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Wind Analysis of Tall Building with Vertical Setback for Different Height & Area Ratio

Pradeep Sindal, Savita Maru

Abstract: ***The Tall building is being used as much as possible, to live, to commercial and to make statue. It will be of all the building different shapes, design and Structure. From this point of view any building having different discontinuity in mass, geometry of Structure and stiffness. This discontinuity impart the irregularities in the structure. The collapse of high rise building due to irregularities like in symmetries of mass, stiffness, height ratio and geometry of structure. To keep this needs for a long time, we must find out the permissible irregularities to get the maximum building strength/ building life. For design of tall building we need to consider wind load. So, the effect of vertically irregularities in the wind analysis performance of structure becomes really important. Now we will study about behavior of high rise building with different vertical setback and Area ratio on different models of moment resisting rigid frame structure with optimum location of shear wall.***

In this scrutinize, G+30 story rigid frame structure is taken with two different aspect ratio 1:4:9 and 1:1.56:2.25 for different set-back position in the structure. The set-back provided in the structure are Setback at 15&25 story, Setback at 15&20 Story, Setback at 10&25 Story, Setback at 10&15 Story, Setback at 5&20 Story and Setback at 5&15 Story. Story drift, Story Displacement, Base shear Result are revaluated. On the basis of this result best structure to be discover.

Keywords- Vertical setback, Stiffness, Mass irregularities, Story drift, Story Displacement, Base shear, ETABS.

I. INTRODUCTION

In the Urban Area, Tall Building have became a compulsion of people. To fulfill the same compulsion, Tall buildings are being built everywhere. The buildings can be broadly categorized as regular and irregular buildings. The building are made up of different shapes, design and types of structure. And the same structure where the changes occur at any point of area as compare to upper and lower storey of building. This is what we call Irregular building. The building which have been in irregular category and failure of structure can take place by discontinuity in geometry, mass, load resisting and lacks symmetry building. Height wise changes in Overturning, storey displacement, mass deflection and stiffness. The structure irregularities can be broadly categorized as horizontal (plan) and Vertical irregularity. The irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building are constructed in high Lateral load, the analysis and design becomes more complicated. The different types of vertical irregularity are Stiffness Irregularity (Soft Storey), Mass Irregularity, Vertical Geometric Irregularity, In plane Discontinuity in vertical element resisting lateral load, Strength Irregularity (Weak storey), Floating or stub columns, Irregular modes of oscillation in two principal plan direction. From different types of irregularity the project is taken on Vertical Geometry irregularity.

II. VERTICAL GEOMETRY IRREGULARITIES:-

At any height of the building, The immediate changes in area is said to be Vertical Geometry Irregularities. The presence of Abrupt reduction of the lateral dimension of the building at specific levels of the elevation is a very common kind of vertical geometrical irregularities. This types of building belongs under set-back building. It is possible to be position of set-back is symmetric or asymmetric. The set-back in a tall building may be one or more. As per Indian standard code IS 1893(Part 1): 2016, Clause 7.1, Define the vertical irregular structure, Vertical geometry irregularity shall be considered to exist, when the horizontal dimension of the lateral force resisting system in any storey is more than 125 percent of the storey below.

III. MODELING

Table-I: Modeling Data

Structural Detail	
No. of Story	G+30
Height of Building	105 m
Shape of Building	Square
Area 1(i.e 1:4:9) Area 2(i.e 1:1.56:2.25)	400 m^2, 1600 m^2, 3600 m^2 1600 m^2, 2500 m^2, 3600 m^2,
Type of Frame	Rigid Frame
Geometric Details	
Height of Each Story	3.5 m
Beam	0.40*0.65 m
Column	0.9*0.9 m
	0.8*0.8 m
	0.75*0.75 m
Slab	0.15 m
Shear Wall	0.25 m Thick
Material Details	
Concrete Grade	M35
Rebar	HYSD500
Specification	
Place of Building	Kolkata
Wind Speed	50 Kmps
Terrain Category	1
Class of the Structure	C
Foundation	Fixed at Ground Level

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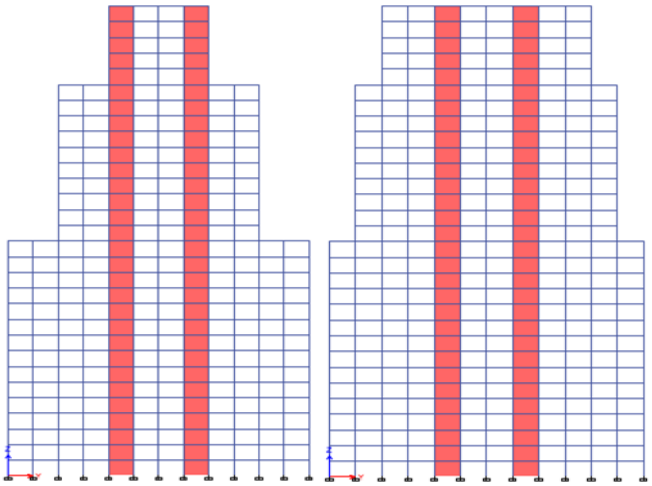
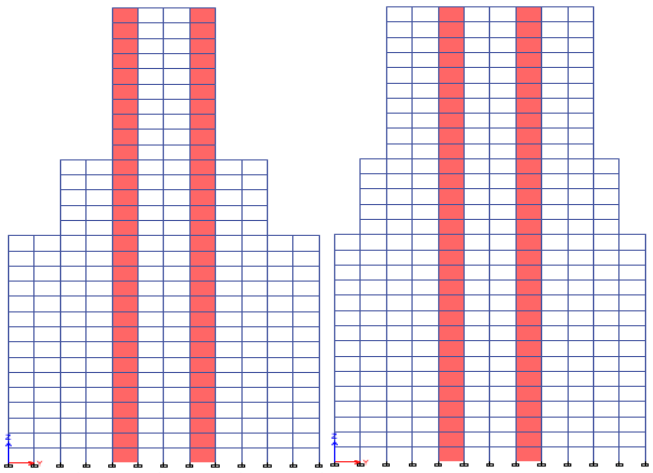
* Correspondence Author
Pradeep Sindal*, Department of Civil Engineering, Government Engineering College, Ujjain, India. Email: sindal.pradeep3@gmail.com
Dr.Savita Maru, Department of Civil Engineering, Government Engineering College, Ujjain, India. Email: savitamaru@yahoo.com

The Modeling is obtained when static wind analysis of G+30 Story with different setback condition and with respect to different aspect ratio i.e. 1:4:9 and 1:1.56:2.25 are as follow:-



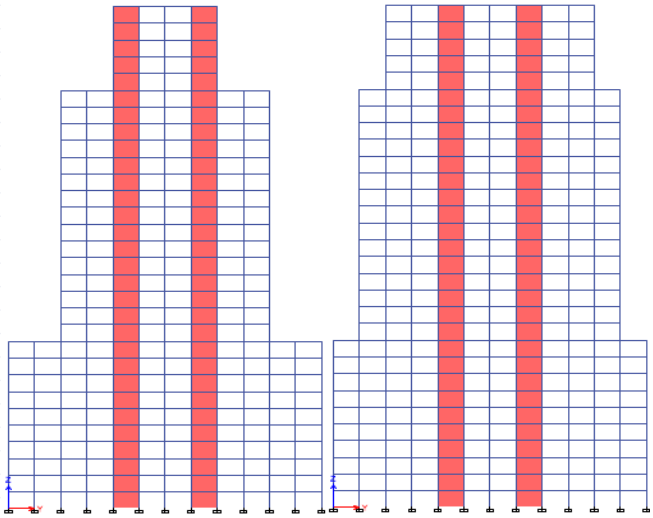
Model - 1(A) Aspect Ratio-1:4:9 | Model - 1(B) Aspect Ratio-1:1.56:2.25

Figure 1:Setback at 15,25 story



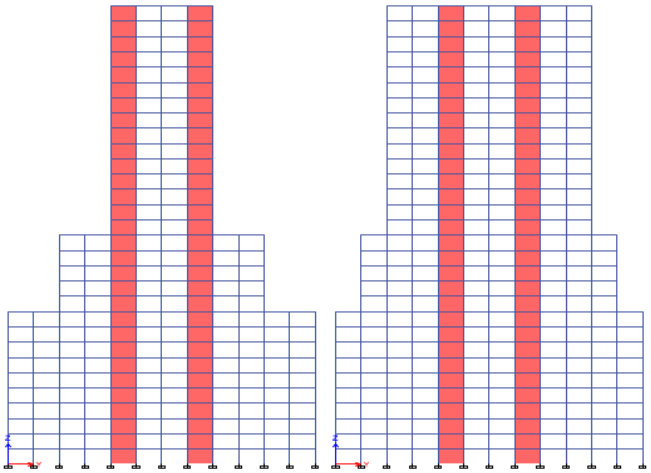
Model - 2(A) Aspect Ratio-1:4:9 | Model - 2(B) Aspect Ratio-1:1.56:2.25

Figure 2:Setback at 15,20 story



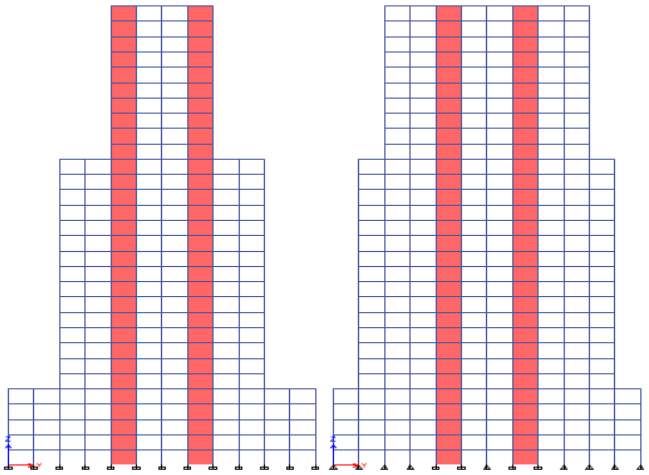
Model - 3(A) Aspect Ratio-1:4:9 | Model - 3(B) Aspect Ratio-1:1.56:2.25

Figure 3:Setback at 10, 25 story



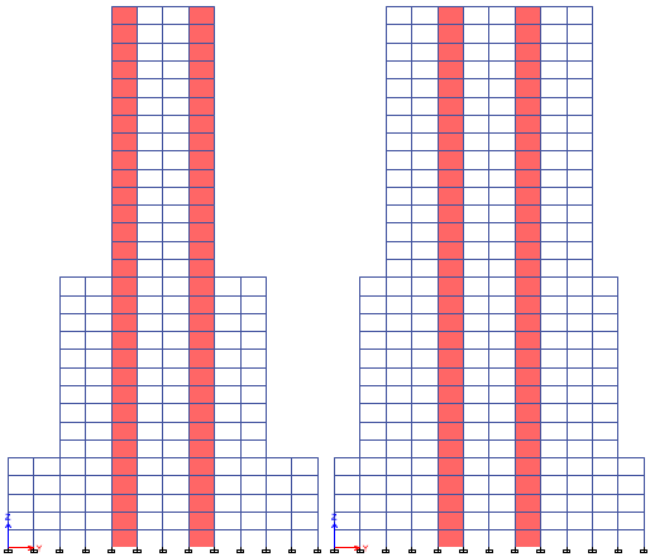
Model - 4(A) Aspect Ratio-1:4:9 | Model - 4(B) Aspect Ratio-1:1.56:2.25

Figure 4:Setback at 10, 15 story



Model - 5(A) Aspect Ratio-1:4:9 | Model - 5(B) Aspect Ratio-1:1.56:2.25

Figure 5:Setback at 5, 20 story



Model - 6(A) Aspect Ratio-1:4:9 | Model - 6(B) Aspect Ratio-1:1.56:2.25

Figure 6:Setback at 5, 15 story

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IV. RESULT AND DISCUSSION

4.1. Maximum Story Displacement :

Table-II: Maximum Story Displacement With Aspect Ratio 1:4:9

Maximum Story Displacement						
Aspect Ratio 1:4:9						
Story	Setback at 15, 25 from the base	Setback at 15, 20 from the base	Setback at 10, 25 from the base	Setback at 10, 15 from the base	Setback at 05, 20 from the base	Setback at 05, 15 from the base
30	38.9	39.3	44.1	50.7	50	56.6
29	38	38.1	43.1	49	48.7	54.9
28	37.1	36.9	42.1	47.3	47.3	53
27	36.1	35.6	41	45.5	45.8	51.2
26	35.1	34.2	39.9	43.6	44.3	49.2
25	34.1	32.8	38.8	41.6	42.7	47.1
24	33.1	31.4	37.7	39.6	41	45
23	32.1	29.9	36.5	37.4	39.3	42.8
22	31	28.4	35.3	35.2	37.6	40.5
21	29.8	26.9	33.9	32.9	35.9	38.1
20	28.5	25.4	32.5	30.6	34.1	35.7
19	27.2	24.1	30.9	28.3	32.6	33.2
18	25.8	22.8	29.3	25.9	31	30.7
17	24.3	21.5	27.5	23.6	29.3	28.3
16	22.8	20.2	25.7	21.4	27.5	25.9
15	21.3	18.9	23.8	19.3	25.7	23.6
14	20	17.8	21.8	17.5	23.8	21.6
13	18.7	16.7	19.8	15.8	21.9	19.7
12	17.3	15.5	17.7	14.1	19.8	17.7
11	15.9	14.2	15.7	12.5	17.8	15.8
10	14.4	12.9	13.8	11	15.6	13.9
9	12.8	11.5	12.2	9.7	13.5	11.9
8	11.2	10.1	10.6	8.5	11.3	10
7	9.6	8.7	9	7.2	9.2	8.1
6	7.9	7.2	7.4	6	7.1	6.3
5	6.3	5.7	5.9	4.7	5.3	4.7
4	4.7	4.3	4.4	3.5	3.9	3.5
3	3.1	2.9	2.9	2.4	2.6	2.3
2	1.8	1.6	1.6	1.3	1.4	1.3
1	0.6	0.6	0.6	0.5	0.5	0.4

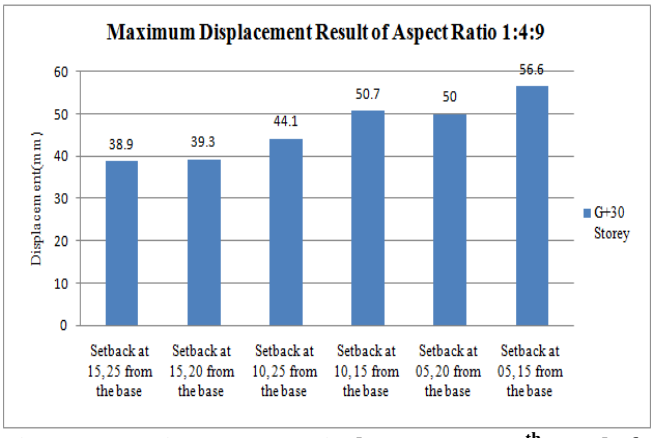

Figure 7: Maximum Story Displacement on 30th Level of Aspect Ratio 1:4:9.

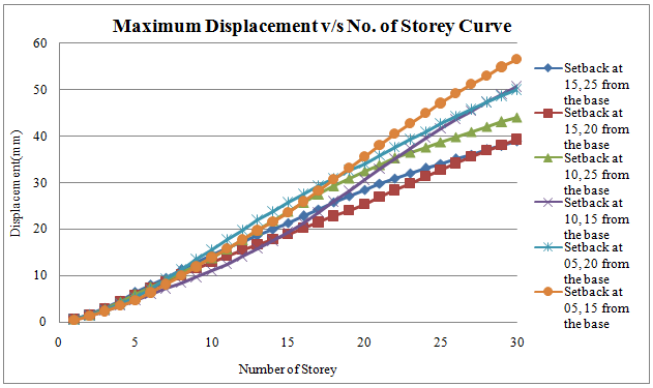

Figure 8: Maximum Story Displacement in Building of Aspect Ratio 1:4:9.

Discussion:- From above result, we get:-

1.The increase in number of story is directly proportional to the displacement.

2.On the basis of Maximum story displacement v/s No. of Story curve we conclude that in G+30 Story, Setback at 15, 25 Story is minimum displacement occurred and The maximum displacement is at Setback at 15, 20 story up to setback at 5, 15 except setback at 10, 15 story. So it conclude that setback at 15, 25 from the base is better than other setback design.

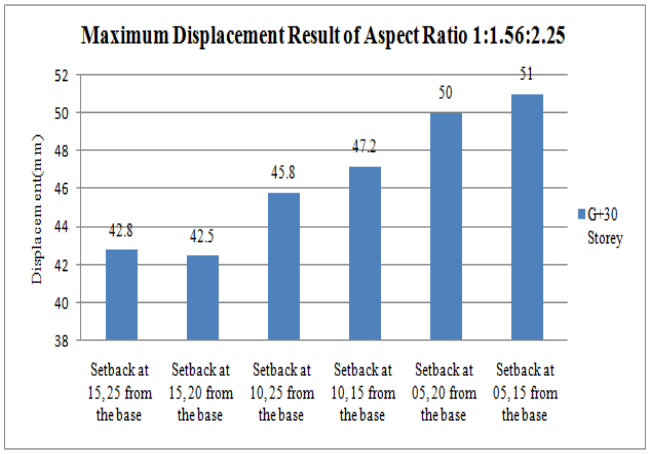

Figure 9: Maximum Story Displacement on 30th Level of Aspect Ratio 1:1.56:2.25.

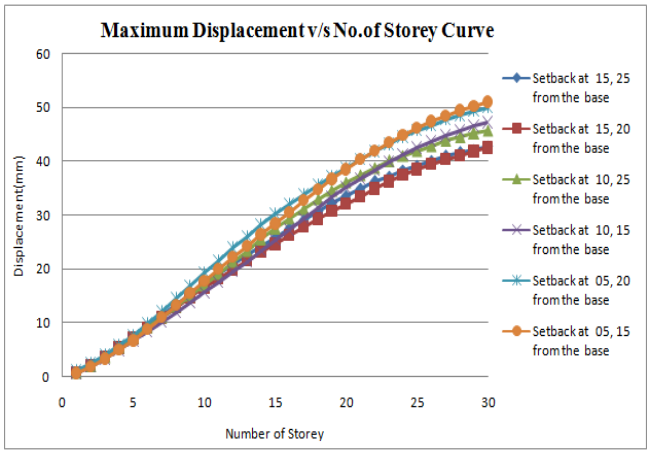

Figure 10: Maximum Story Displacement in Building of Aspect Ratio 1:1.56:2.25.

Table-III: Maximum Story Displacement With Aspect Ratio 1:1.56:2.25

Maximum Story Displacement						
Aspect Ratio 1:1.56:2.25						
Story	Setback at 15, 25 from the base	Setback at 15, 20 from the base	Setback at 10, 25 from the base	Setback at 10, 15 from the base	Setback at 05, 20 from the base	Setback at 05, 15 from the base
30	42.8	42.5	45.8	47.2	50	51
29	42.2	41.8	45.2	46.5	49.3	50.2
28	41.6	41.1	44.5	45.6	48.5	49.4
27	40.9	40.3	43.8	44.7	47.7	48.4
26	40.1	39.5	42.9	43.7	46.7	47.4
25	39.2	38.5	42	42.5	45.7	46.2
24	38.3	37.4	41	41.3	44.5	44.9
23	37.3	36.2	40	39.9	43.2	43.5
22	36.2	34.9	38.8	38.4	41.8	42
21	35	33.5	37.5	36.8	40.3	40.3
20	33.7	32.1	36.1	35.1	38.8	38.5
19	32.3	30.8	34.6	33.3	37.3	36.7
18	30.8	29.3	33	31.3	35.6	34.7
17	29.2	27.8	31.2	29.4	33.9	32.7
16	27.5	26.2	29.4	27.3	32.1	30.5
15	25.8	24.6	27.5	25.3	30.2	28.4
14	24.3	23.1	25.5	23.4	28.2	26.4
13	22.6	21.6	23.4	21.4	26.1	24.3
12	20.9	19.9	21.3	19.5	23.9	22.2
11	19.1	18.2	19.1	17.5	21.6	20
10	17.2	16.5	17	15.6	19.3	17.8
9	15.3	14.7	15	13.8	16.9	15.5
8	13.4	12.8	13.1	12	14.5	13.3
7	11.4	10.9	11.1	10.2	12.2	11
6	9.4	9	9.2	8.4	9.8	8.8
5	7.4	7.1	7.2	6.7	7.6	6.7
4	5.5	5.3	5.4	4.9	5.8	5
3	3.7	3.6	3.6	3.3	4	3.3
2	2.1	2	2	1.8	2.5	1.8
1	0.7	0.7	0.7	0.6	1.1	0.6

Discussion:-

1.The increase in number of story the displacement also increases.

2.On the basis of Maximum story displacement v/s No. of Story curve we conclude that in G+30 Story, Setback at 15, 20 Story is minimum displacement occurred and The maximum displacement is at Setback at 15, 25 story up to setback at 5, 15 Story. So it conclude that setback at 15, 20 from the base is better than other setback design.

4.2 Maximum story drift:

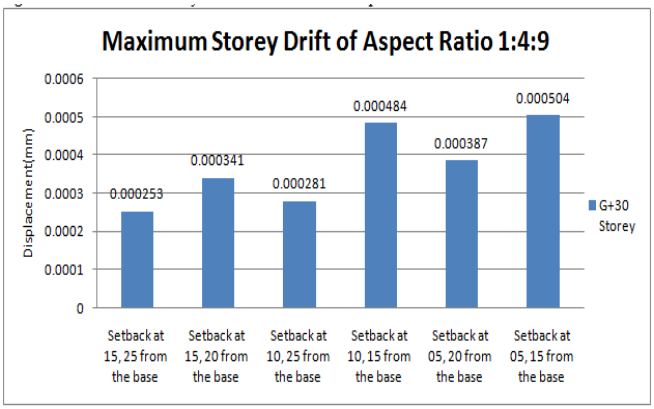

Figure 11: Maximum Story Drift on 30th Level of Aspect Ratio 1:4:9.

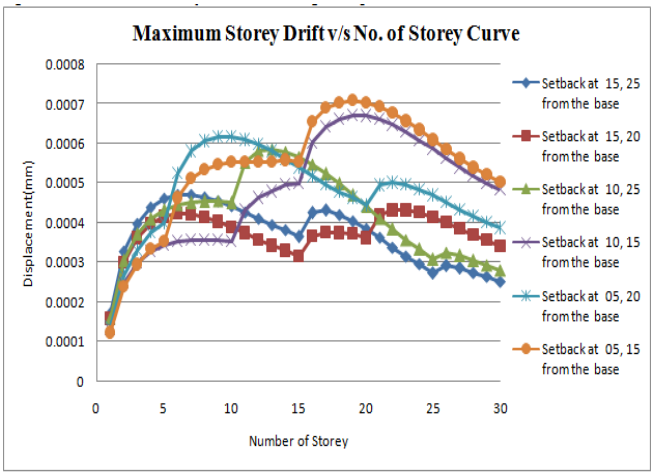

Figure 12: Maximum Story Drift in Building of Aspect Ratio 1:4:9.

Table-IV: Maximum Story Drift With Aspect Ratio 1:4:9.

Maximum Story Drift(mm) Aspect Ratio 1:4:9						
Aspect Ratio 1:4:9						
Story	Setback at 15, 25 from the base	Setback at 15, 20 from the base	Setback at 10, 25 from the base	Setback at 10, 15 from the base	Setback at 05, 20 from the base	Setback at 05, 15 from the base
30	0.000253	0.000341	0.000281	0.000484	0.000387	0.000504
29	0.000264	0.000356	0.000293	0.000501	0.000402	0.000522
28	0.000275	0.00037	0.000305	0.000519	0.000417	0.00054
27	0.000286	0.000385	0.000317	0.00054	0.000434	0.000562
26	0.000292	0.000401	0.000325	0.000563	0.000452	0.000586
25	0.000273	0.000415	0.000308	0.000587	0.00047	0.00061
24	0.000296	0.000426	0.000333	0.000609	0.000485	0.000635
23	0.000316	0.000432	0.000357	0.00063	0.000496	0.000657
22	0.000339	0.000432	0.000384	0.000648	0.000502	0.000678
21	0.000363	0.000419	0.000412	0.000662	0.000495	0.000694
20	0.000385	0.000362	0.000441	0.00067	0.000444	0.000704
19	0.000405	0.000372	0.00047	0.000671	0.000463	0.000709
18	0.000421	0.000374	0.000498	0.000662	0.000478	0.000704
17	0.000432	0.000376	0.000524	0.000643	0.000497	0.00069
16	0.000425	0.000366	0.000547	0.000603	0.000518	0.000655
15	0.000365	0.000315	0.000566	0.0005	0.00054	0.000554
14	0.000382	0.00033	0.00058	0.000496	0.000561	0.000559
13	0.000396	0.000343	0.000585	0.000479	0.000581	0.000554
12	0.000411	0.000358	0.000582	0.000464	0.000598	0.000553
11	0.000427	0.000374	0.000552	0.000433	0.00061	0.000554
10	0.000442	0.000389	0.000451	0.000353	0.000617	0.000553
9	0.000455	0.000403	0.000456	0.000357	0.000617	0.000547
8	0.000466	0.000415	0.000454	0.000356	0.000606	0.000535
7	0.000471	0.000422	0.000451	0.000356	0.000581	0.000513
6	0.000471	0.000423	0.000445	0.000353	0.000526	0.000464
5	0.000461	0.000416	0.000432	0.000345	0.0004	0.000354
4	0.000439	0.000398	0.00041	0.000329	0.000376	0.000334
3	0.000398	0.000362	0.000371	0.0003	0.000332	0.000295
2	0.000329	0.0003	0.000305	0.000249	0.000268	0.000239
1	0.000173	0.000158	0.00016	0.000132	0.000138	0.000124

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Discussion:-

1.If the Setback is at half of the building height and the area is smaller to bottom of the building then story drift will be more or increase to other aspect.

2.On the basis of Maximum story drift v/s No. of Story curve we examine that in G+30 Story, Setback at 15, 25 Story is minimum story drift occurred and The maximum story drift is Setback at 15, 20 story up to setback at 5, 15 Story. So it conclude that setback at 15, 25 from the base is better than other setback design.

Table-V: Maximum Story Drift With Aspect Ratio 1:1.56:2.25.

Maximum Story Drift						
Aspect Ratio 1:1.56:2.25						
Story	Setback at 15, 25 from the base	Setback at 15, 20 from the base	Setback at 10, 25 from the base	Setback at 10, 15 from the base	Setback at 5, 20 from the base	Setback at 5, 15 from the base
30	0.000159	0.00018	0.000172	0.000217	0.000199	0.000225
29	0.000181	0.000203	0.000194	0.000241	0.000223	0.000249
28	0.000202	0.000226	0.000216	0.000265	0.000246	0.000273
27	0.000226	0.000253	0.000241	0.000294	0.000274	0.000302
26	0.000249	0.000281	0.000265	0.000325	0.000304	0.000334
25	0.000259	0.000311	0.000277	0.000359	0.000335	0.000368
24	0.000288	0.000339	0.000307	0.000393	0.000365	0.000402
23	0.000316	0.000366	0.000337	0.000426	0.000395	0.000437
22	0.000346	0.00039	0.000369	0.00046	0.000423	0.000471
21	0.000375	0.000404	0.0004	0.000491	0.000443	0.000504
20	0.000403	0.000391	0.000432	0.000521	0.000437	0.000535
19	0.00043	0.000413	0.000463	0.000547	0.000465	0.000563
18	0.000454	0.000431	0.000494	0.000568	0.000492	0.000586
17	0.000474	0.000448	0.000523	0.000583	0.000519	0.000605
16	0.000483	0.000456	0.00055	0.000582	0.000547	0.000609
15	0.000455	0.00043	0.000574	0.000541	0.000574	0.000573
14	0.000475	0.000449	0.000594	0.000555	0.000601	0.000593
13	0.000493	0.000466	0.00061	0.000561	0.000625	0.000608
12	0.00051	0.000484	0.000618	0.000565	0.000646	0.000622
11	0.000528	0.000501	0.000609	0.000555	0.000664	0.000636
10	0.000543	0.000517	0.000551	0.000503	0.000676	0.000645
9	0.000556	0.00053	0.000559	0.000511	0.000682	0.00065
8	0.000565	0.000539	0.000561	0.000512	0.00068	0.000646
7	0.000568	0.000544	0.000559	0.000511	0.000665	0.000632
6	0.000564	0.00054	0.000551	0.000506	0.000625	0.000594
5	0.00055	0.000527	0.000535	0.000491	0.000531	0.000503
4	0.00052	0.000499	0.000505	0.000465	0.000502	0.000473
3	0.00047	0.000452	0.000455	0.00042	0.000451	0.000422
2	0.000385	0.000371	0.000373	0.000345	0.000382	0.000342
1	0.000201	0.000194	0.000195	0.000181	0.00032	0.000178

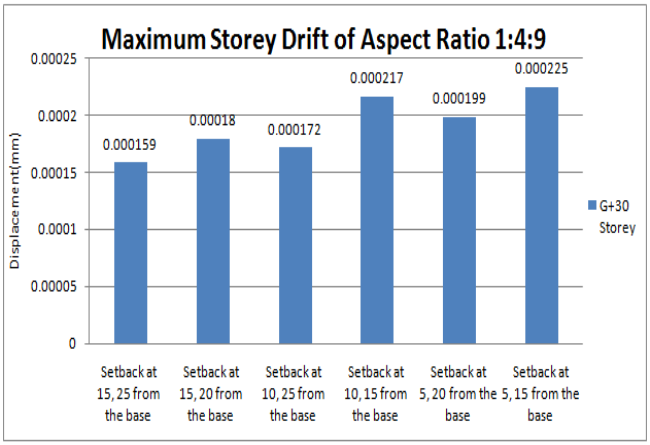

Figure 13: Maximum Story Drift on 30th Level of Aspect Ratio 1:1.56:2.25.

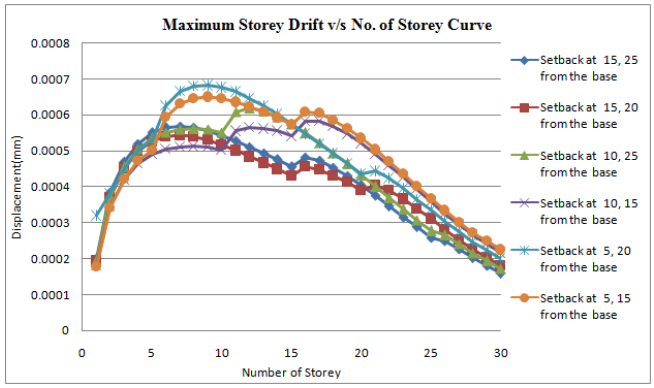

Figure 14: Maximum Story Drift in Building of Aspect Ratio 1:1.56:2.25.

Discussion:-

1.The Setback is at half of the building height and the area is smaller to bottom of the building then story drift will be higher.

2.On the basis of Maximum story drift v/s No. of Story curve we examine that in G+30 Story, Setback at 15, 25 Story is minimum story drift occurred and The maximum story drift is Setback at 15, 20 story up to setback at 5, 15 Story. So it conclude that setback at 15, 25 from the base is better than other setback design.

5.3 Base Shear Results:

Table-VI: Maximum Base Shear

Base Shear of G+30 Story			
S no.	Setback	Aspect Ratio 1:1.56:2.25	Aspect Ratio 1:4:9
1	Setback at 15, 25 from the base	20389.99	17602.98
2	Setback at 15, 20 from the base	19681.34	16185.68
3	Setback at 10, 25 from the base	19738.57	16300.14
4	Setback at 10, 15 from the base	18346.33	13515.67
5	Setback at 5, 20 from the base	18429.20	13681.41
6	Setback at 5, 20 from the base	17745.62	12314.24

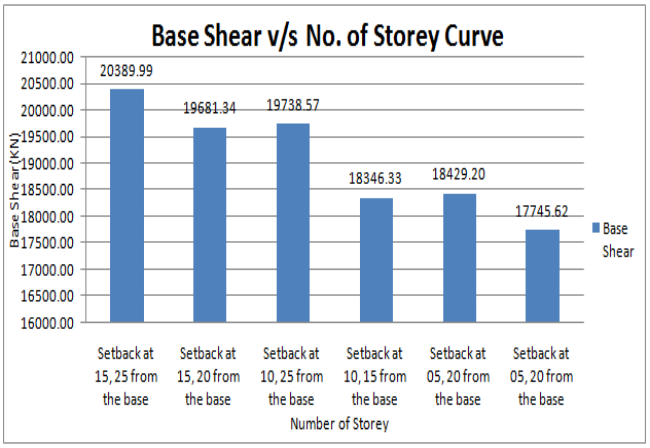

Figure 15: Base Shear of G+30 Story building of Aspect Ratio 1:4:9.

Discussion:-

1.The Setback is at half of the building height and the area is smaller to bottom of the building then Base shear will be lower than other design.

2.From this graph, If Setback is before perpetual story than base shear is increased.

3.On the basis of Base Shear v/s No. of Story curve we examine that in G+30 Story, Setback at 5, 15 Story is minimum Base Shear introdued and The maximum base shear is Setback at 5, 20 story up to setback at 15, 25 Story. So it conclude that setback at 5, 15 from the base is better than other setback design.

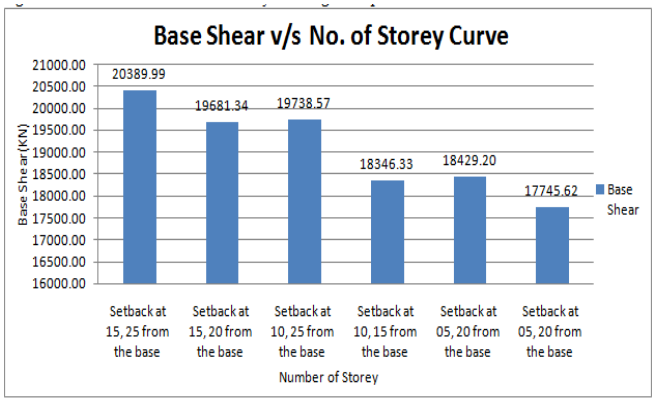

Figure 16: Base Shear of G+30 Story building of Aspect Ratio 1:1.56:2.25.

Discussion:-

1.If building having setback before long continued story then base shear is high.

2.In this graph, If Setback is after perpetual story than base shear is less.

3.On the basis of Base Shear v/s No. of Story curve we examine that in G+30 Story, Setback at 5, 15 Story is minimum Base Shear introduced and The maximum base shear is Setback at 5, 20 story up to setback at 15, 25 Story. So it conclude that setback at 5, 15 from the base is better than other setback design.

V. CONCLUSION

1. The maximum story displacement is offered setback at 5&15 story from the base with base ratio 1:4:9 and minimum story displacement at 15&25 with a aspect ratio 1:4:9. With this result, The setback at 15&25 story of aspect ratio 1:4:9 is appropriate for the design.
2. The Story drift is heavily scrutinized on setback at 5&15 story based on aspect ratio 1:4:9, and minimum story drift is checked at setback at 15&25 story of area ratio 1:1.56: 2.25. According to the above figures, it is concluded that the setback at 15&25 story from the base with area ratio 1:1.56:2.25 is superior.
3. The base shear of the G+30 story building is achieving a high result at setback at 15&25 story from a base ratio of 1:1.56:2.25 and a minimum value carried out at setback at 5&15 storey of area ratio of 1: 4: 9. So it scrutinize that on the setback at 5&15 story the minimum base shear based on a range ratio of 1:4:9 is better.
4. When three results are revealed i.e. Story Display, Story Drift and Base Shear conclude that the G+30 story setback is given a minimum value at 15&25 story from the base with an aspect ratio of 1:4:9, so it is safe.
5. When study of all the model with different setback and aspect ratio than the outcome response, that the Storey Base shear increases with the Storey Displacement, Storey Drift decreases.

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AUTHORS PROFILE

Pradeep Sindal did his Bachelor of Technology(BE) from Mahakal Institute of Technology, Ujjain, Madhya Pradesh in 2017 and Pursuing his Master of Engineering(ME) in Computer Aided Structural Design & Drafting(CASDD) at Government Engineering College, Ujjain, Madhya Pradesh.

Dr. Savita Maru, PG Coordinator at Government Engineering College, Ujjain in Civil Engineering Department. She has 16 Years of Teaching Experience. She has several papers in reputed national and internationals journal' and conferences.

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