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To Study the Effect of Behavior Factor on Response of Framed Structure

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***Abstract*—Seismic analysis is considered as an important parameter for any structural design. The strength and ductility of frame members in seismic design depends on the response reduction factor. In my project 3 framed structures are considered of different heights under the Fourth zone condition. The primary emphases of this work are regarding calculation of response reduction factor values attained from designing RC framed structures. The results are computed by applying non-linear analysis. ETABS software is used for analyzing the non-linear behavior of the structure. Hence, in the present research, it is attempted to investigate the sufficiency of the code-based 'R' factor in assessment of seismic behavior using nonlinear dynamic analysis (NLD) for the structural models considered. Moreover, the results obtained, clearly envisages the influence of structural configuration changes on dynamic characteristics in terms of ductility and over strength values. It can be clearly observed that, the code specified constant 'R' for a particular structural type appears erroneous, emphasizing the need for its adequate estimation. This should involve consideration of the dynamic characteristics of the structure resulting in a realistic assessment of seismic demand, thereby contributing to a safe, functional and economical design configuration.**

Keywords: Seismic behavior, Ductility factor Over strength factor Response reduction factor, dynamic analysis.

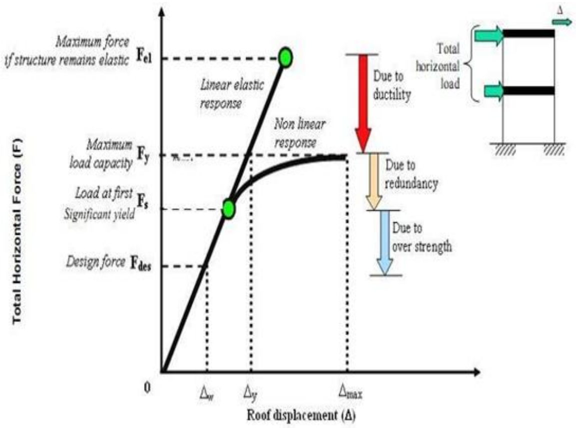
I. INTRODUCTION

There are many natural hazards in the world but earthquakes are one of the most destructive natural hazards that can result in severe social and economic impact, so that earthquake engineering has developed as a branch of engineering concerned with the estimation of earthquake impacts, since last few decades. Earthquake forces are random in nature and unpredictable, the static and dynamic analysis of the structures have become the primary concern. The basic principle in design of any structure for seismic loading is that it should not collapse but some amount of structural damage may be allowed that can be repaired after seismic activity. Therefore, while designing the structure and to keep the structure within elastic it must be designed for less seismic forces compared to that obtained due to severe shaking. Seismic design of structures is based on elastic force. The nonlinear response of structure is not incorporated in design philosophy but its effect is incorporated by using appropriate behavior factor in seismic coefficient method the actual base shear can be reduced with the help of behavior factor(R). This reduced base shear makes the structure to behave elastically during earthquake shaking. R factor is used in seismic coefficient method for earthquake resistant design to reduce base shear for obtaining design lateral force.

According to IS 1893-2016 definition, R factor which is used to reduce actual base shear forces to design lateral forces, because at design basis earthquake shaking structure should remain in elastic response. In Indian seismic code IS 1893- 2016 value of R for reinforced concrete structures is varies from 3 to 5 in IS 1893 depending on the type of moment resisting frame (OMRF), special moment resisting frame (SMRF) and latest intermediate moment resisting frame (IMRF). R factor reflects the capability of the structure to dissipate energy through inelastic behavior. R factor is the function of different parameters such as: Strength, Ductility, Damping, and Redundancy. The relation between R and above-mentioned parameter is mathematically expressed as

$$R = R_{\mu}\, \Omega\, \mathrm{R_R}\, \mathrm{R_\xi}$$

Where, $R\mu$, Ω, RR and $R\xi$ stand for ductility, overstrength, redundancy and damping factors. The evaluation of behavior factor is done using static nonlinear Pushover Analysis and Time history



II. CONCEPT OF REDUCTION FACTOR.

The code provision allows the structure to be damaged in the case of sever shaking.Hence, the structure is designed for seismic force much lesser than that expected under strong earthquakes if the structure were to remain linearly elastic. Thus, the Indian seismicstandard IS 1893 provides Response reduction factor. In other words, the term R gives an indication of the level of over strength and ductility that a structure is expected to have. Thus, the structure can be designed for much lower force than is implied by the strong shaking by considering the following factors, overstrength factor (Rs), redundancy factor (Rr), ductility factor (Rμ) which will prevent the collapse of the structure. Response reduction factor 'R' is mainly dependent on three factors.

$$R=R\mu\times Rs\times Rr$$

Where.
Rs=Over strength factor
Rμ =Ductility factor
Rr=Redundancy factor

III. PROBLEM FORMULATION

Proposed Work
After exclusive study of literature carried by various researchers, the unfocused area is identified as problem for proposed dissertation. carried out using following points

1. The main objective of this study is analyzing the different height of building using different response factor to achieve the most economical and stable structure.
2. To perform dynamic analysis of RCC structure using G+5, G+7 and G+9 story building using time history method.
3. To evaluate response reductions factor using push over analysis.

MODEL PROPERTIES :
Three reinforced concrete RC framed structures having the same number of bays, but different number of storeys are considered in this study. Five, Seven and nine storey models were created for R =1,3,5 . Each storey height is 3 m and the total width of the building in X-direction is 20 m with 5m bay width and the total width in Y-direction is 12 m with 4m bay width. The building Plan and elevation for a 5 ,7 and 9 storey model is shown in Figure 1 ,2 and 5.M-25 grade of concrete and Fe-500 grade of reinforcing steel are used for all the models in this study. A slab of thickness of 150 mm, wall of thickness of 230 mm and height 3 m, a parapet of height 1.2 m and thickness 230 mm were assumed. The dead loads were assigned as per IS 875 (Part 1) 12 and live loads as per IS 875 (Part 2) 3. Seismic loads were computed as per IS 1893 2016 . The seismic parameters assumed are zone IV, medium soil condition, R=1,3 for OMRF and R=5 for SMRF, damping 5%, importance factor 1.

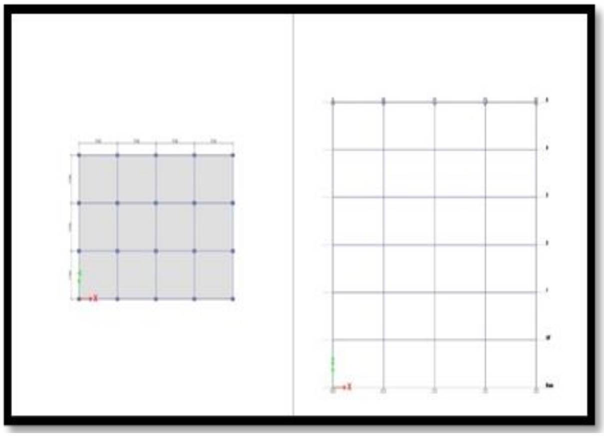
Mechanical Property of Reinforcement Steel

Storey height	Beam size	Column size
G+5	230X380	GF,1^{st},2^{nd} =300x450
	230X450	3^{rd},4^{th},5^{th} =300x380
G+7	230x380	GF,1^{ST},2^{ND} =300X550
	230x450	3^{RD},4^{TH},5^{TH} =300X450
		6^{TH},7^{TH} =300X380
G+9	230X380	GF,1^{ST},2^{ND},3^{RD} =300X600
	230X450	4^{TH},5^{TH},6^{TH} =300X550
		7^{TH},8^{TH},9^{TH} =300X450

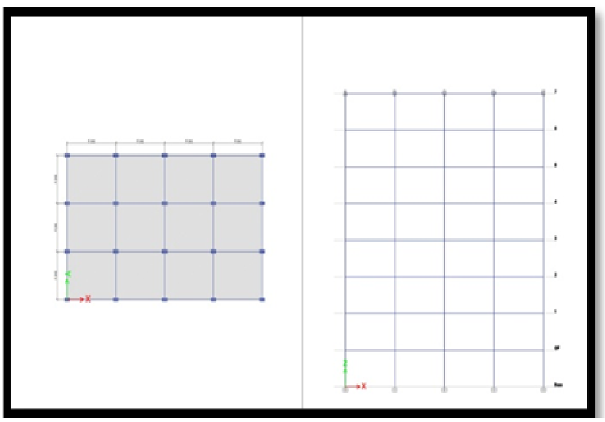
Types of Loads
Unless otherwise specified, all loads listed, shall be considered in design for the Indian Code following load combinations shall be considered.
Load case
1) DL: Dead load
2) LL: Live load
3) EQ: Earthquake load

Load combination
1. 1.5DL+1.5LL
2. 1.2DL+1.2LL + 1.2EX
3. 1.2DL+1.2LL- 1.2EX
4. 1.2DL+1.2LL+ 1.2EY

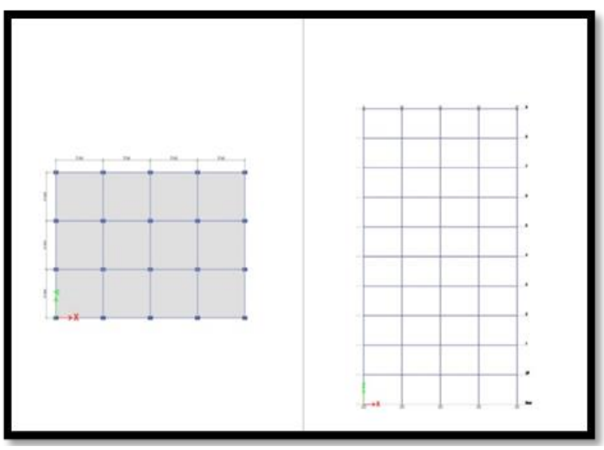
5. 1.2DL+1.2LL - 1.2EY
6. (0.9DL±1.5EQ)



G+5 Story Building Model



G+7 Story Building Model



G+9 Story Building Model

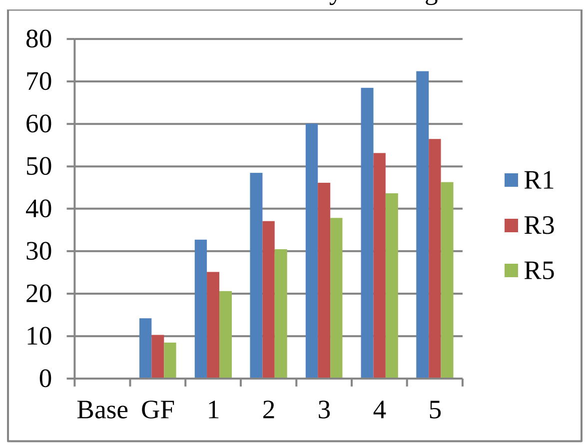
IV. RESULTS

Time History Results-Analysis of RCC G+5, G+7 & G+9 story building in different response factor i.e., 1, 2 & 3 with time history method in darfild Earthquake.

G+5 story building Displacement Results for Darfield earthquake for different Response Reductions Factor.

Ground Motion Darfield				
Story	Elevation	R=1	R=3	R=5
	m	mm	mm	mm
Base	0	0	0	0
GF	3	14.191	10.291	8.45
1	6	32.718	25.093	20.596
2	9	48.492	37.084	30.438
3	12	60.044	46.118	37.856
4	15	68.527	53.143	43.624
5	18	72.41	56.418	46.312

Graph . Darfield earthquake for different Response Reductions Factor at G+5 story building

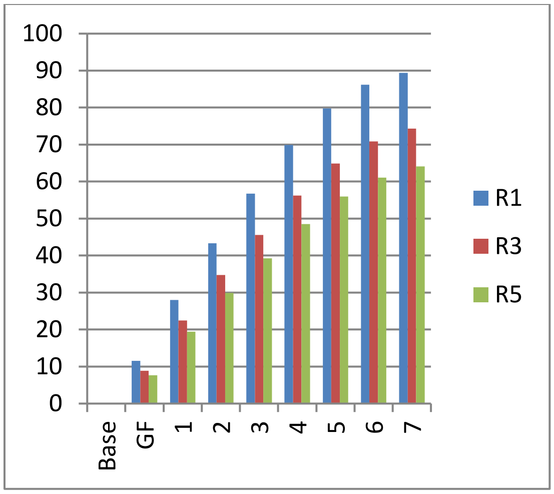


The Analysis of G+5 story structure for different response reductions factors i.e., 1, 3 & 5, in time history analysis method displacement shows 31.89% and 21.82% decreases

G+7 story building Displacement Results for Darfield earthquake for different Response Reductions Factor

Ground Motion Darfield				
Story	Elevation	R=1	R=3	R=5
	m	mm	mm	mm
Base	0	0	0	0
GF	3	11.569	8.832	7.613
1	6	27.997	22.504	19.4
2	9	43.358	34.727	29.937
3	12	56.729	45.563	39.278
4	15	69.935	56.267	48.506
5	18	79.755	64.928	55.973
6	21	86.192	70.895	61.116
7	24	89.404	74.319	64.068

Graph . Darfield earthquake for different Response Reductions Factor at G+7 story building

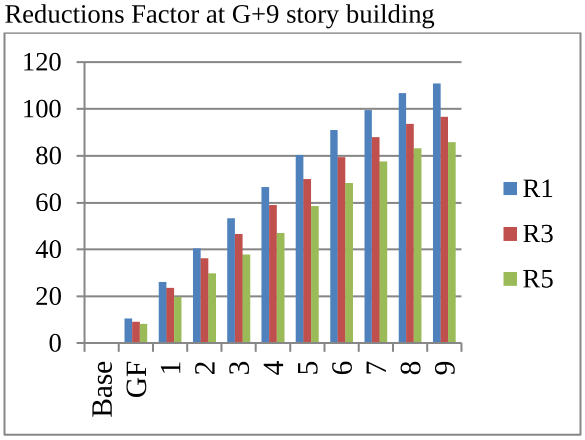


The Analysis of G+7 story structure for different response reductions factors i.e., 1, 3 & 5, in time history analysis method displacement shows 20.29% and 16% decreases

G+9 story building Displacement Results for Darfield earthquake for different Response Reductions Factor

Ground Motion Darfield				
Story	Elevation	R=1	R=3	R=5
	m	mm	mm	mm
Base	0	0	0	0
GF	3	10.549	9.161	8.146
1	6	26.125	23.634	19.87
2	9	40.469	36.194	29.715
3	12	53.228	46.748	37.769
4	15	66.577	59	47.078
5	18	80.388	69.979	58.435
6	21	91.041	79.29	68.462
7	24	99.572	87.871	77.578
8	27	106.822	93.648	83.166
9	30	110.912	96.592	85.691

Graph Darfield earthquake for different Response Reductions Factor at G+9 story building



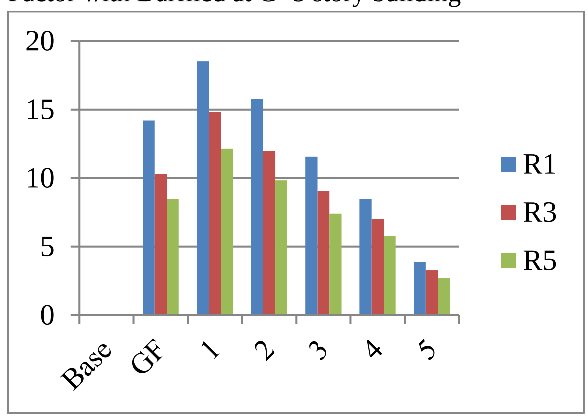
The Analysis of G+9 story structure for different response reductions factors i.e., 1, 3 & 5, in time history analysis method displacement shows 14.82% and 12.72% decreases

Story Drift Results

Table. G+5 Story Drift Building Results for Different Response Reductions Factor with Darfield Earthquake

Ground Motion Darfield				
Story	Elevation	R=1	R=3	R=5
	m	mm	mm	mm
Base	0	0	0	0
GF	3	0.0047	0.00343	0.00281
1	6	0.00617	0.004934	0.004048
2	9	0.005258	0.003997	0.00328
3	12	0.003986	0.003011	0.002472
4	15	0.00282	0.00234	0.001922
5	18	0.00129	0.00109	0.000896

Graph Story Drift Vs. Different Response Reductions Factor with Darfiled at G+5 story building



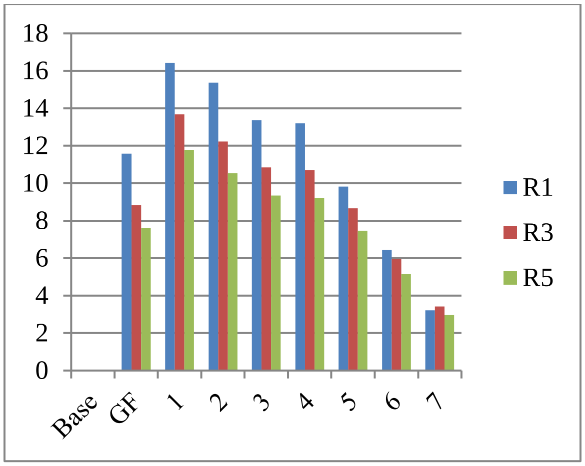
The Drift ratio of G+5 story structure for different response reductions factors i.e., 1, 2 & 3 is 20% and 17%

Table. G+7 Story Drift Building Results for Different Response Reductions Factor with Darfield earthquake.

Ground Motion Darfield				
Story	Elevation	R=1	R=3	R=5
	m	mm	mm	mm
Base	0	0	0	0
GF	3	0.00385	0.00294	0.00253
1	6	0.00547	0.0045	0.00392
2	9	0.00512	0.00407	0.00351
3	12	0.00457	0.00361	0.0031
4	15	0.0044	0.00356	0.003
5	18	0.00327	0.002887	0.002477

6	21	0.00214	0.00198	0.00171
7	24	0.00107	0.0011	0.0009

Graph Story Drift Vs. Different Response Reductions Factor with Darfield earthquake at G+7 story building

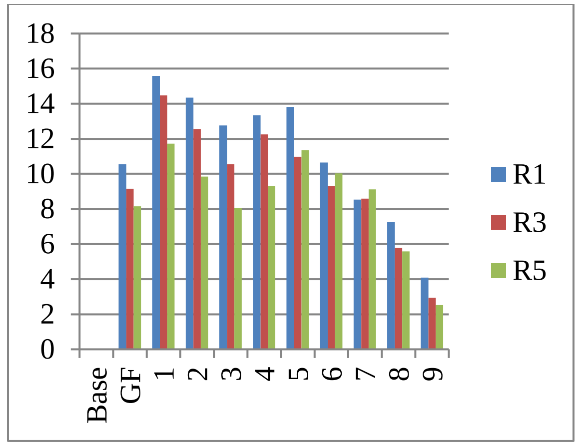


The Drift of G+7 story structure for different response reductions factors i.e., 1, 2 & 3 is 18% and 13%

Table. G+9 Story Drift Building Results for Different Response Reductions Factor with Darfield Earthquake

Ground Motion Darfield				
Story	Elevation	R=1	R=3	R=5
	m	mm	mm	mm
Base	0	0.00351	0.00305	0.00271
GF	3	0.00519	0.00482	0.0039
1	6	0.00478	0.00328	0.00328
2	9	0.00425	0.00268	0.00268
3	12	0.0044	0.0031	0.0031
4	15	0.0046	0.00378	0.00378
5	18	0.00355	0.00334	0.00334
6	21	0.00284	0.00303	0.00303
7	24	0.00241	0.00192	0.00186
8	27	0.00136	0.000981	0.00084
9	30	0.00351	0.00305	0.00271

Graph . Story Drift Vs. Different Response Reductions Factor with Darifield Earthquake at G+9 story building

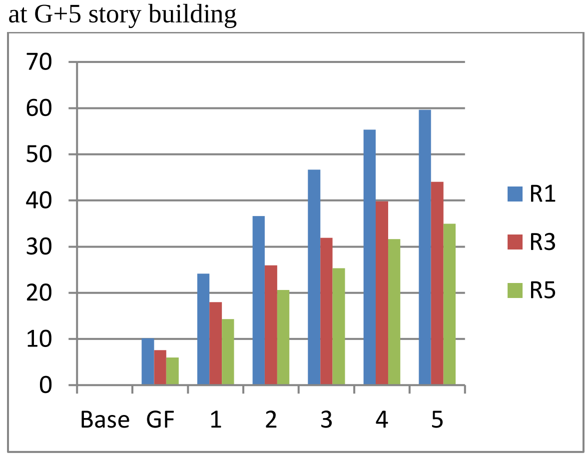


The drift of G+9 story structure for different response reductions factors i.e., 1, 2 & 3 is 7.5% and 19%

Table . G+5 story building Displacement Results for Valley earthquake for different Response Reductions Factor

Ground Motion: Valley				
Story	Elevation	R=1	R=3	R=5
	m	mm	mm	mm
Base	0	0	0	0
GF	3	10.132	7.563	6.006
1	6	24.119	17.969	14.27
2	9	36.617	25.942	20.601
3	12	46.704	31.878	25.315
4	15	55.332	39.842	31.639
5	18	59.601	44.008	34.948

Graph . Earthquake displacement vs. Valley earthquake for different Response Reductions Factor at G+5 story building

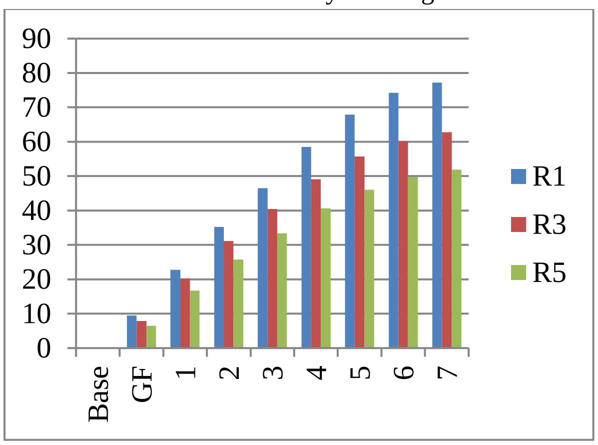


The Analysis of G+5 story structure for different response reductions factors i.e., 1, 3 & 5, in time history analysis method displacement shows 26.16% and 20.58% decreases.

Table . G+7 story building Displacement Results for Valley earthquake for different Response Reductions Factor

Ground Motion: Valley				
Story	Elevation	R=1	R=3	R=5
	m	mm	mm	mm
Base	0	0	0	0
GF	3	9.505	7.865	6.497
1	6	22.778	20.273	16.748
2	9	35.199	31.148	25.731
3	12	46.479	40.43	33.399
4	15	58.461	49.141	40.595
5	18	67.922	55.744	46.05
6	21	74.196	60.19	49.722
7	24	77.251	62.8	51.878

Graph valley earthquake for different Response Reductions Factor at G+7 story building.

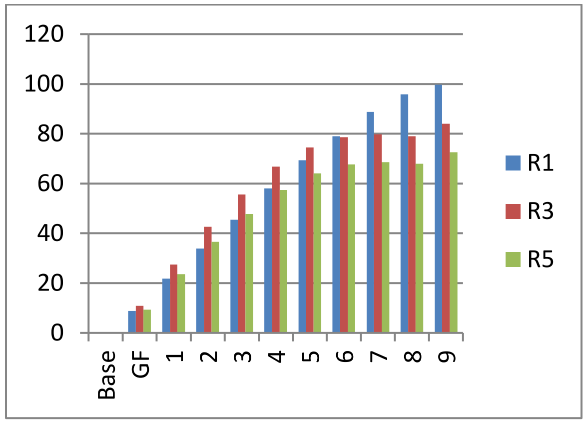


The Analysis of G+7 story structure for different response reductions factors i.e., 1, 3 & 5, in time history analysis method displacement shows 23.01% and 18.87% decreses.

Table . G+9 story building Displacement Results for valley earthquake for different Response Reductions Factor

Ground Motion: Valley				
Story	Elevation	R=1	R=3	R=5
	m	mm	mm	mm
Base	0	0	0	0
GF	3	8.799	10.806	9.283
1	6	21.763	27.478	23.615
2	9	33.82	42.608	36.631
3	12	45.419	55.552	47.769
4	15	58.087	66.8	57.45
5	18	69.311	74.455	64.033
6	21	78.981	78.65	67.64
7	24	88.76	79.783	68.611
8	27	95.887	78.932	67.943
9	30	99.64	84.047	72.529

Graph valley earthquake for different Response Reductions Factor at G+9 story building

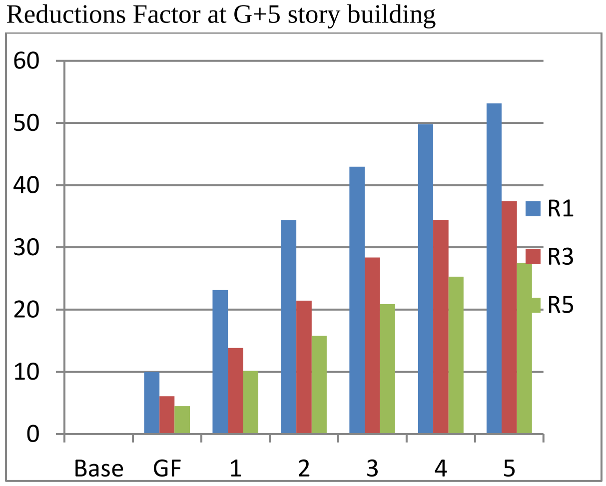


The Analysis of G+9 story structure for different response reductions factors i.e., 1, 3 & 5, in time history analysis method displacement shows 18.55% and 15.88% decreses

Table . G+5 story building Displacement Results for Managua earthquake for different Response Reductions Factor

Ground Motion: Managua				
Story	Elevation	R=1	R=3	R=5
	m	mm	mm	mm
Base	0	0	0	0
GF	3	9.982	6.074	4.466
1	6	23.146	13.814	10.157
2	9	34.393	21.435	15.761
3	12	42.993	28.375	20.864
4	15	49.796	34.429	25.316
5	18	53.127	37.422	27.516

Graph . Managua earthquake for different Response Reductions Factor at G+5 story building

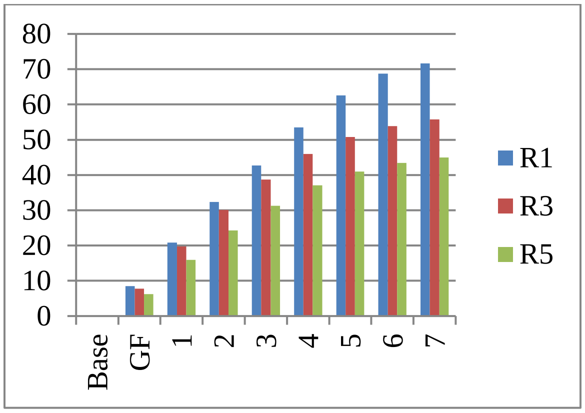


The Analysis of G+5 story structure for different response reductions factors i.e., 1, 3 & 5, in time history analysis method displacement shows 29.56% and 26.47% decreases

Table . G+7 story building Displacement Results for Managua earthquake for different Response Reductions Factor

Ground Motion: Managua				
Story	Elevation	R=1	R=3	R=5
	m	mm	mm	mm
Base	0	0	0	0
GF	3	8.523	7.766	6.263
1	6	20.842	19.73	15.911
2	9	32.375	30.129	24.298
3	12	42.688	38.716	31.223
4	15	53.507	45.972	37.074
5	18	62.57	50.802	40.97
6	21	68.747	53.824	43.406
7	24	71.674	55.77	44.976

Graph . Managua earthquake for different Response Reductions Factor at G+7 story building

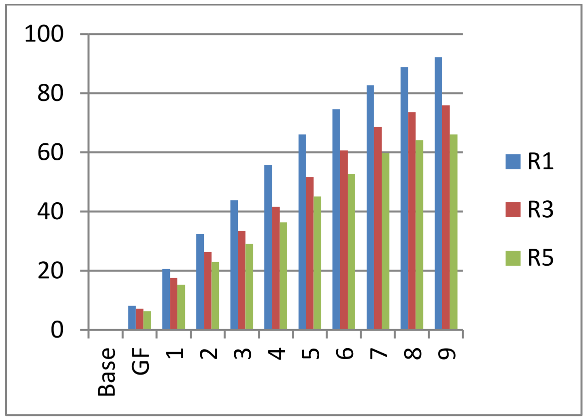


The Analysis of G+7 story structure for different response reductions factors i.e., 1, 3 & 5, in time history analysis method displacement shows 28.51% and 23.99% decreases

Table . G+9 story building Displacement Results for Managua earthquake for different Response Reductions Factor

Ground Motion: Managua				
Story	Elevation	R=1	R=3	R=5
	m	mm	mm	mm
Base	0	0	0	0
GF	3	8.211	7.215	6.284
1	6	20.54	17.599	15.328
2	9	32.366	26.319	22.923
3	12	43.86	33.453	29.136
4	15	55.798	41.698	36.318
5	18	66.07	51.756	45.078
6	21	74.57	60.638	52.813
7	24	82.749	68.712	59.846
8	27	88.833	73.661	64.156
9	30	92.213	75.898	66.105

Graph. Managua earthquake for different Response Reductions Factor at G+9 story building



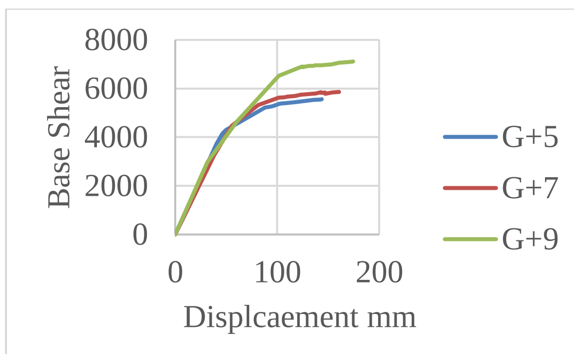
The Analysis of G+9 story structure for different response reductions factors i.e., 1, 3 & 5, in time history analysis method displacement shows 21.49% and 14% decreases

PUSHOVER PARAMETERS

Table Pushover Analysis for Response Reductions Factor (R) 1

Model	Yield Displ	Max Displ	Design Base Shear	Max base shear
G+5	51.303	143	473	5561
G+7	59.637	160	5086	5860
G+9	68.903	174	6341	7315

Graph Base Shear Vs. Displacement for Response Reductions Factor 1

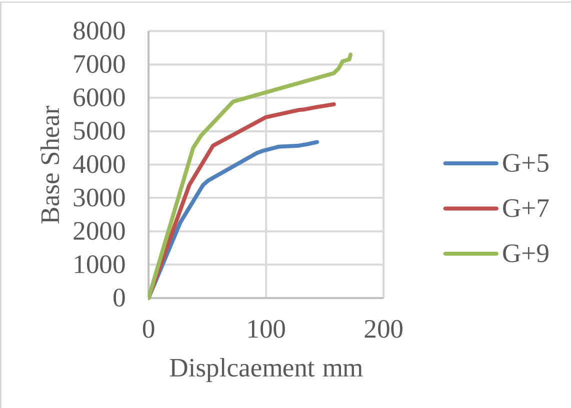


The Pushover Analysis of Different height of structure i.e., G+5, G+7 & G+9 story structure for response reductions factor 1, in yield displacement, displacement is increased with professional to height of structure i.e., 11.62%, 13.43 % as compare to G+5 story building and also base shear is increased 10.53%, 13.15% as compare to G+5 story building

Table : Pushover Analysis for response reductions factor (R)3

Model	Yield Displ	Max Displ	Design Base Shear	Max base shear
G+5	43	143	3654	4674.03
G+7	47	157	5116	5817.64
G+9	57	171	6498	7296.11

Graph Base Shear Vs. Displacement for Response Reductions Factor 3

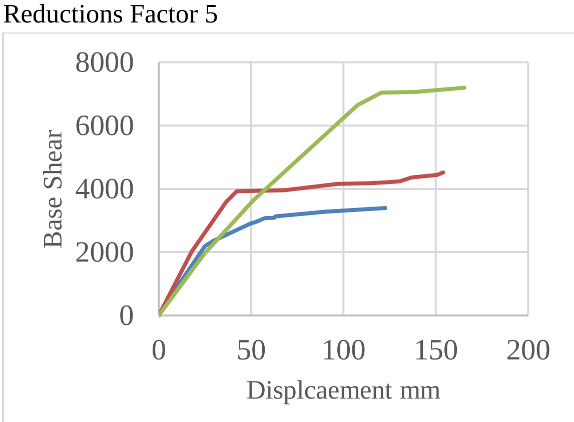


The Pushover Analysis of Different height of structure i.e., G+5, G+7 & G+9 story structure for response reductions factor 3, in yield displacement, displacement is increased with porporinol to height of structure i.e., 10.8%, 13.16 % as compare to G+5 story building and also base shear is increased 12.44%, 15.16% as compare to G+5 story building.

Table : Pushover Analysis for Response Reductions Factor (R) 5

Model	Yield Displ	Max Displ	Design Base Shear	Max base shear
G+5	30	122	2663	3394
G+7	46	153	3781	4520
G+9	56	165	4560	5295

Graph Base Shear Vs. Displacement for Response Reductions Factor 5



The Pushover Analysis of Different height of structure i.e., G+5, G+7 & G+9 story structure for response reductions factor 3, in yield displacement, displacement is increased with proportional to height of structure i.e., 15.27%, 18.66 % as compare to G+5 story building and also base shear is increased 13.316%, 15.598% as compare to G+5 story building.

Calculation of R=1 Factor.

Model	ductility	Overstrength	R
G+5	2.80	1.17	3.276
G+7	2.6935	1.15	3.097
G+9	2.5343	1.14	2.88

Calculation of R=3 Factor.

Model	ductility	Overstrength	R
G+5	3.3843	1.21	4
G+7	3.24	1.13	3.66
G+9	2.98	1.12	3.33

Calculation of R=5 Factor.

Model	ductility	Overstrength	R
G+5	4.030	1.27	5.11
G+7	3.31	1.195	3.95
G+9	2.91	1.16	3.37

Analysis of RCC building with different response reductions factor i.e., 1, 3 & 5 using for different height structure G+5, G+7 and G+9 story, R factor is decreased with proportional to increased height of structure and also response reductions factor 3 & 5 show good performance in RCC structure.

V. CONCLUSION

In the present study, Analysis of RCC G+9, G+7, G+5 story structure with Response Reductions Factors i.e., 1, & 5 in earthquake zone III using medium soil, and also different method is used for analysis i.e., Response Spectrum Method, Time History Analysis Method and push over analysis method.

1. The displacement is increased as compare to height but percentage variations is same in all different height of structure.
2. From time history analysis method it is conclude that displacement is increses when the R factor decreases
3. Analysis of RCC building with different response reductions factor i.e., 1, 3 & 5 in pushover analysis, for different height structure G+5, G+7 and G+9 story, R factor is decreased with proportional to increased height of structure and

also response reductions factor 3 & 5 show good performance in pushover analysis.

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