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Behavior of Beam Column Joint in RCC Frames Subjected to Lateral Loading

Deepika Singh[1], Asst. Prof. Shiwani Bharti[2], B.S. Tyagi[3]

[1]M. Tech. Student of Structural Engineering, Department of Civil Engineering, RGEC, Meerut-250004,U.P., INDIA
[2]Assistant Professor, Department of Civil Engineering, ABSS Institute of Engineering & Technology, Meerut , INDIA
[3]HOD Department of Civil Engineering, RGEC, MEERUT, U.P., INDIA

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Abstract –*Beam column joint is a point or location where beam and column intersect each other. Joint can be basically classified in three types i.e. interior joint, exterior joint, and corner joint. Using SAP software displacement, stress, stiffness variation can be analyzed. In the past many experimental research has been conducted on Beam Column Joint Behavior subjected to lateral loads. Different research studies considered different parameters i.e. poor anchorage of bars, weak columns and insufficient transverse reinforcement.*

Key Words: Beam column joint analysis, Stiffness, Ductility, displacement, shear, moment, axial force SAP2000v20.2.0.

1. INTRODUCTION

1.1 Objectives

Crucial zone in an RCC frame or steel structure is Beam Column Joint. When Beam column joint is subjected to lateral loading, there is great influence on the response of whole structure of the behavior of beam column joint. Portion of the RCC frame building where beam column joint intersect is known as Beam column joint. When higher shear forces are developed due to lateral loading, joint becomes fail to resist the failure. It means it is the weakest portion of the structure. Due to higher shear forces, shear failure will takes place which is brittle in nature and Joints are not capable to withstand against this because of limited strength of constituent materials. It is not an easy task to repair the joints. Hence joints should be enough strong to bear the lateral load effect. In our design provision joint is considered to be rigid. But If joint is rigid brittle failure will take place. On the other hand it is not possible to become joint ad ductile because it will cause more deformation. So, the objective of the project is

a)To find out optimum value of rigidity i.e. Rigid Zone Factor in SAP for a joint at which the joint is neither fully rigid nor fully ductile using SAP2000v20.2.0.

b)To study the results obtained after the analysis of building different no. of storeys using SAP2000v20.2.0.

c)The various parameters such as lateral displacement/storey displacement, axial force, stress, shear force and bending moment will be compared when joint is ductile and when joint is semi rigid (i.e. will give same value of deflection and other parameter as when joint is fully rigid).

1.2 Methodology

The process involved in this study is:

a) Modelling of RCC frame with different no. of storeys.
b) Then, provide optimum value of rigidity.
c) comparison of the result .
d) Presentation of results in the form of graphs and tables.
e) Coclusion .

2. LITERATURE REVIEW

Vladmir Guilherne Haach, Ana Lucia Home De Cresce El Debs, Mounir Khalil El Debs- Effect of column axial load is studied on joint shear strength through numerical simulation. Numerical study is based on FINITE ELEMENT METHOD done by ABAQUS software. A comparison is given between numerical and experimental result . It is observed that the column axial load made the joint more stiff but also introduced stresses in the beam longitudinal reinforcement. It also represents the effect of stirrup ratio on the joint. Conclusion of the research is that Tension stress is absorbed by stirrups provided in the joint portion.

Hegger Josef Sherif Alaa and Roeser Wolfgang – The author for this study used ANTENA software. He studied the behavior of exterior and interior joints by nonlinear analysis of RCC structure. Shear strength is influenced by different parameters for exterior and interior joints. Comparison between experimental and numerical value is done and significant result is shown.

Kuang J.S. and Wong H. F.- This research is based on experimental approach. Exterior joints are subjected to reversed cyclic loading. Main concentration was on the anchorage and lap location when it is subjected to earthquake like loading. Beam column joint's shear strength is highly dependent on axial load on column.

Kuang J.S. and Wong H. F. Beam column joint affects seriously due to lack of ductility. High strength concrete beam column joints were designed by providing anchored type intermediate bars and doubly closed stirrups are provided near the joints. This approach minimized the damage of failure of joint and improved the performance of beam column joint under cyclic loading i.e. structure will safe when it will be subjected to lateral loading.

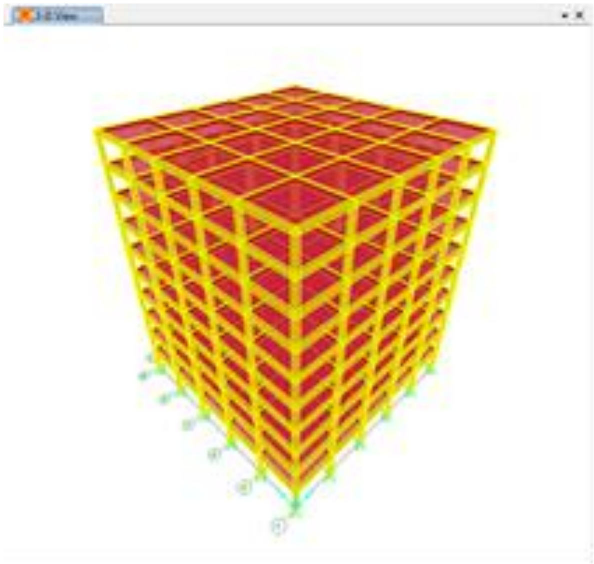
3. MODEL CONFIGURATION

Three building models of 10, 20, 30 storey are created.
The data related to models is as follows:

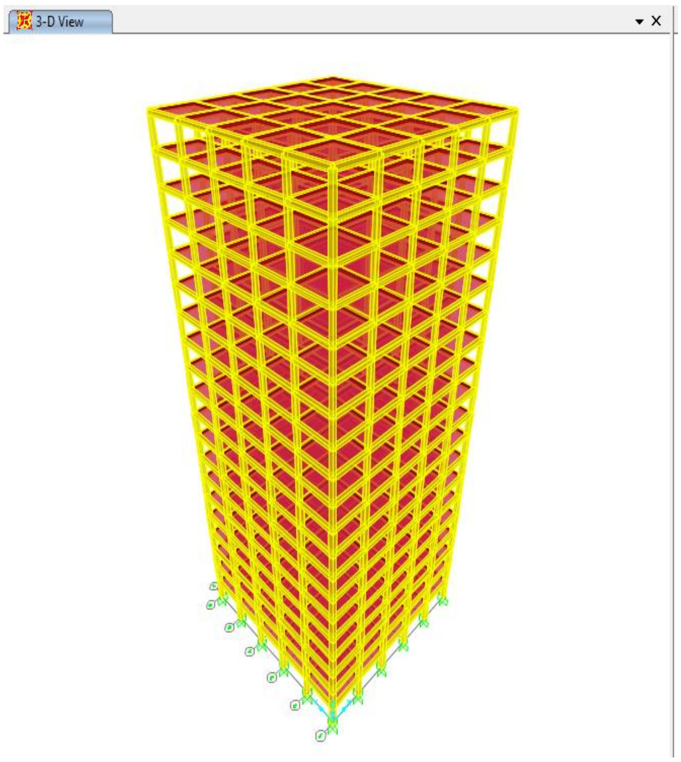
Plan Area	= 625m^2
No. of Bays in X & Y direction	= 5@5mc/c
Height of storey	= 3m
Beam M25	= 450mmx350mm, 450mmx400mm, 500mmx450mm
Column M30 &M35	= 400mmx400mm, 600mmx600mm 450mmx450mm
Slab M25	= 125mm thick
Grade of steel	= Fe415 & Fe500
Live Load	= 3KN/m^2
Floor Finish Load	= 2KN/m^2
Earthquake Load	= As per IS 1893:2016 (Part-I)
Software used	= SAP2000v20.2.0

Table1: Various Parameters

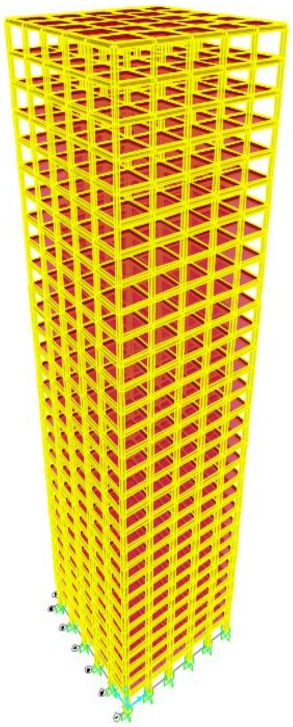
Frame Type	Special Moment Resisting Frame
Ecc, Ratio	.05
Seismic Zone Factor	.24 (IV)
Importance Factor	1
Response Reduction Factor R	5
Soil Type	2 (Medium)
Time Period	User Defined (.075h^.75)



10 STOREY



20 STOREY



30STOREY

Table3:

Storey	SHEAR FORCE			MOMENT		
	RZF=0	RZF=1	RZF=.78	RZF=0	RZF=1	RZF=.78
10	-39.243	-40.855	-40.457	-36.213	-43.542	-41.825
9	-43.195	-45.707	-45.095	-49.113	-58.628	-58.403
8	-42.349	-44.49	-43.971	-46.41	-54.84	-53.874
7	-41.977	-44.057	-43.563	-45.59	-53.974	-52.956
6	-41.388	-43.328	-42.854	-44.103	-52.062	-51.207
5	-40.611	-42.42	-41.99	-42.295	-49.8	-48.954
4	-39.783	-41.32	-40.943	-40.11	-47.051	-46.941
3	-38.744	-40.07	-39.697	-37.508	-43.739	-42.939
2	-37.588	-38.573	-38.33	-34.707	-40.286	-39.505
1	-37.013	-36.565	-38.678	-32.013	-34.71	-34.351

4. COMPARISON OF RESULTS

COMPARISON OF 10 STOREY BUILDING

Table 2:

Storey	DISPLACEMENT			STRESS		
	RZF=0	RZF=1	RZF=.78	RZF=0	RZF=1	RZF=.78
10	0.028	0.021	0.022	3056.46	3727.76	3667.09
9	0.027	0.02	0.02	4195.8	5024.41	4929.49
8	0.025	0.019	0.019	3936.56	4655.7	4601.57
7	0.023	0.017	0.018	3866.88	4578.45	4492.3
6	0.02	0.015	0.015	3739.63	4413.96	4396.72
5	0.017	0.012	0.013	3584.69	4220.26	4172.42
4	0.013	0.01	0.01	3399.85	3989.36	3901.53
3	0.009	0.007	0.007	3181.53	3712.8	3690.03
2	0.006	0.004	0.005	2941.26	3414.37	3305.65
1	0.002	0.002	0.002	2798.04	2965.56	2932.05

COMPARISON OF 20 STOREY BUILDING

Table 4:

Storey	DISPLACEMENT			STRESS		
	RZF=0	RZF=1	RZF=.81	RZF=0	RZF=1	RZF=.81
20	0.055	0.039	0.04	4072.11	4889.69	4799.52
19	0.054	0.039	0.041	5490.24	6529.05	6463.17
18	0.052	0.037	0.038	5206.33	6124.81	6082.02
17	0.051	0.036	0.036	5164.7	6083.68	5989.08
16	0.048	0.034	0.035	5075.17	5973.65	5892.32
15	0.046	0.032	0.032	4968.07	5845.78	5794.75
14	0.043	0.03	0.032	4838.86	5690.66	5601.23
13	0.04	0.028	0.029	4686.94	5508.05	5489.02
12	0.036	0.025	0.026	4517.4	5305.07	5299.46
11	0.033	0.023	0.024	4270.63	5021.07	4969.36
10	0.029	0.02	0.02	4485.61	5451.45	5402.6
9	0.026	0.018	0.018	4581.67	5544.65	5396.41
8	0.023	0.016	0.017	4386.13	5297.37	5213.14
7	0.019	0.014	0.014	4202.34	5055.93	4981.62
6	0.016	0.011	0.011	4007.8	4804.67	4775.7

5	0.013	0.009	0.01	3795.54	4528.24	4501.03
4	0.01	0.007	0.007	3566.39	4228.8	4198.36
3	0.007	0.005	0.005	3319.93	3905.58	3892.57
2	0.004	0.003	0.003	3051.07	3548.73	3490.64
1	0.001	0.001	0.001	2760.57	3156	3095.05

Table 5 :

Storey	SHEAR FORCE			MOMENT		
	RZF=0	RZF=1	RZF=.81	RZF=0	RZF=1	RZF=.81
20	-47.72	-50.23	-49.92	-55.2	-65.192	-64.69
19	-53.81	-57.81	-57.17	-73.38	-86.956	-85.817
18	-52.78	-56.33	-55.95	-70.21	-82.517	-81.596
17	-52.51	-56.06	-55.36	-69.63	-82.006	-81.925
16	-52.04	-55.49	-54.99	-68.43	-80.535	-79.832
15	-51.47	-54.81	-54.63	-67	-78.826	-77.941
14	-50.78	-53.98	-53.52	-65.26	-76.749	-76.001
13	-49.97	-53.01	-52.49	-63.21	-74.292	-73.869
12	-49.06	-51.92	-51.46	-60.96	-71.578	-70.914
11	-47.71	-50.35	-49.92	-57.38	-67.491	-66.898
10	-48.74	-52.21	-51.92	-60.87	-73.707	-73.129
9	-48.93	-52.47	-52.36	-61.63	-74.597	-73.496
8	-47.96	-51.12	-50.99	-59.15	-71.38	-71.013
7	-46.97	-49.91	-49.41	-56.67	-68.157	-67.998
6	-45.91	-48.55	-48.09	-54.03	-64.731	-64.001
5	-44.77	-47.05	-46.98	-51.16	-60.988	-60.408
4	-43.53	-45.43	-45.1	-48.06	-56.932	-56.515
3	-42.2	-43.69	-43.43	-44.72	-52.553	-51.962
2	-40.76	-41.78	-41.6	-41.13	-47.802	-47.139
1	-39.14	-39.6	-39.52	-36.95	-42.197	-41.902

COMPARISON OF 30 STOREY BUILDING

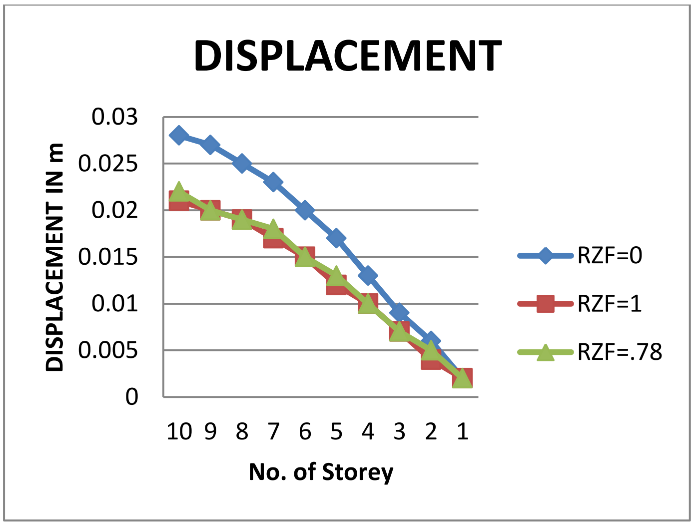
Table 6:

Storey	DISPLACEMENT			STRESS		
	RZF=0	RZF=1	RZF=.83	RZF=0	RZF=1	RZF=.83
30	0.068	0.047	0.049	4034.98	4740.75	4695.82
29	0.068	0.047	0.048	5455.84	6351.29	6297.31
28	0.067	0.046	0.047	5210.03	6002.8	5997.51
27	0.065	0.045	0.045	5183.02	5975.01	5940.1
26	0.064	0.043	0.044	5128.67	5910.63	5777.79
25	0.062	0.042	0.042	5063.11	5834.6	5793.68
24	0.06	0.041	0.042	4984.53	5743.31	5698.71
23	0.058	0.039	0.039	4892.95	5637.34	5611.31
22	0.055	0.037	0.037	4789.14	5515.32	5392.97
21	0.052	0.035	0.035	4631.94	5349.72	5299.3
20	0.05	0.033	0.033	4911.92	5926.92	5744.6
19	0.047	0.031	0.031	5072.54	6100.6	6017.04
18	0.045	0.03	0.03	4936.67	5940.02	5850.35
17	0.042	0.028	0.028	4809.84	5779.86	5606.74
16	0.04	0.026	0.026	4680.97	5624.79	5556.37
15	0.037	0.024	0.024	4540.02	5453.76	5390.79
14	0.034	0.022	0.022	4388.19	5269.61	5192.46
13	0.031	0.02	0.02	4224.8	5070.83	4920.07
12	0.028	0.018	0.018	4048.54	4856.27	4712.45
11	0.026	0.016	0.016	3855.67	4623.05	4585.59
10	0.023	0.014	0.014	3753.42	4738.09	4714.77
9	0.02	0.013	0.013	3690.44	4655.59	4595.1
8	0.017	0.011	0.011	3539.64	4463.79	4390.36
7	0.015	0.009	0.009	3776.01	4237.34	4176.48
6	0.012	0.008	0.008	3208.33	4007.81	3959.16
5	0.009	0.006	0.006	3030.69	3763.84	3628.24
4	0.007	0.004	0.004	2841.33	3502.86	3481.59
3	0.004	0.003	0.003	2641.25	3223.38	3197.79
2	0.002	0.001	0.001	2431.01	2915.85	2889.03
1	0.001	0	0	2217.97	2617.84	2609.78

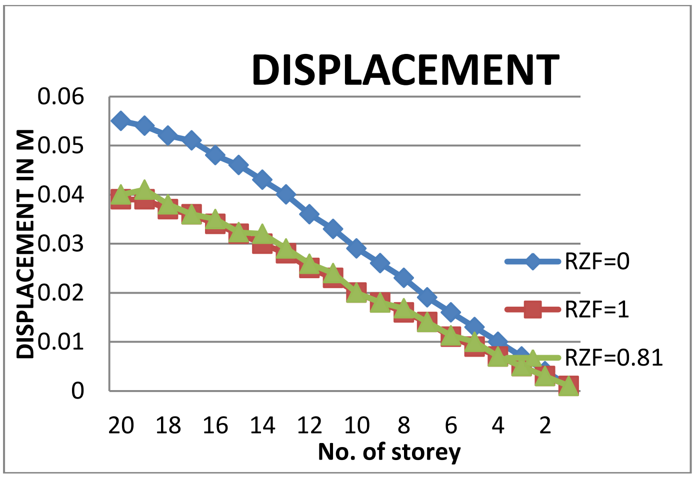
Table 7:

Storey	SHEAR FORCE			MOMENT		
	RZF=0	RZF=1	RZF=.83	RZF=0	RZF=1	RZF=.83
30	-58.146	-60.962	-60.48	-75.96	-87.376	-85.463
29	-67.023	-71.824	-70.992	-101.1	-117.32	-114.57
28	-65.827	-70.117	-69.376	-97.6	-112.36	-109.85
27	-65.583	-69.873	-69.133	-97.08	-111.88	-109.37
26	-65.191	-69.413	-68.685	-96.07	-110.69	-108.21
25	-64.707	-68.852	-68.138	-94.85	-109.28	-106.83
24	-64.128	-68.182	-67.484	-93.38	-107.58	-105.18
23	-63.452	-67.399	-66.721	-91.66	-105.61	-103.25
22	-62.69	-66.503	-65.852	-89.75	-103.36	-101.07
21	-61.459	-65.22	-64.563	-86.51	-100.03	-97.714
20	-63.564	-69.062	-68.053	-92.43	-111.05	-107.73
19	-64.44	-70.21	-69.153	-94.85	-114.1	-110.66
18	-63.506	-69.07	-68.044	-92.48	-111.21	-107.87
17	-62.575	-67.917	-66.933	-90.14	-108.31	-105.07
16	-61.605	-66.739	-65.794	-87.7	-105.35	-102.21
15	-60.551	-65.458	-64.554	-85.05	-102.13	-99.09
14	-59.415	-64.076	-63.216	-82.2	-98.604	-95.731

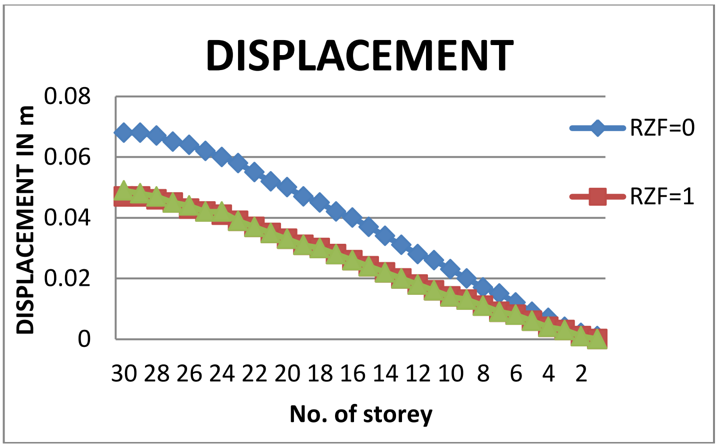
13	-58.196	-62.59	-61.778	-79.13	-94.843	-92.12
12	-56.865	-60.962	-60.204	-75.79	-90.843	-88.166
11	-55.403	-59.251	-58.531	-72.09	-86.531	-83.945
10	-54.684	-59.78	-58.769	-70.49	-88.979	-85.526
9	-54.043	-58.981	-57.996	-68.98	-87.051	-83.668
8	-52.949	-57.518	-56.604	-66.24	-83.393	-80.185
7	-51.743	-55.867	-55.04	-63.21	-79.252	-76.264
6	-50.484	-54.142	-53.407	-60.06	-74.931	-72.174
5	-49.151	-52.367	-51.672	-56.72	-70.336	-67.827
4	-47.736	-50.35	-49.822	-53.17	-65.437	-63.197
3	-46.237	-48.26	-47.85	-49.42	-60.202	-58.257
2	-44.633	-45.996	-45.719	-45.4	-54.536	-52.924
1	-42.96	-43.638	-43.498	-41.17	-48.567	-47.3



(i)



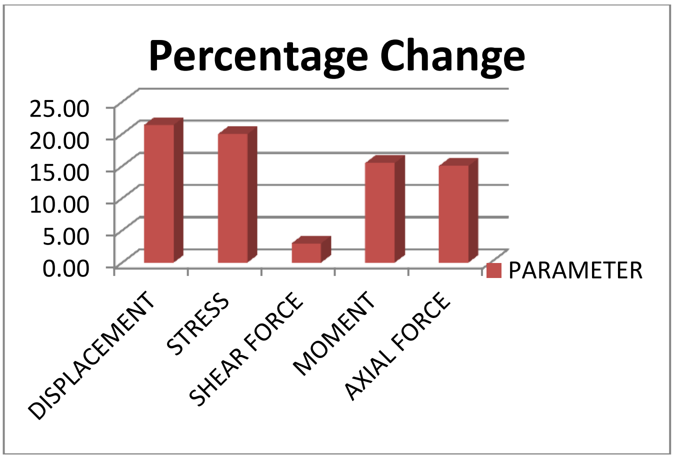
(ii)



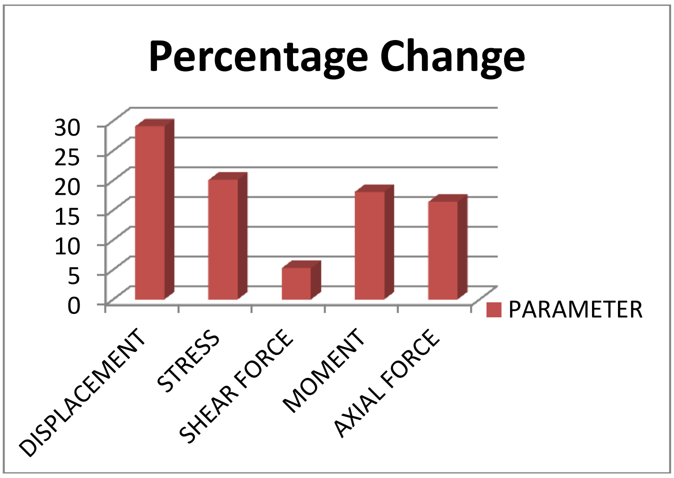
(iii)

Chart (i),(ii),(iii) showing displacement for all the models for different Rigidity Factor (RZF).

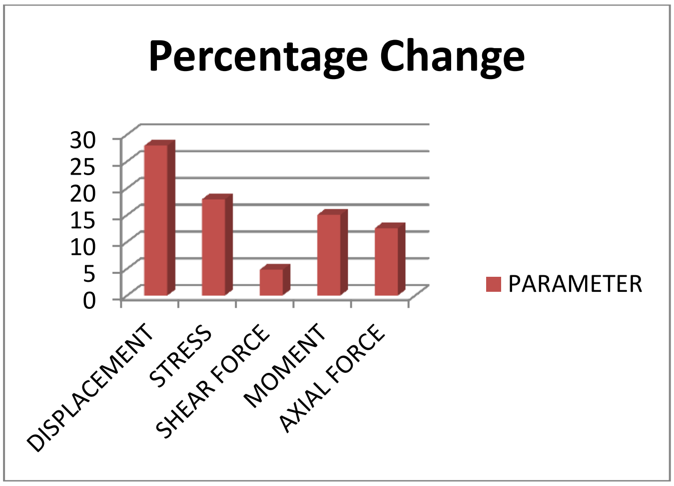
NOTE: Displacement values are taken @ U1 translation in Direction 1.



(a)



(b)



(c)

Chart (a), (b), (c) showing percentage change in various parameters for different storey building.

5. RESULT

Percentage change between RZF as zero to optimum value of RZF keeping RZF=0 as initial value the changes for different storeys are as follows-

Table-8: Percentage comparison

Storey	10	20	30
Percentage in displacement in top storey	21.43	29.09	27.94
Percentage change in stress in top storey	19.98	20.08	17.49
Percentage change in shear in top storey	3.09	16.38	4.8
Percentage change in moment	15.5	18.10	15.02

6. CONCLUSION

1. Study shows that there is different value of Rigidity Zone Factor for different storeys i.e. 0.78 for 10 storey building, 0.81 for 20 storey building, and 0.83 for 30 storey building.
2. At these values displacement is almost equal to the displacement obtained at full rigidity.
3. Hence it shows that at these values building is not fully rigid and the displacement is same as that in case of full rigidity but stiffness is low i. e. less chances of brittle failure.

7. ACKNOWLEDGEMENT

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