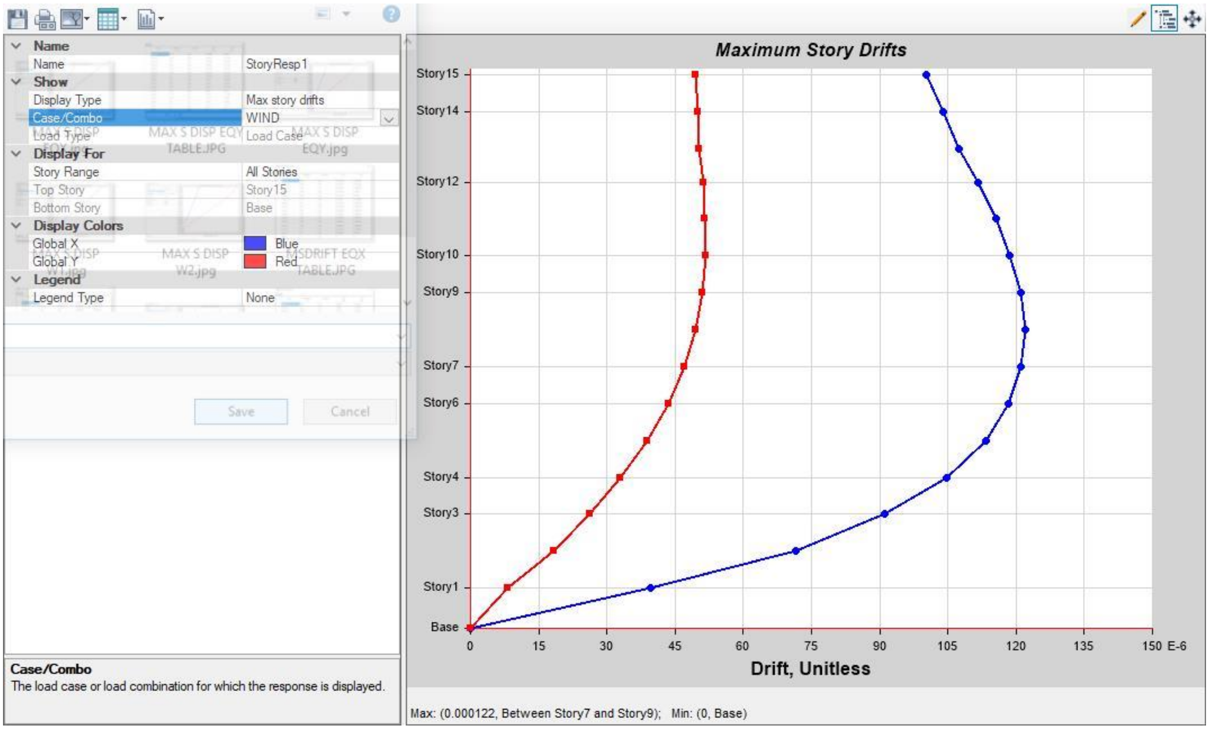

TABLE- MAXIMUM STORY DRIFT WIND1

Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story15	49.5	Top	0.0001	5E-05
Story14	46.2	Top	0.000104	5E-05
Story13	42.9	Top	0.000107	5E-05
Story12	39.9	Top	0.000112	5.1E-05
Story11	36.6	Top	0.000115	5.2E-05
Story10	33.3	Top	0.000119	5.2E-05
Story9	30	Top	0.000121	5.1E-05
Story8	26.7	Top	0.000122	4.9E-05
Story7	23.4	Top	0.000121	4.7E-05
Story6	20.1	Top	0.000118	4.4E-05
Story5	16.8	Top	0.000113	3.9E-05
Story4	13.5	Top	0.000105	3.3E-05
Story3	10.2	Top	9.1E-05	2.6E-05
Story2	6.9	Top	7.1E-05	1.8E-05
Story1	3.6	Top	4E-05	8E-06
Base	0	Top	0	0

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MAXIMUM STORY DRIFT WIND2

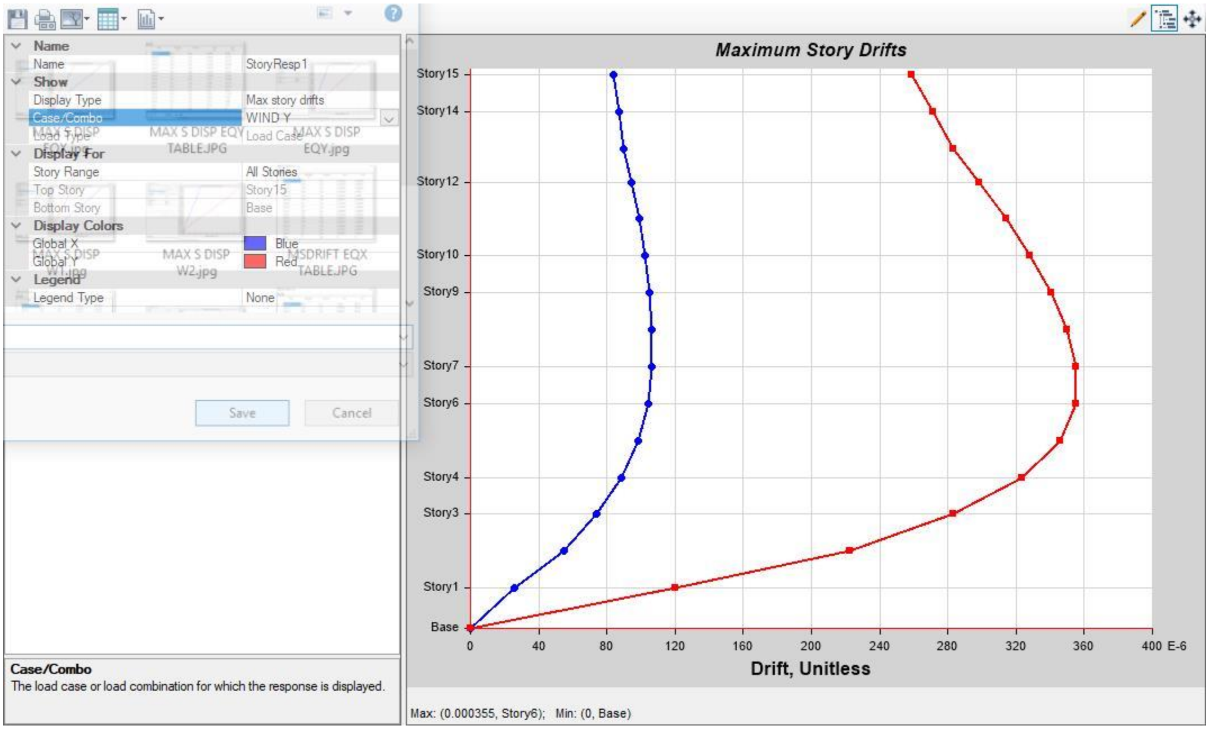
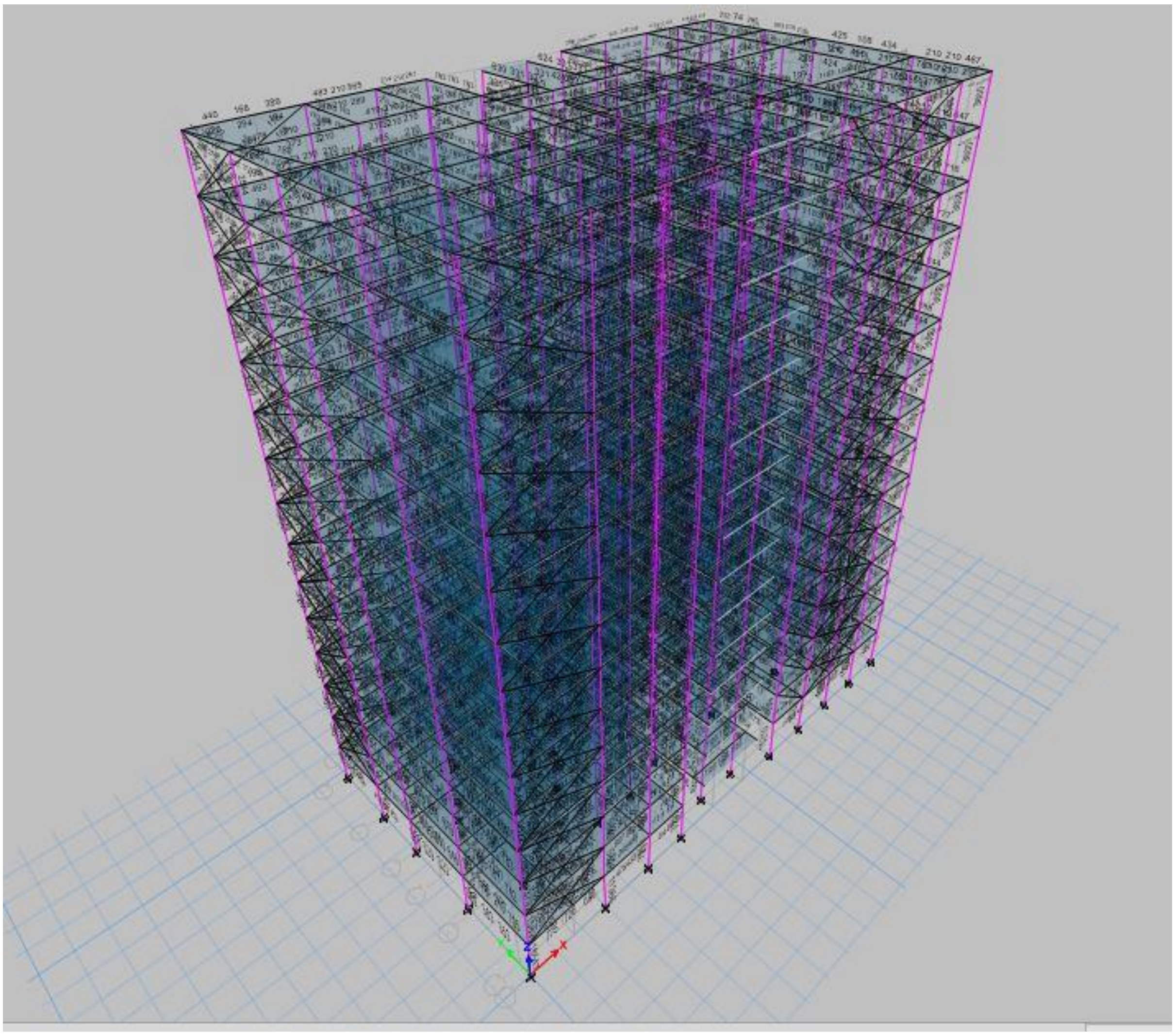


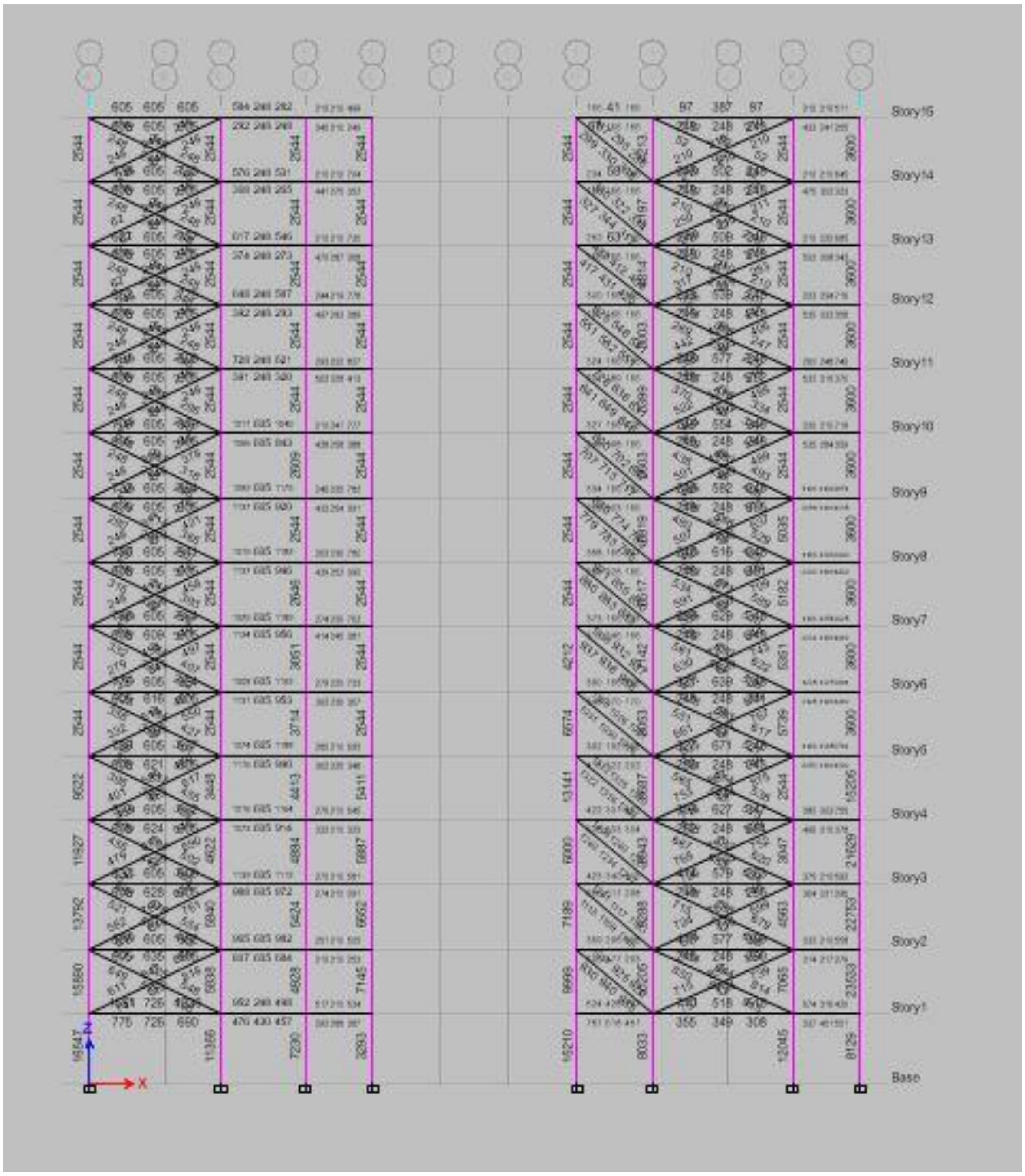
TABLE-MAXIMUM STORY DRIFT WIND2

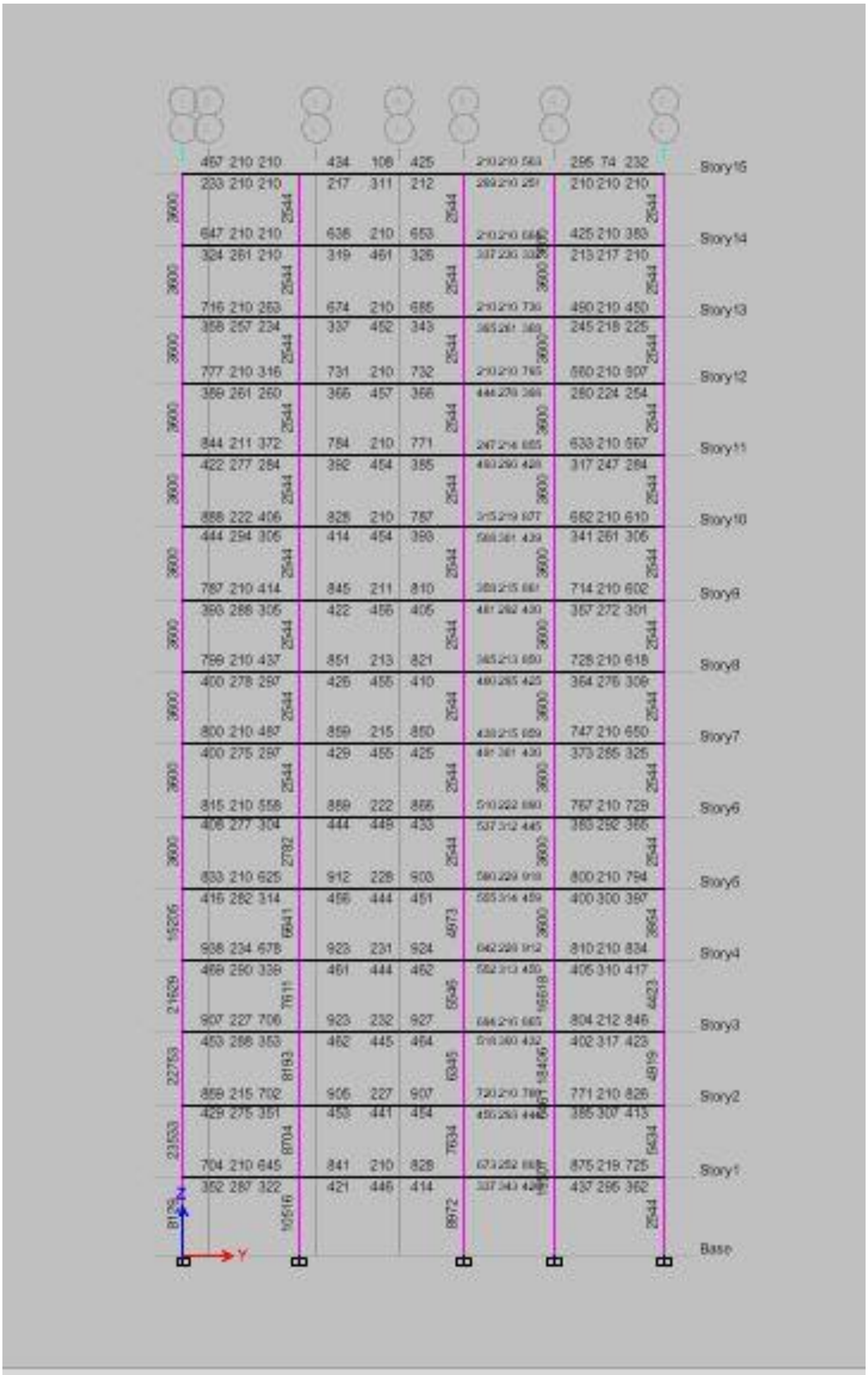
Story Response

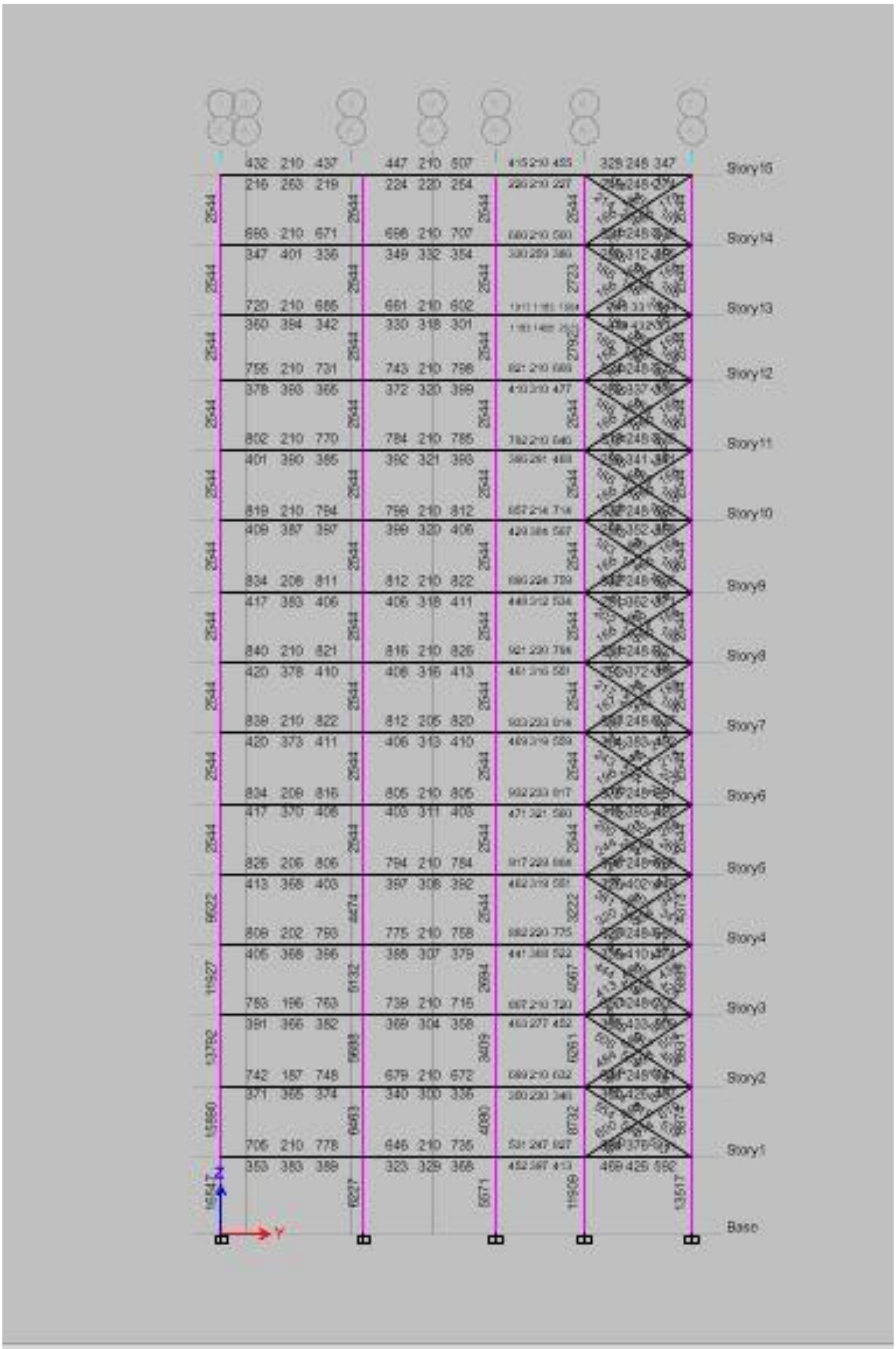
Story	Elevation m	Location	X-Dir	Y-Dir
Story15	49.5	Top	8.4E-05	0.000258
Story14	46.2	Top	8.7E-05	0.000271
Story13	42.9	Top	9E-05	0.000283
Story12	39.9	Top	9.4E-05	0.000299
Story11	36.6	Top	9.9E-05	0.000314
Story10	33.3	Top	0.000102	0.000328
Story9	30	Top	0.000105	0.00034
Story8	26.7	Top	0.000106	0.00035
Story7	23.4	Top	0.000107	0.000355
Story6	20.1	Top	0.000104	0.000355
Story5	16.8	Top	9.8E-05	0.000346
Story4	13.5	Top	8.8E-05	0.000323
Story3	10.2	Top	7.4E-05	0.000283
Story2	6.9	Top	5.5E-05	0.000223
Story1	3.6	Top	2.6E-05	0.00012
Base	0	Top	0	0

MODEL3 STRUCTURAL MODAL WITH BRACINGS




Story16
Story14
Story13
Story12
Story11
Story10
Story9
Story8
Story7
Story6
Story5
Story4
Story3
Story2
Story1
Base


Story15
Story14
Story13
Story12
Story11
Story10
Story9
Story8
Story7
Story6
Story5
Story4
Story3
Story2
Story1
Base


Story15
Story14
Story13
Story12
Story11
Story10
Story9
Story8
Story7
Story6
Story5
Story4
Story3
Story2
Story1
Base

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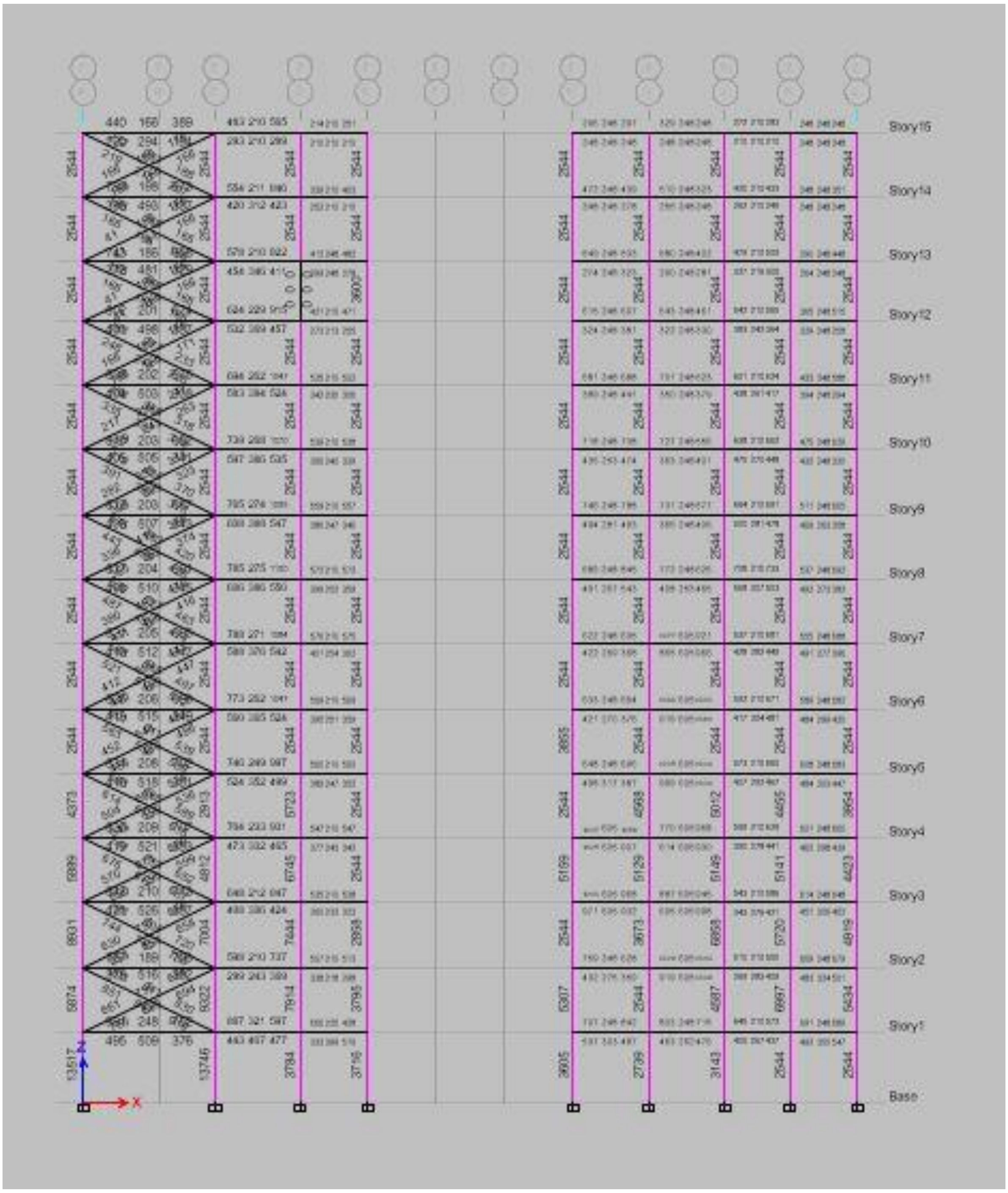

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MAXMIMUM STOREY DISPLACEMENT EQX

TABLE- MAXMIMUM STOREY DISPLACEMENT EQX

Story Response

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story15	49.5	Top	70.985	23.578
Story14	46.2	Top	68.17	23.268
Story13	42.9	Top	64.731	22.68
Story12	39.9	Top	61.127	21.843
Story11	36.6	Top	56.518	20.558
Story10	33.3	Top	51.485	19.01
Story9	30	Top	46.193	17.259
Story8	26.7	Top	40.686	15.311
Story7	23.4	Top	35.092	13.262
Story6	20.1	Top	29.524	11.145
Story5	16.8	Top	23.992	8.925
Story4	13.5	Top	18.608	6.719
Story3	10.2	Top	13.449	4.591
Story2	6.9	Top	8.528	2.463
Story1	3.6	Top	3.843	0.608
Base	0	Top	0	0

MAXMIMUM STOREY DISPLACEMENT EQY

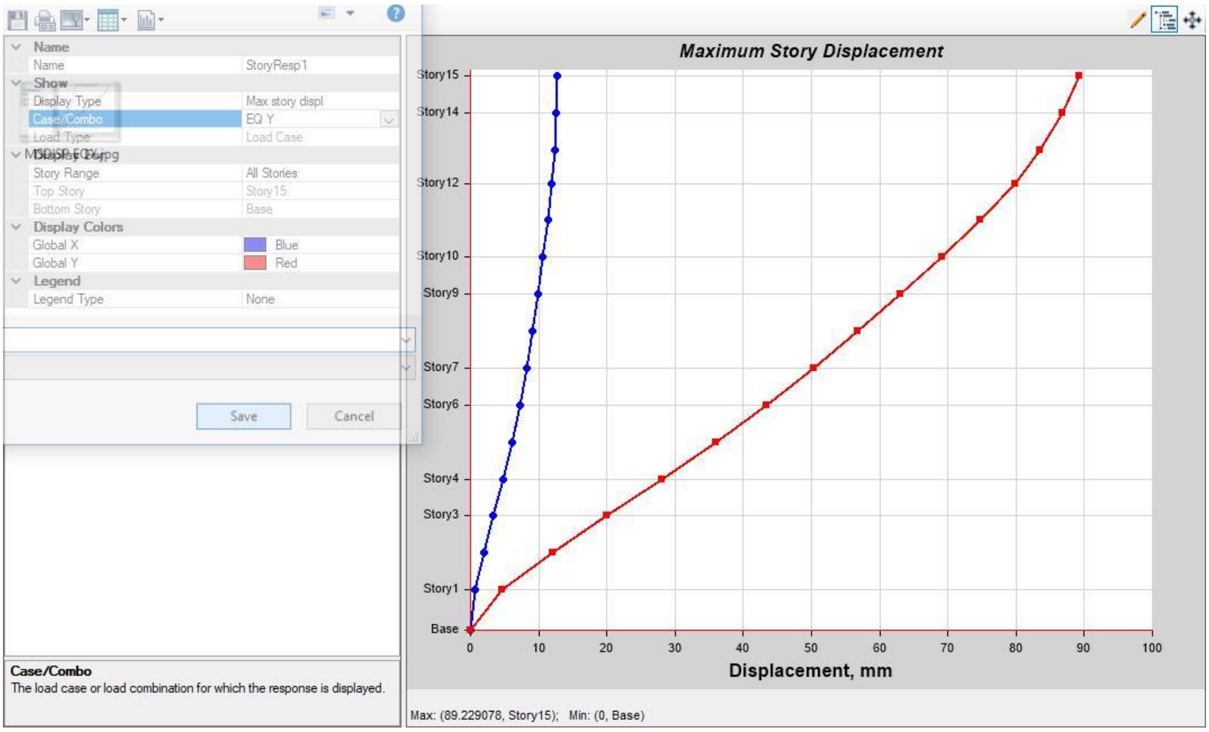

TABLE-MAXMIMUM STOREY DISPLACEMENT EQY

Story Response

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story15	49.5	Top	12.728	89.229
Story14	46.2	Top	12.614	86.836
Story13	42.9	Top	12.322	83.537
Story12	39.9	Top	11.908	79.792
Story11	36.6	Top	11.314	74.777
Story10	33.3	Top	10.591	69.089
Story9	30	Top	9.823	63.053
Story8	26.7	Top	9.037	56.785
Story7	23.4	Top	8.199	50.283
Story6	20.1	Top	7.236	43.388
Story5	16.8	Top	6.082	35.925
Story4	13.5	Top	4.771	28.023
Story3	10.2	Top	3.367	19.959
Story2	6.9	Top	1.899	11.973
Story1	3.6	Top	0.58	4.598
Base	0	Top	0	0

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MAXMIMUM STOREY DISPLACEMENT WIND1

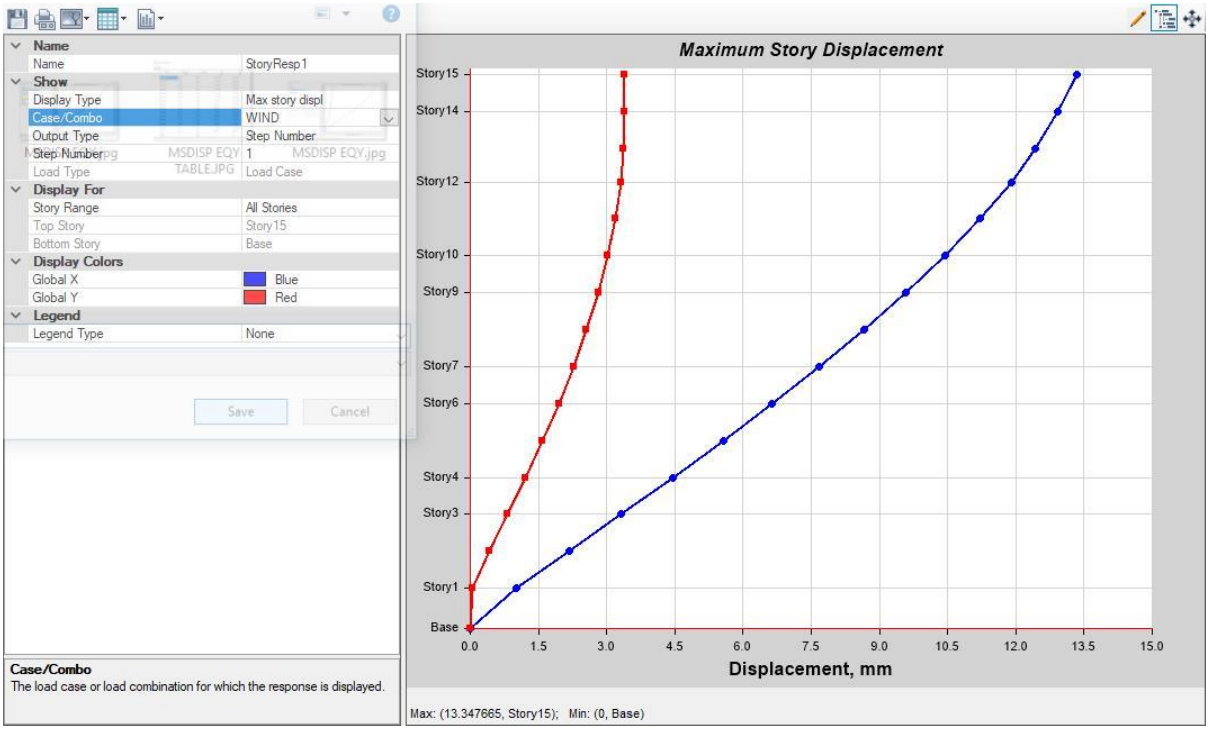

TABLE--MAXMIMUM STOREY DISPLACEMENT WIND1

Story Response

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story15	49.5	Top	13.348	3.395
Story14	46.2	Top	12.931	3.402
Story13	42.9	Top	12.428	3.378
Story12	39.9	Top	11.899	3.314
Story11	36.6	Top	11.21	3.192
Story10	33.3	Top	10.433	3.027
Story9	30	Top	9.584	2.818
Story8	26.7	Top	8.658	2.561
Story7	23.4	Top	7.672	2.271
Story6	20.1	Top	6.64	1.951
Story5	16.8	Top	5.56	1.593
Story4	13.5	Top	4.45	1.216
Story3	10.2	Top	3.324	0.828
Story2	6.9	Top	2.182	0.413
Story1	3.6	Top	1.02	0.048
Base	0	Top	0	0

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MAXMIMUM STOREY DRIFT EQX

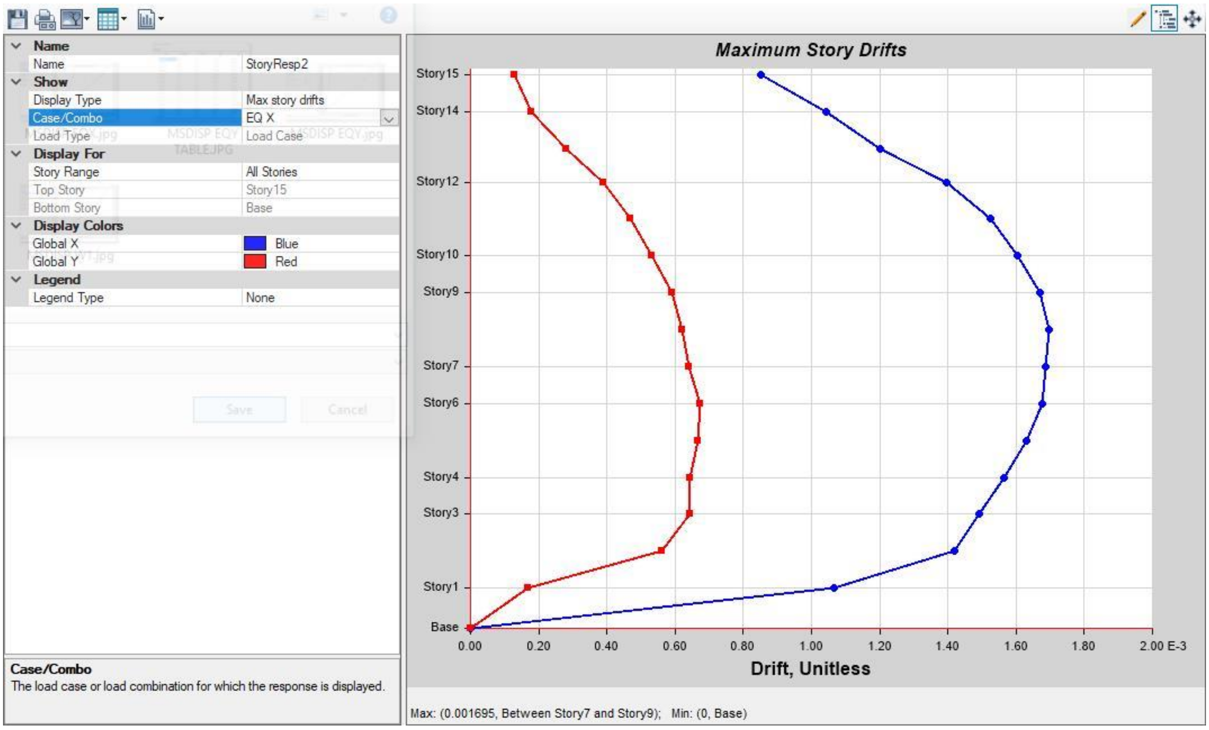

TABLE-MAXMIMUM STOREY DRIFT EQX

Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story15	49.5	Top	0.000853	0.000129
Story14	46.2	Top	0.001042	0.000178
Story13	42.9	Top	0.001201	0.000279
Story12	39.9	Top	0.001397	0.00039
Story11	36.6	Top	0.001525	0.000469
Story10	33.3	Top	0.001603	0.00053
Story9	30	Top	0.001669	0.00059
Story8	26.7	Top	0.001695	0.000621
Story7	23.4	Top	0.001687	0.000642
Story6	20.1	Top	0.001676	0.000673
Story5	16.8	Top	0.001632	0.000668
Story4	13.5	Top	0.001563	0.000645
Story3	10.2	Top	0.001491	0.000645
Story2	6.9	Top	0.00142	0.000562
Story1	3.6	Top	0.001067	0.000169
Base	0	Top	0	0

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MAXMIMUM STOREY DRIFT EQY

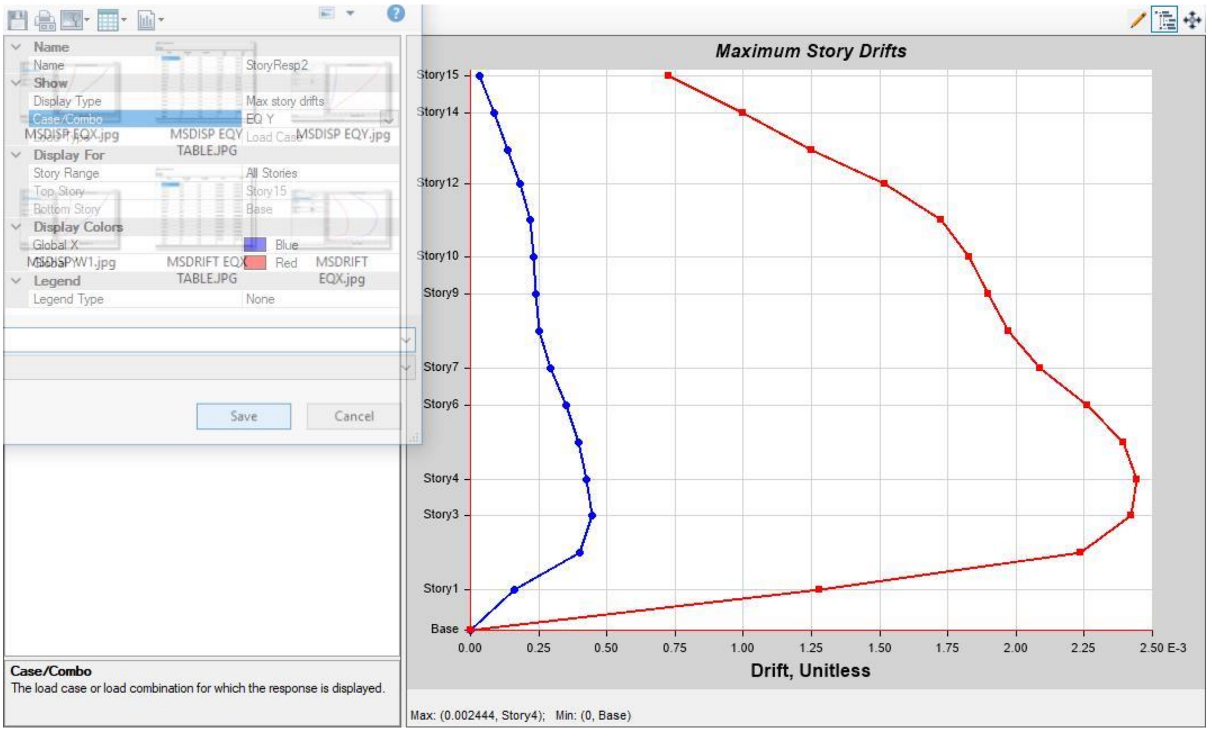

TABLE-MAXMIMUM STOREY DRIFT EQY

Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story15	49.5	Top	3.5E-05	0.000725
Story14	46.2	Top	8.9E-05	0.001
Story13	42.9	Top	0.000138	0.001248
Story12	39.9	Top	0.00018	0.00152
Story11	36.6	Top	0.000219	0.001724
Story10	33.3	Top	0.000233	0.001829
Story9	30	Top	0.000238	0.001899
Story8	26.7	Top	0.000254	0.00197
Story7	23.4	Top	0.000292	0.002089
Story6	20.1	Top	0.00035	0.002262
Story5	16.8	Top	0.000397	0.002394
Story4	13.5	Top	0.000425	0.002444
Story3	10.2	Top	0.000445	0.00242
Story2	6.9	Top	0.0004	0.002235
Story1	3.6	Top	0.000161	0.001277
Base	0	Top	0	0

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MAXMIMUM STOREY DRIFT WIND 1

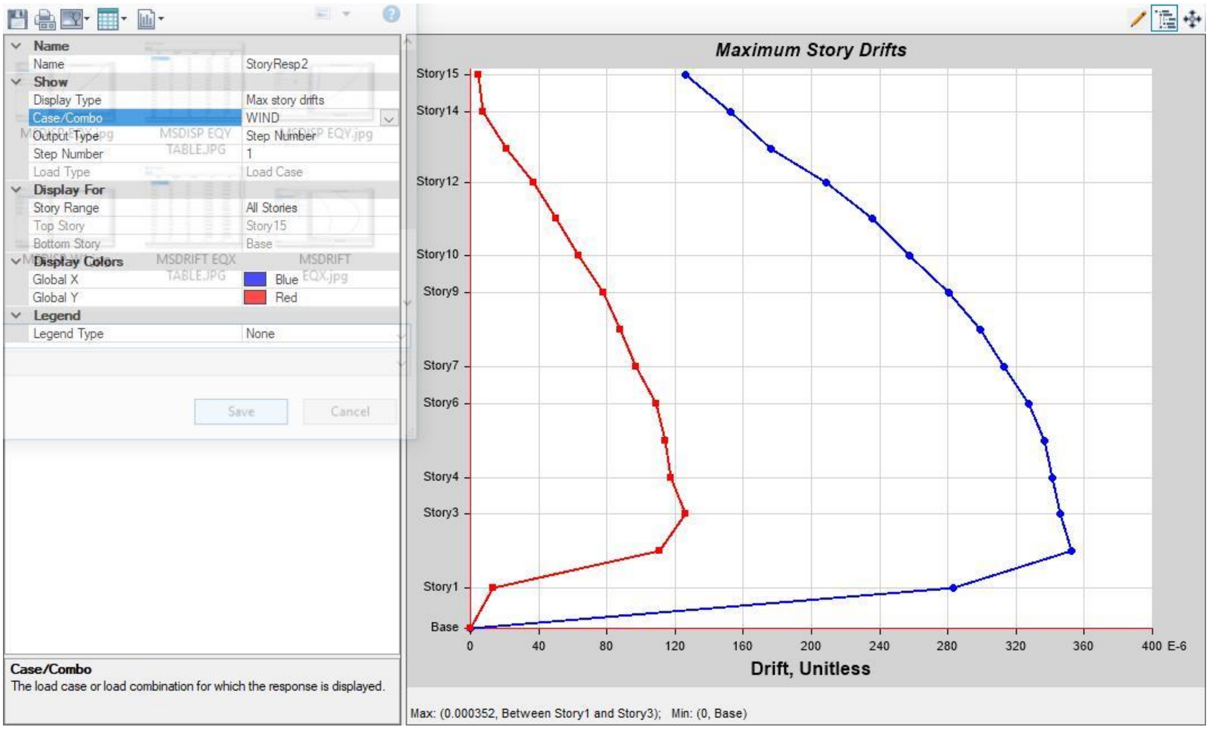

TABLE-MAXMIMUM STOREY DRIFT WIND1

Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story15	49.5	Top	0.000126	4E-06
Story14	46.2	Top	0.000152	7E-06
Story13	42.9	Top	0.000176	2.1E-05
Story12	39.9	Top	0.000209	3.7E-05
Story11	36.6	Top	0.000235	5E-05
Story10	33.3	Top	0.000258	6.3E-05
Story9	30	Top	0.00028	7.8E-05
Story8	26.7	Top	0.000299	8.8E-05
Story7	23.4	Top	0.000313	9.7E-05
Story6	20.1	Top	0.000327	0.000109
Story5	16.8	Top	0.000336	0.000114
Story4	13.5	Top	0.000341	0.000117
Story3	10.2	Top	0.000346	0.000126
Story2	6.9	Top	0.000352	0.000111
Story1	3.6	Top	0.000283	1.3E-05
Base	0	Top	0	0

CONCLUSIONS

From the above results introducing shear walls reduces the sway or displacement

Providing shearwalls at adequate locations substantially reduces the displacements due to earthquake

Base Shear Of The above Mentioned Structures Heavily Increases And makes the Structure stable against siesmic loading.

The Natural Time period of the above designed Structures are highly reduced after placing of bracings and Shear walls with comparison to Normal structure.

The lateral forces are resisting capacity is highly incresed after the placement of Shear wall.

When Comparing the above Structures Lateral displacements are minimal when Shear wall are applied.

From the above Comparison of structures and through discussion it is concluded that Shear wall could improve the lateral Stability of the structures.

FURTHER IMPROVEMENT OF WORK

Different locations of Shear wall can be placed and analysed.

Different types of bracings such as Vshape, Y shape, Inverted V shape, can also be used for further analysis.

Different Multistoried structures can be used for further analysis

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