International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 06, June-2019

Evaluation of R factor using Pushover Analysis

Nayan Survase[1], Dr. M. R. Shiyekar[2]

[1]*Mtech Student of Structural Engineering, Applied Mechanics Department*
[2]*Adj. Professor, Applied Mechanics Department*

Abstract*— SMRF and OMRF frames are been used along with and without concentric and eccentric braces to compare the base shear capacity and ductility of buildings. SMRF frames are commonly used as it is used in highly seismic zones instead of OMRF. The response reduction factor R is evaluated for buildings with and without bracings provided in buildings. The performance of framed structure has been evaluated using pushover analysis. To achieve this objective; G+10, G+ 20 structures OMRF and SMRF, with and without bracings are carried out in ETABS 2016, and from the capacity curve, the R value is to be obtained by studying the parameters such as over strength and ductility reduction factor.

***Keywords*— OMRF, SMRF, Bracings, Pushover Analysis, Response Reduction Factor, Roof Displacement, Capacity Spectrum Curve, ETABS 2016**

I. INTRODUCTION

The main aim is to perform pushover analysis on commercial building of irregular shape with 10 and 20 story. The earthquake occurred in highly seismic region gave us the importance of lateral stability in structures. This problem is of significant importance to be investigated. Researchers figured out an effective idea of applying bracings to the framed structure like concentric and eccentric bracings. The bracing system provides the structure the capacity to sustain the energy, if the building is under seismic excitation. The structure requires a good amount of balance between strength, stability and energy dissipation.

Bracing system in structures plays a significant role in structural behaviour during earthquake. Steel bracing is an efficient and cost-effective solution for resisting lateral forces in a framed structure.

II. STRUCTURAL MODELLING

For the purpose of this study, G+10 and G+ 20 stories framed buildings with concentric and eccentric bracings are designed in order to determine the behaviour of the structure during high seismic activity. The material properties are selected on the basis of displacement limitations and strength as per IS 800-2007. The models are designed as OMRF and SMRF along with concentric and eccentric bracings. An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.

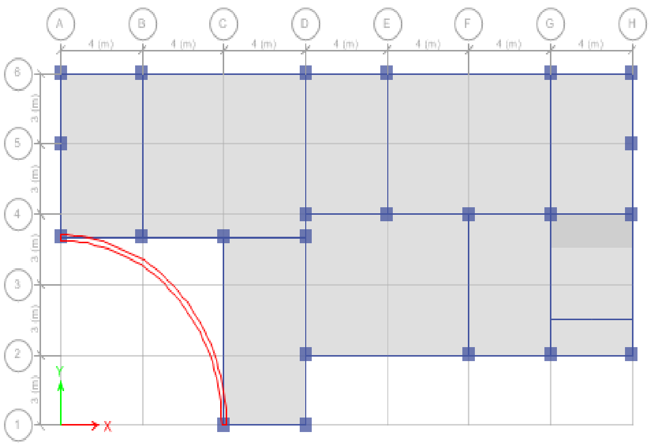

Fig. 1 Plan of an irregular building

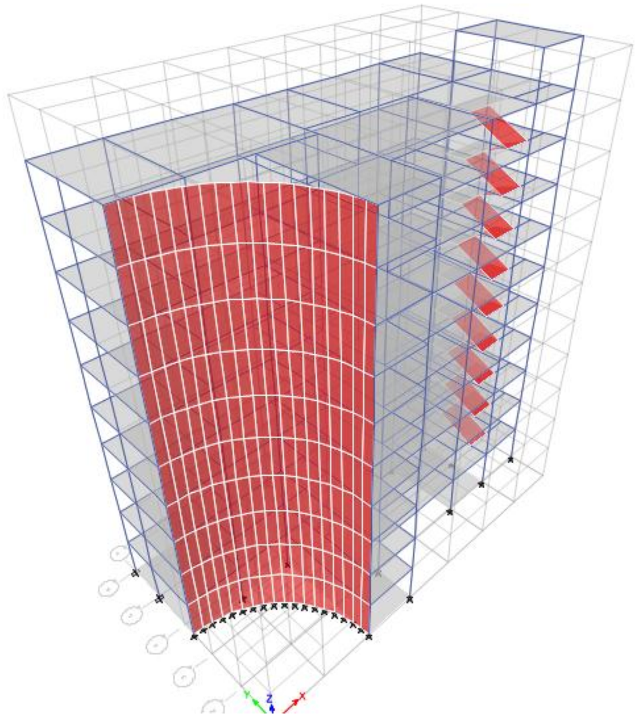

Fig. 2 3D view of an irregular building

III. STRUCTURE CONSIDERED FOR ANALYSIS

Model 1: 10th story bare frame

Model 2: 10th story bare frame with concentric bracing

Model 3: 10th story bare frame with eccentric bracing

Model 4: 20th story bare frame

Model 5: 20th story bare frame with concentric bracing

Model 6: 20th story bare frame with eccentric bracing

TABLE I
MATERIAL AND GEOMETRIC PROPERTIES

Serial no	**Material properties**	
1	Column size	600x600mm
2	Beam size	300x450mm
3	Bracing details	ISWB550
4	Thickness of slab	230mm
5	Grade of steel	HYSD500
6	Grade of concrete	M35
7	Live load	2 KN/m^2
8	Floor finish	1 KN/m^2
9	No. of stories	G+10, G+20
10	Floor to floor height	3 m
11	Type of soil	Medium soil
12	Seismic zone	4
13	Importance factor	1

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IV. RESPONSE REDUCTION FACTOR

The response reduction factor R, represents the ratio of maximum lateral force (Ve), to the lateral force (Vd). The response factor R is expressed as a function of various parameters of the structural system such as strength, ductility, damping, and redundancy.

$$R = R_s \; R_\mu \, R_\xi \; R_r$$

Where R_s is strength factor, R_r is redundancy factor, R_μ is ductility factor and R_ξ is damping factor.

V. STEEL BRACING SYSTEM

The bracings both concentric and eccentric carry the lateral load and transfer the axial load to the column.

- Concentric bracing increases the lateral stiffness of the frame which in turn increases the natural frequency and also decreases lateral story drift. This bracing increases axial compression in the columns to which they are connected by decreasing the bending moment and shear forces in columns.
- Eccentric bracing improves the energy dissipation capacity and reduces the lateral stiffness of system. At the point of connection of eccentric bracing on the beam, vertical component of the bracing force due to earthquake causes concentrated load.

VI. NON LINEAR STATIC ANALYSIS

Pushover is a method of non linear static analysis in which a structure is subjected to gravity load and a lateral load pattern controlled by monotonic displacement. Lateral load represents the range of base shear induced by earthquake loading. Non linear static analysis is performed on the structures to estimate the redundancy and ductility capacity, which is required to determine the R factor. In this procedure, the lateral load is distributed to the overall building height. In this analysis, non linear plastic hinges have been assigned to all the elements. Moment hinges (M3- hinges) are assigned to the beam and axial – moment 2 – moment 3 hinges (P-M2-M3) are assigned to the column.
The result of the non linear static pushover analysis is presented in the form of pushover curve which is a graph of base shear vs. Displacement.

VII. CAPACITY SPECTRUM METHOD

The capacity spectrum, a graphical procedure that compares the capacity of the structure with the demands of earthquake ground motion on the structure.
The capacity of the structure is represented by the force displacement curve obtained by non linear static pushover analysis. This graphical representation makes possible the evaluation of the structure as it performs when subjected to earthquake ground motions.

VIII. RESULTS AND DISCUSSION

1. STORY SHEAR

TABLE III

Story no.	10th story OMRF	10th story SMRF
Story 1	16.5	22.4
Story 2	16.3	22.2
Story 3	15.8	21.7
Story 4	15.0	20.8
Story 5	14.0	19.4
Story 6	12.6	17.6
Story 7	10.9	15.2
Story 8	9.0	12.3
Story 9	6.7	8.80
Story 10	4.1	4.70

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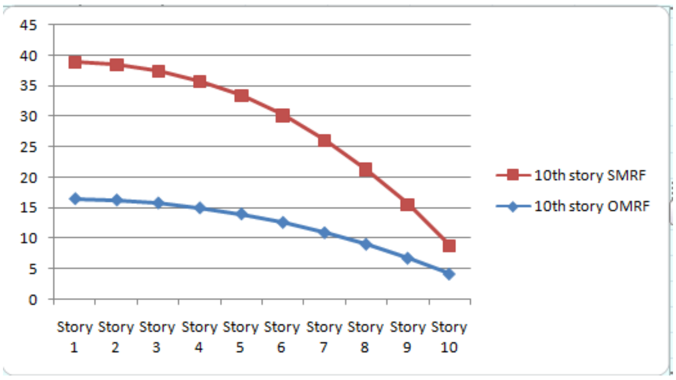

Fig. 3 Results of 10th story OMRF and SMRF

TABLE IIIII

Story no.	10th story concentric OMRF	10th story concentric SMRF
Story 1	16.4	25.7
Story 2	16.2	25.4
Story 3	15.7	24.7
Story 4	14.9	23.6
Story 5	13.9	21.9
Story 6	12.5	19.7
Story 7	10.8	16.9
Story 8	8.9	13.6
Story 9	6.6	9.6
Story 10	4.0	5.1

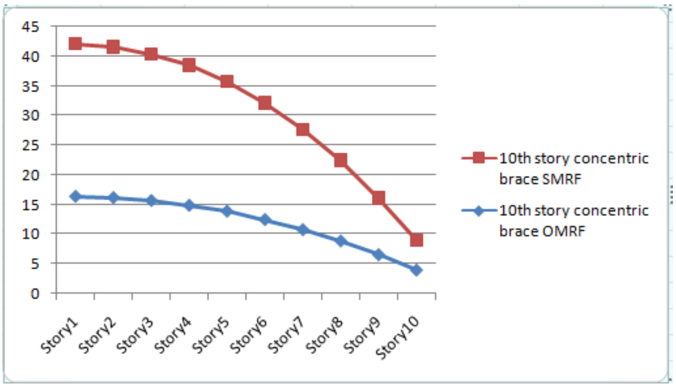

Fig. 4 Results of 10th story concentric OMRF and SMRF

TABLE IVV

Story no.	10th story eccentric OMRF	10th story eccentric SMRF
Story 1	25.4	31.5
Story 2	23.6	28.5
Story 3	21.8	25
Story 4	20.9	23.8
Story 5	19.6	22.2
Story 6	17.7	19.9
Story 7	15.3	17.1
Story 8	12.4	13.7
Story 9	8.8	9.7
Story 10	4.7	5.2

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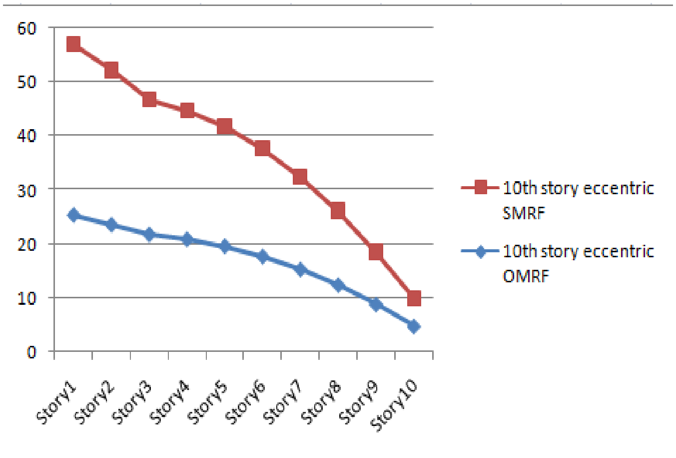

Fig. 5 Results of 10th story eccentric OMRF and SMRF

TABLE V

Story no.	20th story OMRF	20th story SMRF
Story 1	3.6	4.8
Story 2	3.5	4.8
Story 3	3.4	4.6
Story 4	3.3	4.4
Story 5	3.2	4.2
Story 6	3.0	3.9
Story 7	2.8	3.5
Story 8	2.6	3.1
Story 9	2.4	2.7
Story 10	2.1	2.3
Story 11	1.9	1.8
Story 12	1.7	1.5
Story 13	1.4	1.3
Story 14	1.2	1.2
Story 15	1.0	1.0
Story 16	0.8	0.9
Story 17	0.6	0.7
Story 18	0.4	0.5
Story 19	0.3	0.4
Story 20	0.1	0.2

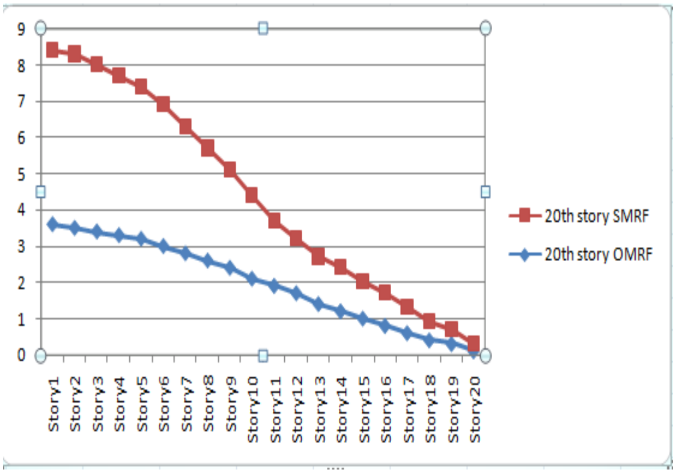

Fig. 6 Results of 20th story OMRF and SMRF

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TABLE VI

Story no.	20^{th}story concentric OMRF	20^{th}story concentric SMRF
Story 1	3.6	4.7
Story 2	3.5	4.6
Story 3	3.4	4.5
Story 4	3.3	4.3
Story 5	3.2	4
Story 6	3	3.7
Story 7	2.8	3.4
Story 8	2.6	3
Story 9	2.4	2.6
Story 10	2	2.2
Story 11	1.6	1.8
Story 12	1.5	1.7
Story 13	1.3	1.4
Story 14	1.1	1.2
Story 15	0.9	1
Story 16	0.7	0.8
Story 17	0.5	0.6
Story 18	0.45	0.5
Story 19	0.25	0.3
Story 20	0.1	0.2

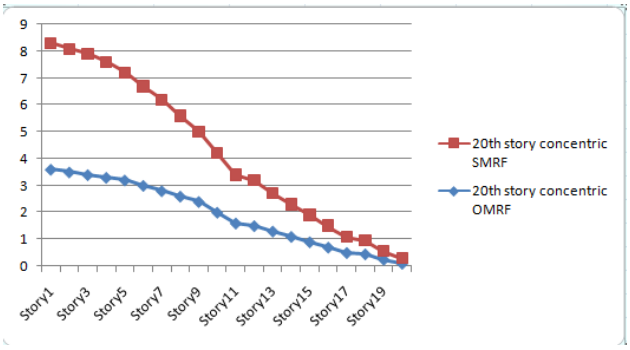

Fig. 7 Results of 20th story concentric OMRF and SMRF

2. STORY DRIFT

TABLE VII

Story no.	10th story OMRF	10th story SMRF
Story 1	4.47×10^{-7}	1×10^{-6}
Story 2	1×10^{-6}	2×10^{-6}
Story 3	2×10^{-6}	3×10^{-6}
Story 4	2×10^{-6}	4×10^{-6}
Story 5	3×10^{-6}	5×10^{-6}
Story 6	3×10^{-6}	5×10^{-6}
Story 7	3×10^{-6}	6×10^{-6}
Story 8	4×10^{-6}	6×10^{-6}
Story 9	4×10^{-6}	6×10^{-6}
Story 10	4×10^{-6}	6×10^{-6}

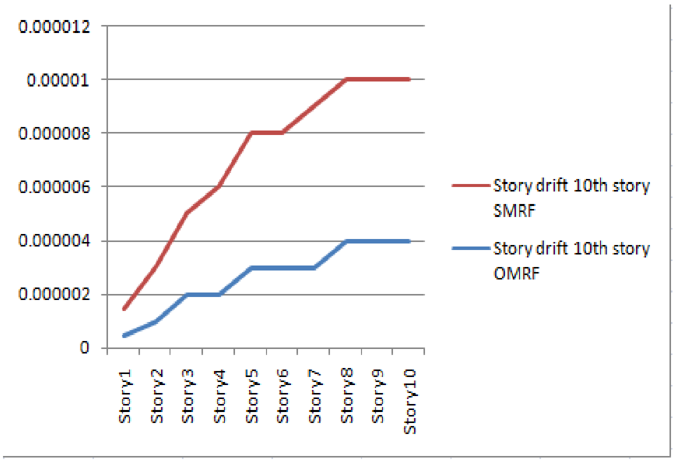

Fig. 8 Results of 10th story OMRF and SMRF

TABLE VIII

Story no.	20th story OMRF	20th story SMRF
Story 1	1.5×10^{-4}	2.8×10^{-4}
Story 2	1×10^{-3}	1.5×10^{-3}
Story 3	1×10^{-3}	2×10^{-3}
Story 4	2×10^{-3}	4×10^{-3}
Story 5	3×10^{-3}	6×10^{-3}
Story 6	5×10^{-3}	8×10^{-3}
Story 7	6×10^{-3}	1.1×10^{-2}
Story 8	7×10^{-3}	1.4×10^{-2}
Story 9	1×10^{-2}	1.7×10^{-2}
Story 10	1.5×10^{-2}	2×10^{-2}
Story 11	1.8×10^{-2}	2.3×10^{-2}
Story 12	2.1×10^{-2}	2.7×10^{-2}
Story 13	2.5×10^{-2}	3×10^{-2}
Story 14	2.8×10^{-2}	3.4×10^{-2}
Story 15	3.2×10^{-2}	3.7×10^{-2}
Story 16	3.5×10^{-2}	4.1×10^{-2}
Story 17	4.1×10^{-2}	4.5×10^{-2}
Story 18	4.3×10^{-2}	4.8×10^{-2}
Story 19	4.7×10^{-2}	5.2×10^{-2}
Story 20	5×10^{-2}	5.6×10^{-2}

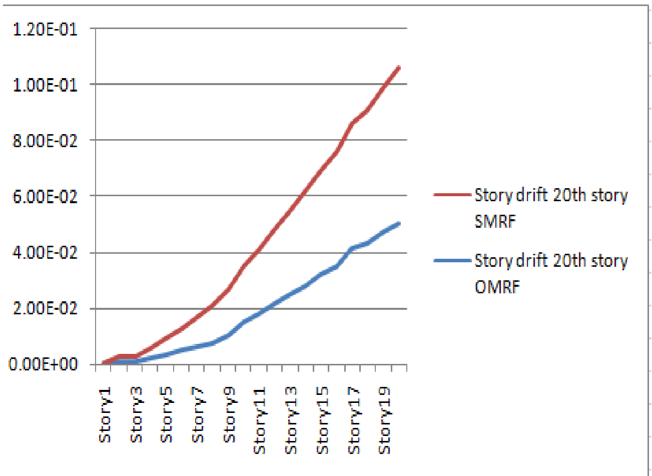

Fig. 9 Results of 20th story OMRF and SMRF

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IX. CALCULATION OF R FACTOR

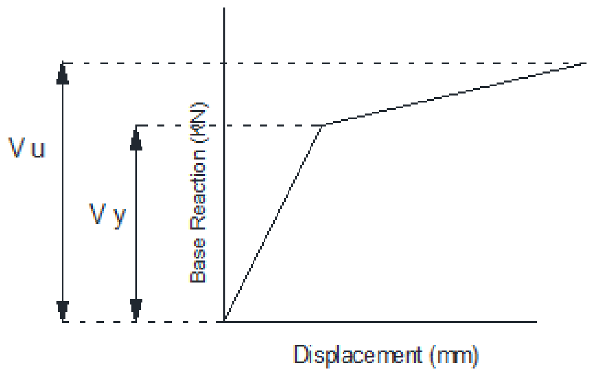

Fig. 10 Yield and Ultimate pionts

PUSHOVER PARAMETERS

- Vu = 270 KN
- Vy = 220 KN

The pushover parameters and R components in x and y direction are given in the table below:

TABLE IX

Model	Vu (KN)	Vy (KN)	Rr	$R\mu$	R
10S OMRF	270	220	1.227	2.24	2.73
10S SMRF	260	230	1.13	2.50	2.82
10S OMRF conc. Brace	160	140	1.143	2.61	2.97
10S SMRF conc. Brace	110	72	1.52	2.14	3.25
10S OMRF eccen. Brace	155	130	1.19	2.36	2.80
10S SMRF eccen. brace	100	80	1.25	3.04	3.8
20S OMRF	200	180	1.11	2.78	3.08
20S SMRF	360	325	1.10	2.76	3.04
20S OMRF conc. Brace	120	75	1.6	2.89	4.62
20S SMRF conc. Brace	500	300	1.67	3.13	5.22
20S OMRF eccen. Brace	135	88	1.53	3.48	5.33
20S SMRF eccen. brace	125	90	1.38	3.50	4.83

X. CONCLUSIONS

Effects on model have been shown in the graph and results are been discussed. Here, story shear and story drifts results are been shown for 10^{th} and 20^{th} story OMRF and SMRF. From the above results it is clear that SMRF gives better results than OMRF along with bracings. The bracing in the building reduces story displacement as compared to buildings without bracing for lateral loads. The use of bracings increases the stiffness of the structure and attracts more lateral force. The pushover analysis provides various performance limits under the effect of lateral loads.

REFERENCES

[1] Apurba Mondal, et.al "Performance based evaluation of response reduction factor for ductile RC frames", 2013, Engineering Structures 56, 1808-1819M. Young, The Technical Writers Handbook, Mill Valley, CA: University Science, 1989.
[2] Indian Standard Criteria for Earthquake Resistant Design of Structures Part I: General Provisions and Buildings, IS 1893: 2002. New Delhi: Bureau of Indian Standards.

[3] G. Brandonisio, et.al, “Seismic design of concentric braced frames”, Journal of Construction Steel Research, Vol. 78, pp. 22-37, 11//2012
[4] Arturo Tena-Colunga, et.al, “Assessment of Redundancy factors for seismic design of SMRF”, 2015 Latin American Journal of Solids and Structures, 12, 2330-2350.
[5] Divya Brahmavrathan and C. Arunkumar, “Evaluation of Response Reduction factor of irregular reinforced concrete framed structures”, 2016, Indian Journal of Science and Technology, 9(23)
[6] Popov EP, Engelhardt. E “Seismic eccentrically braced frames”, Journal of construct steel research Vol. 10 (1998), pp 321-354
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