Study of different parameter of High Rise Structure with Multiple Soft Storey under Earthquake & Wind Effect

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***Abstract*: In country like India which is in its developing phase, growth of population is on its all-time higher rates. Also rapid industrialization in country is going on, as effect of this now a days construction industry growing rapidly. The growth is because of countries developing phase. So in order to serve people and businesses multi-storied building structures are constructed and used for different purposes. In this situation open storeys becoming more beneficial feature of multi-storied buildings in India. These open stories are widely used for Parking, Offices, Hotels, Gyms, etc. Such open storey is the storey without any walls and is composed of columns only so it becomes soft i.e. weak in stiffness relative to the other storeys. So such storey is also known as soft storey. During some of the previous earthquakes, potential hazards associated with soft storeys have been observed. Structurally such imbalances are dangerous & unhealthy and the soft storeys in buildings are well known for being affected by past big earthquakes.**

Generally high rising building structures are affected more by wind than the earthquakes. As wind is a randomly varying dynamic phenomenon, and it has significant dynamic effects on buildings and structures especially on high rise flexible building structures. In the primary design of the structure, including the proportioning of the structure, varying site parameters, varying wind force on the structure and structural parameters should be known. So these soft stories in high rise buildings becomes more critical and more susceptible to collapse due to high wind. So in this paper a study is done on the multiple soft stories in high rise building under the effect of earthquake and wind for Zone III of different earthquake zones.

***Keywords*: ETABS 2016, Infill, Seismic analysis, Soft storey, Wind analysis.**

1. INTRODUCTION

Data of the Codes and standards are the mainstream of information to the designers of civil engineering structure. Earthquakes and winds are natural phenomenon under which disasters are mainly caused by damage or collapse of building structures. Objective of seismic as well as wind analysis is stated as the structure should be able to withstand minor shaking intensity without any considerable damage, thus leaving the structure serviceable after the event. The structure should withstand moderate levels of earthquake ground motion and the variety of wind forces on a structure with variation of site parameters and structural parameters without any considerable structural damage, but possibly with some non-structural damage. The structure should sustain severe earthquake ground motion and high wind loads without collapse of structural framework, but possibly with some structural as well as non-structural damage.

1.1 Soft Storey

Now a day construction of high rise multi-storied Reinforced Cement Concrete (RCC) framed building structure is becoming common in countries like India. The most common type of vertical irregularity finds in building structures that have an open ground story. Many building structures constructed in recent times have some special features that some stories within the building structure are left open for the purpose of parking, reception, offices, service purpose, etc. Such buildings are often called open storey or soft storey buildings or buildings on stilts. Such stories become soft i.e. weak relative to the other stories in the building structure, due absence of walls in the storey. Structurally those imbalances are dangerous and unhealthy and soft storey buildings are well known for being susceptible to collapse through past earthquakes.

1.2 Behaviour of Soft Storey

In building structures with soft stories the storey to storey drift in the soft storey is more. The strength demand on the column in such storey for these building structure is also large, however, in the other stories the forces in the columns are effectively reduced due to presence of brick infill walls which share the forces. If the open floor is significantly less strong or more flexible, a large portion of the total building deflections tends to concentrate on that floor. The presence of walls in other stories makes them much stiffer than the open storey. Thus the other stories move almost together as a single block and most of the horizontal displacement of the building occurs in the soft storey. Thus, such building behaves like multiple units and shows irregular direction of motion. If only one open storey at ground level is present in the building, then such building behaves like an inverted pendulum with the open story columns acting as the pendulum rod and the rest of the building acting as a rigid pendulum mass during earthquake. As a consequence, large movement occurs in the ground story alone and the columns in the open ground storey are severely stressed. If the columns are weak (do not have the required strength to resist these high stresses), they may be severely damaged which may even lead to the collapse of the building structure.

In this paper, seismic analysis and wind analysis have been studied to understand the behaviour of multi-storeyed RCC framed building structure by preparing models prepared according to IS 1893 (Part 1): 2002 using commercial software ETABS.

2. MODELLING

For the study two models are prepared on ETABS 2016. One model is of bare frame while the other is with the bracings around the soft stories and the different loads and load combinations are applied on each model.

2.1 Building details

2.1.1 Architectural details to study the behavior of RCC building under high Seismic forces as here taken

- Area covering : 21.5 x 22.5 m. (As shown in fig 01)
- Total Height of the building : 95 m
- Floor to Floor Height : 3 m
- Floor to Floor Height AT service floor : 3.4 m

2.1.2 Codes used for analysis of the structure

- R.C.C. design : IS 456: 2000
- Earthquake design : IS1893: 2016
- Code for Dead load : IS875: Part 1
- Code for Live load : IS875: Part 2
- Code for wind load : IS875: Part 2

2.1.3 The basic parameters considered for the Analysis and design

- Slab depth: 125 mm thick : Assumed
- Live load in floor area : 2 kN/sq m : As per IS 875 Part 2
- Live load in Balcony area:2 kN/sq m : As per IS 875 Part 2
- Live load in passage area: 2 kN/sq m : As per IS 875 Part 2
- Live load in urinals: 2 kN/sq m : As per IS 875 Part 2
- Floor finish load: 1.5 kN/ sq m : As per IS 875 Part 1
- Wall thickness: 230 mm thick wall : Assumed
- Stair case loading: 3 kN/sq m : As per IS 875 Part 2
- Lift shaft: 230 mm thick shear wall : Assumed

2.1.4 Structural details

Table 2.1 Columns Details

	RCC Normal	RCC WITH Brace frame
Foundation to 10th	230X750 MM	230X750 MM
10th floor to 20th	230X700MM	230X700MM
20th to30th floor	230X650MM	230X650MM

Table 2.2 Beams Details

	RCC Normal	RCC WITH Brace frame
Foundation to 10th	230X600 MM	230X600 MM
10th floor to 20th	230X530MM	230X530MM
20th to30th floor	230X450MM	230X450MM

2.2 Modelling with ETABS

3-D model is being prepared for the frame static analysis and dynamic time history analysis Of the building in ETABS version 16.0.2

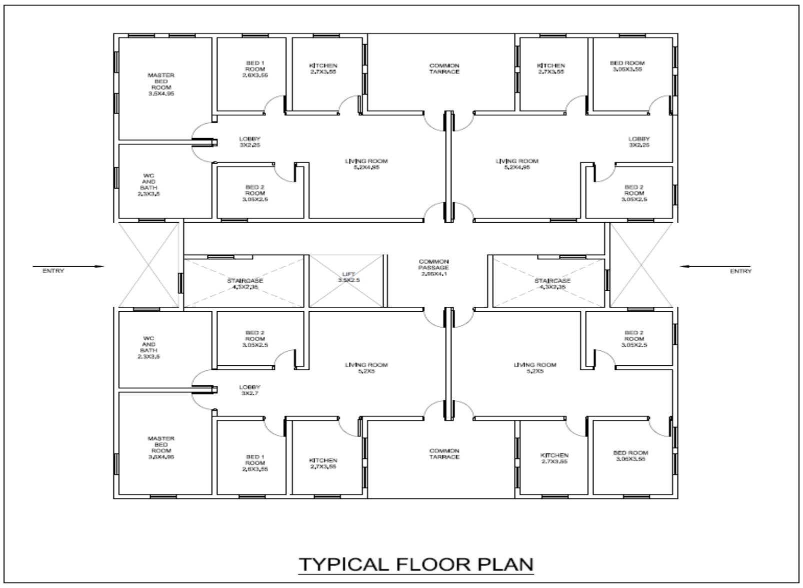


FIG 01: SHOWS THE PLAN OF THE BUILDING

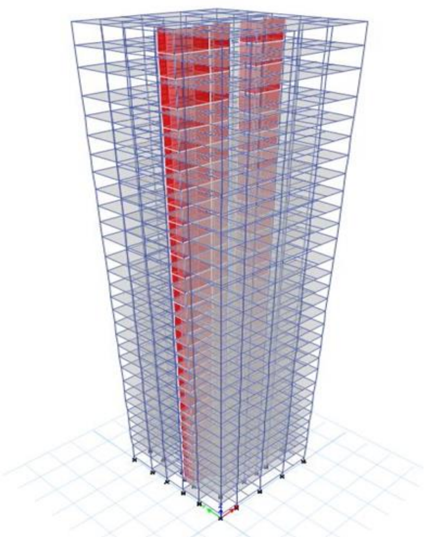


FIG 02: SHOWS THE SKELETON MODEL AND 3D VIEW OF THE STRUCTURE NORMAL FRAME

2.3 Designing with ETABS

Sr. no	Particular	Details	Remarks
1	Foundation depth	9 meter below ground level	No basement floor provided
2	Foundation type	Raft Foundation is provided	Columns are fixed at raft
3	No. of stories	G + 29	3 meter height
4	Walls	9 inch thick	For external walls
5	Lift	Central shaft	Machin room at top
6	Water Tank	At terrace level	

2.4 Earthquake parameters considered

- Zone : III
- Soil type : Hard soil
- Importance factor : 1
- Time period : Based on IS 1893

3. RESULTS

3.1. TIME PERIOD OF THE STRUCTURE UNDER STATIC AND DYNAMIC LOAD CONSIDERATION (FOR NORMAL FRAME)

3.1.1 Static Fundamental time period

DIRECTION	ZONE III
Case	**Time period in sec.**
EX	1.76
EY	1.81

3.1.2 MODAL TIME PERIOD

Modal case	No. of Mode	ZONE III
		Time period in sec.
Modal	**1**	**5.396**
Modal	**2**	**4.662**
Modal	**3**	**3.290**

3.2 TIME PERIOD OF THE STRUCTURE UNDER STATIC AND DYNAMIC LOAD CONSIDERATION (FOR BRACED FRAME)

3.2.1 Static Fundamental time period

DIRECTION	ZONE III
Case	**Time period in sec.**
EX	1.76
EY	1.81

3.2.2 Modal Time Period

MODAL Case	No. of Mode	ZONE III
		Time Period in sec
Modal	1	4.19
Modal	2	3.81
Modal	3	2.68

3.3 BASE SHEAR DETAILS:-

BASE SHEAR IN KN	ZONE III
	RCC NORMAL FRAME
BASE SHEAR FOR STATIC EX	5066.00
BASE SHEAR FOR STATIC EY	4926.23
BASE SHEAR FOR DYNAMIC X	5066.00
BASE SHEAR FOR DYNAMIC Y	4926.23

3.4 DISPLACEMENT DETAILS:-

DIRECTIONS	ZONE III
	RCC NORMAL FRAM
Max storey Drift for EQX	0.0040
Max storey Drift for EQY	0.0038
Max storey Drift for DYNAMIC X	0.0020
Max storey Drift for DYNAMIC Y	0.0026
Max storey Drift for WIND X	0.0011
Max storey Drift for WIND Y	0.0011

3.5 TABLES FOR STOREY STIFFNESS
3.5.1 STOREY STIFFNESS IN EX DIRECTION

Storey	Load Case	FOR NORMAL FRAME	
		Stiffness X kN/m	Stiffness Y kN/m
TARRACE	EX	72827.527	0
29	EX	142509.865	0
28	EX	154514.744	0
27	EX	231500.797	0
26	EX	278761.684	0
25	EX	319883.735	0
24	EX	355991.645	0
23	EX	388127.277	0
22	EX	417256.323	0
21	EX	445599.660	0
20	EX	472056.121	0
19	EX	372861.925	0
18	EX	510180.587	0
17	EX	533959.688	0
16	EX	556559.875	0
15	EX	578964.398	0
14	EX	601866.912	0
13	EX	626153.672	0
12	EX	652684.327	0
11	EX	684581.468	0
10	EX	719374.310	0
9	EX	571610.297	0
8	EX	817330.417	0

7	EX	880891.930	0
6	EX	958857.367	0
5	EX	1060905.371	0
4	EX	1203215.123	0
3	EX	1420238.254	0
2	EX	1797351.431	0
1ST	EX	2074783.444	0
PLINTH	EX	28058505.250	0

3.5.2 STOREY STIFFNESS IN EY DIRECTION

Story	Load Case	FOR NORMAL FRAME	
		Stiffness X kN/m	Stiffness Y kN/m
TARRACE	EY	0	56811.570
29	EY	0	110535.001
28	EY	0	119146.001
27	EY	0	176855.701
26	EY	0	211541.802
25	EY	0	241330.101
24	EY	0	267204.501
23	EY	0	290251.601
22	EY	0	311367.402
21	EY	0	332884.101
20	EY	0	353439.302
19	EY	0	279062.701
18	EY	0	381542.301
17	EY	0	398956.001
16	EY	0	415538.202
15	EY	0	431730.702
14	EY	0	448248.801
13	EY	0	465887.901
12	EY	0	485402.902
11	EY	0	510175.1
10	EY	0	537298.002
9	EY	0	425420.101
8	EY	0	606848.302
7	EY	0	651057.801
6	EY	0	705176.701
5	EY	0	775529.802
4	EY	0	874702.302
3	EY	0	1029288.001
2	EY	0	1311421.001
1ST	EY	0	1665903.002
PLINTH	EY	0	18692831.002

3.5.3 STOREY STIFFNESS IN DEX DIRECTION

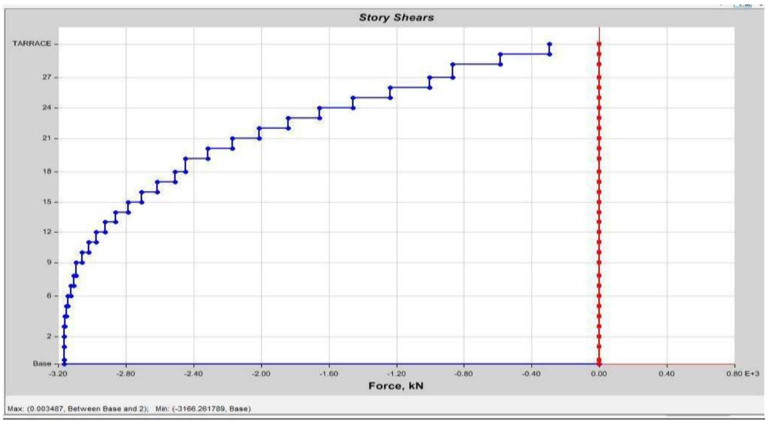
Story	Load Case	FOR NORMAL FRAME	
		Stiffness X kN/m	Stiffness Y kN/m
TARRACE	DEX	153529.130	0
29	DEX	279026.475	0
28	DEX	277290.965	0
27	DEX	389351.865	0
26	DEX	415358.673	0
25	DEX	426039.564	0
24	DEX	429183.636	0
23	DEX	430279.856	0
22	DEX	433232.261	0
21	DEX	442702.641	0
20	DEX	454689.656	0
19	DEX	347709.762	0
18	DEX	472694.817	0
17	DEX	484078.531	0
16	DEX	494553.731	0
15	DEX	505099.606	0
14	DEX	517102.994	0
13	DEX	532519.640	0
12	DEX	553524.101	0
11	DEX	586594.131	0
10	DEX	628317.790	0
9	DEX	503893.784	0
8	DEX	729845.636	0
7	DEX	809737.564	0
6	DEX	902769.874	0
5	DEX	1012370.154	0
4	DEX	1147581.079	0
3	DEX	1332281.698	0
2	DEX	1633068.886	0
1ST	DEX	1823757.363	0
PLINTH	DEX	26110783.140	0

3.5.4 STOREY STIFFNESS IN DEY DIRECTION

Story	Load Case	FOR NORMAL FRAME	
		Stiffness X kN/m	Stiffness Y kN/m
TARRACE	DEY	0	118597.201
29	DEY	0	212266.401
28	DEY	0	208581.401
27	DEY	0	290925.701
26	DEY	0	307737.605
25	DEY	0	315439.001
24	DEY	0	320931.501
23	DEY	0	329203.001
22	DEY	0	342114.901
21	DEY	0	361015.501
20	DEY	0	381469.901
19	DEY	0	299510.001
18	DEY	0	407593.901
17	DEY	0	419503.301
16	DEY	0	432265.801
15	DEY	0	447375.401
14	DEY	0	465470.601
13	DEY	0	486136.302
12	DEY	0	508445.901
11	DEY	0	535246.902
10	DEY	0	563000.601
9	DEY	0	442662.802
8	DEY	0	626930.801
7	DEY	0	675105.701
6	DEY	0	740497.002
5	DEY	0	828167.101
4	DEY	0	947156.001
3	DEY	0	1119442.001
2	DEY	0	1412714.002
1ST	DEY	0	1725802.001
PLINTH	DEY	0	19511497

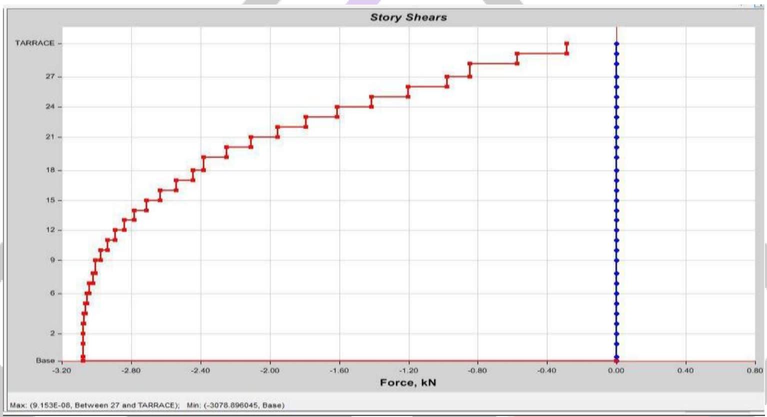
3.6 GRAPHS FOR NORMAL FRAME

3.6.1 STATIC BASE SHEAR IN X DIRECTION



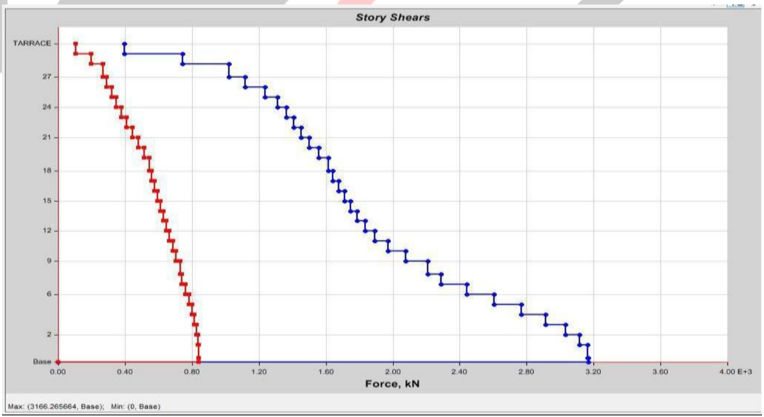
GRAPH: 01

3.6.2 STATIC BASE SHARE IN Y DIRECTION



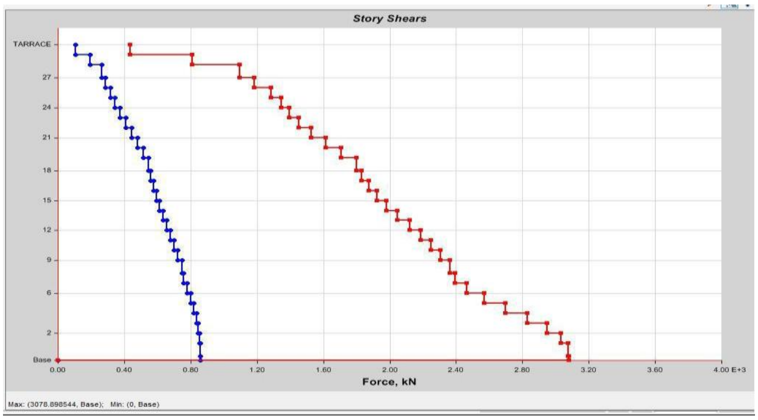
GRAPH: 02

3.6.3 DYNAMIC BASE SHEAR IN X DIRECTION



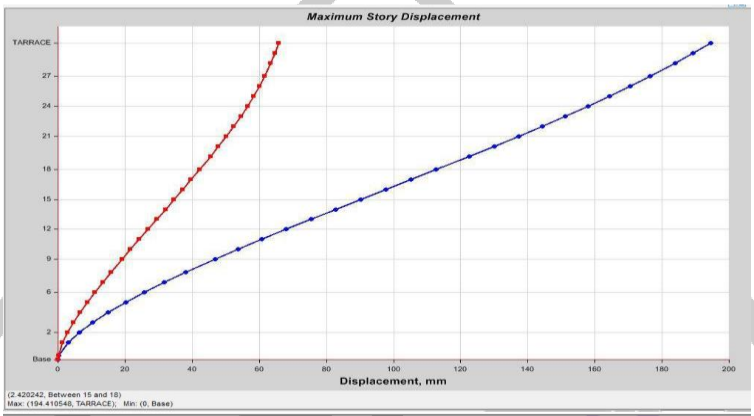
GRAPH: 02

3.6.4 DYNAMIC BASE SHEAR IN Y DIRECTION



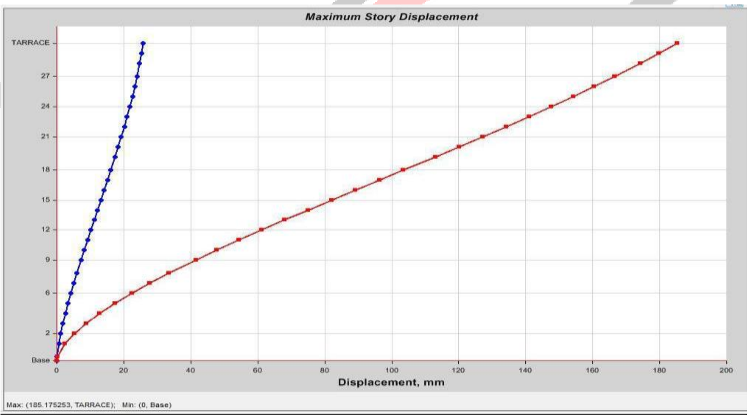
GRAPH: 04

3.6.5 DISPLACEMENT FOR STATIC EARTHQUAKE IN X DIRECTION



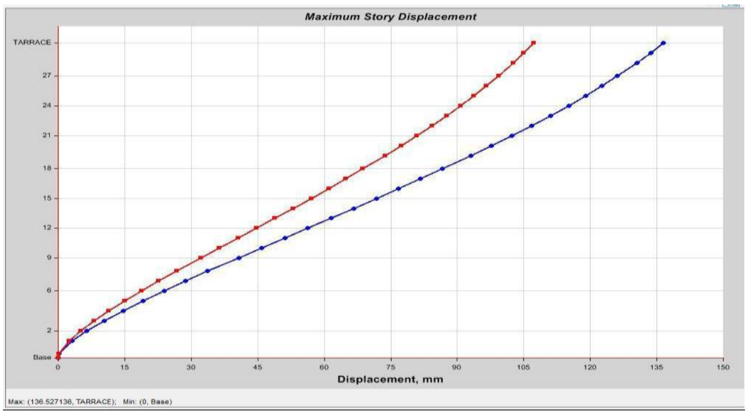
GRAPH: 05

3.6.6 DISPLACEMENT FOR STATIC EARTHQUAKE IN Y DIRECTION



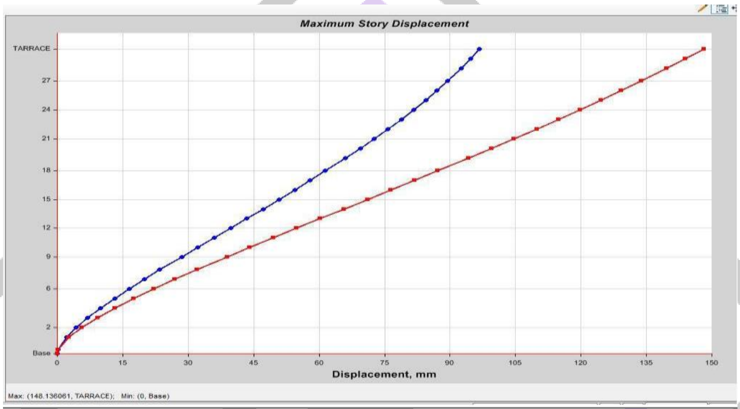
GRAPH: 06

3.6.7 DISPLACEMENT FOR DYNAMIC EARTHQUAKE IN X DIRECTION



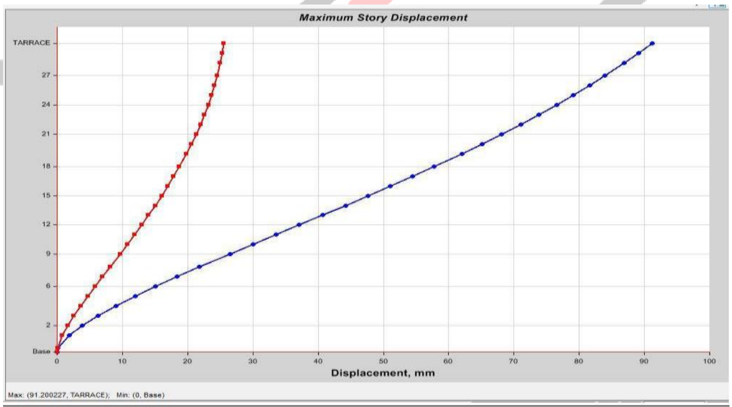
GRAPH: 07

3.6.8 <u>DISPLACEMENT FOR DYNAMIC EARTHQUAKE IN Y DIRECTION</u>



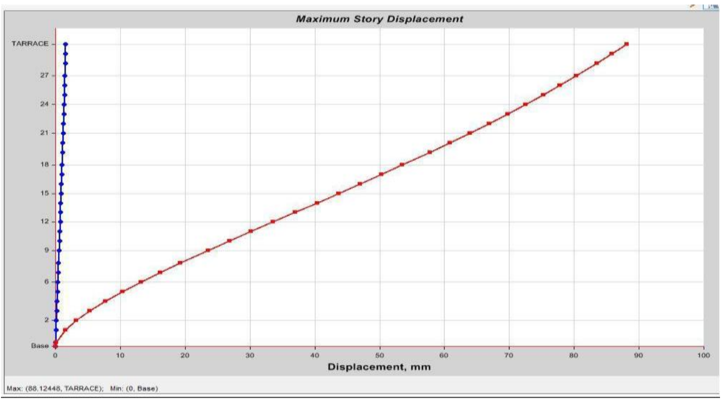
GRAPH: 08

3.6.9 DISPLACEMENT FOR WIND IN X DIRECTION



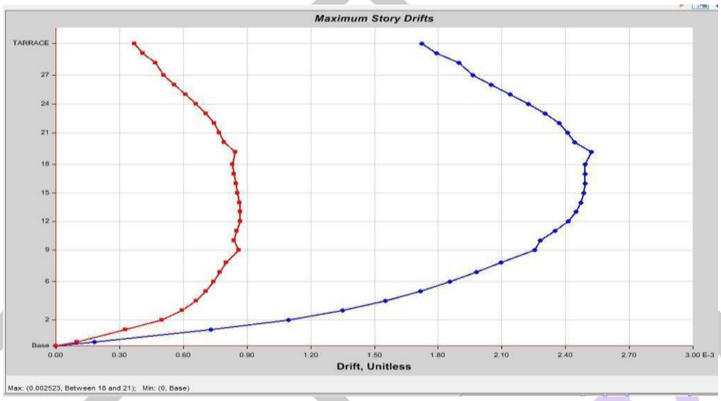
GRAPH: 09

3.6.10 DISPLACEMENT FOR WIND IN Y DIRECTION



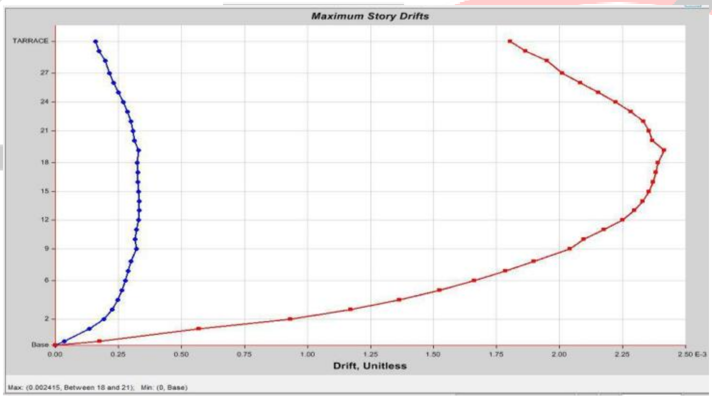
GRAPH: 10

3.6.11 DRIFT FOR STATIC EARTHQUAKE IN X DIRECTION



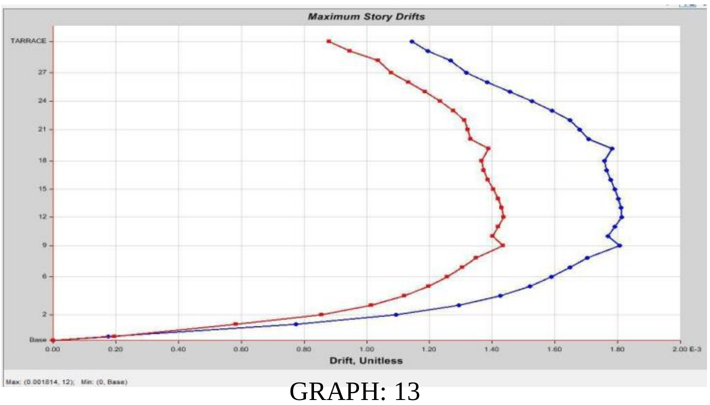
GRAPH: 11

3.6.12 DRIFT FOR STATIC EARTHQUAKE IN Y DIRECTION



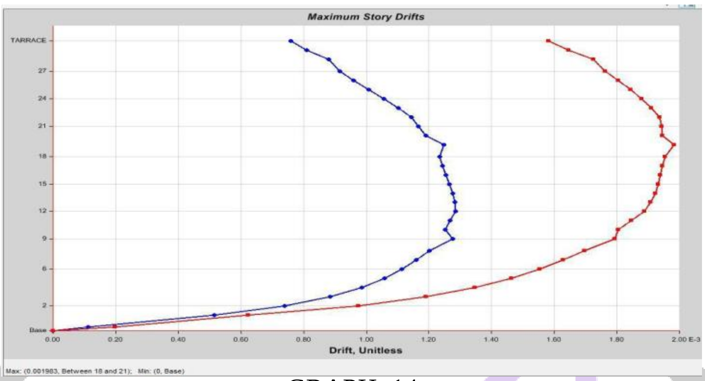
GRAPH: 12

3.6.13 DRIFT FOR DYNAMIC EARTHQUAKE IN X DIRECTION



GRAPH: 13

3.6.14 DRIFT FOR DYNAMIC EARTHQUAKE IN Y DIRECTION



GRAPH: 14

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