

## Response Reduction Factor for Industrial Structures

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### Abstract

The Seismic design makes use of concepts of energy absorption and dissipation to reduce the design forces in order to achieve the economy. The behavior of Response Reduction factor (R) assumes a central role in the seismic design process, since design forces are the quotient of elastic forces. R factor is used in the seismic coefficient method for calculating base shear. This factor allows the structure to behave elastically. Response reduction factor (R) can be obtained by multiplication of over strength factor, ductility factor and redundancy factor and it can be calculated from the actual capacity curve of the structure. For finding out capacity curve we need to analyze structure by nonlinear static analysis method. Indian standards provides guideline for the values of response reduction factor of concrete structure like special moment resisting frame, ordinary moment resisting frame etc. and for steel structure like ordinary concentrically frames, special concentrically frames, eccentrically braced frames, ordinary moment frames, special moment frames. Composite industrial structures are getting more popular nowadays in construction industries due to minimization of cost. Indian standards don't give any guidelines regarding R factor for industrial structures. Present study is focused to evaluate this factor for composite industrial structure for both single bay and multiple bay systems.

### Keywords

Ductility Factor, Earthquake, Industrial Structure, IS 1893: 2002, Over Strength Factor, Response Reduction Factor,

### Introduction

In IS 1893:2002, value of response reduction factor is 3 for OMRF and 5 for SMRF for RCC building design. It does not specify any values for industrial and composite structures. Higher the value of response reduction factor means higher will be the ductility. This factor is incorporated in [2] seismic coefficient method for calculation of base shear. Thus it is necessary to understand the optimum value of [1] response reduction factor for designing industrial and composite structures. In this study industrial building having RCC column with steel trusses are analyzed and designed and its response reduction factors are calculated by using push over analysis in SAP 2000.[4]

### Mathematical Parameter and Analytical Parameter

In this paper, single bay and multi bay truss system with concrete column are analyzed and designed using SAP-2000 and M. S. Excel worksheets considering IS 456:2000 and IS 800:2007. Seismic Zone-V is selected, structure is assumed to be situated at Bhuj, open terrain is considered with well scattered obstruction having height generally between 1.5m to 10m.

For the comparative study single bay and multiple bay industrial structure of 30m length is considered.

For Non-linear analysis SAP-2000 is used and non-linear properties like M- $\phi$  & P-M-M curves for frames are assigned as per IS codes.

#### 1. Single Bay (15 x 30 m) [9]

##### Base Shear (X-dia) [4]

Total Seismic Weight of Building = 555.55 kN

Base Shear,  $V_b = A_h \times W$

= 0.09 x 555.55

= 50 kN

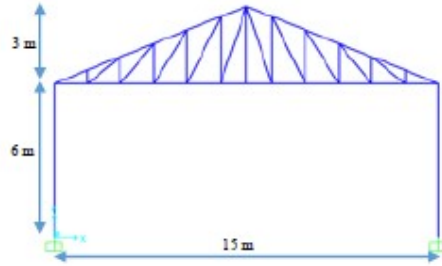


Fig.1: Elevation View of 15 m Span

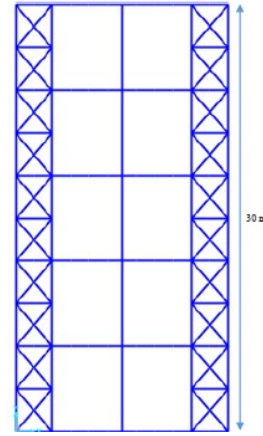


Fig. 2: Plan View of 15 m Span

**2. Multiple Bays (15 x 30 m)**

**Base Shear (X-dia) [4]**

Total Seismic Weight of Building = 1102.78 kN

Base Shear,  $V_b = A_h \times W = 0.09 \times 1102.78 = 99.25 \text{ kN}$

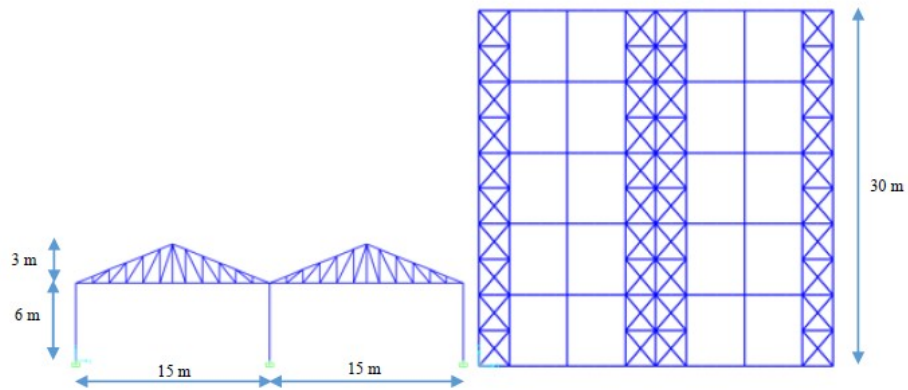


Fig. 3: Elevation & Plan View of Multiple Bay Structure of 30 m Span

**Pushover Curve of Single Bay and Multiple Bays Structure**

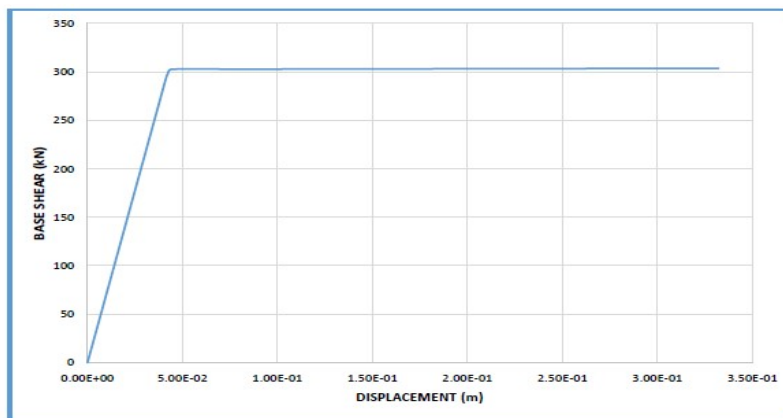


Fig. 4: Capacity Curve of Single Bay Structure of 30 m Span

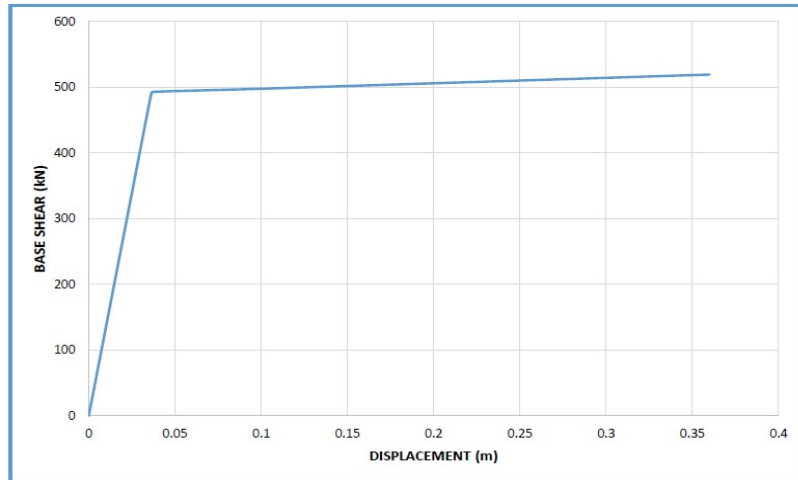


Fig. 5: Capacity Curve of Multiple Bays Structure of 30 m Span

### Results and Discussion

Span	length(m)	Vu(kN)	Vd(kN)	R
15m	30	265.2	50	5.30
2(15)m	30	449.5	99.25	4.53

Table 1: Results of Response Reduction Factor for 15 m Span Single Bay and 2 (15) m Span of 30 m Length

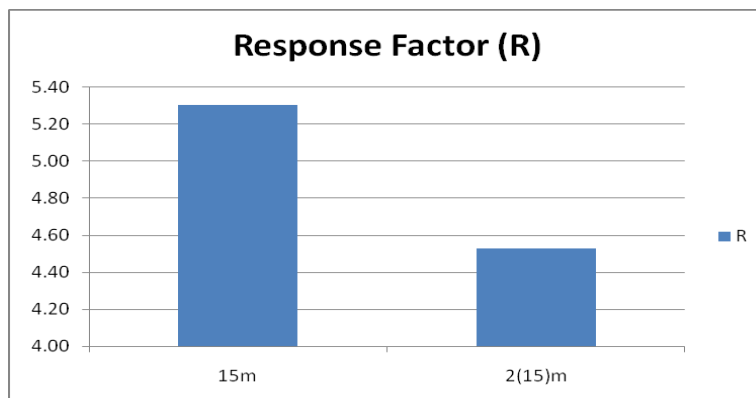


Fig. 6: Comparison of Response Reduction Factor for Single Bay and Multiple Bay Structure of 30 m Span

### Conclusion

Indian standard code does not specify value of response reduction factor to be used in seismic coefficient method for industrial structures. In this paper Study of single bay and multiple bay industrial structure of 30 m span are carried out. From the obtained results it can be observed that the value of response reduction factors increases with increase in bay. Also it can be concluded that lateral dimension of structural system influences the value of R factor. The R value for single bay industrial structure is 5.3 and for multiple bay industrial structure is 4.53. Furthermore research is required to conclude the optimum value of R factor for various configurations.

### References

1. Adeel Zafar:- "Response Modification Factor Of Reinforced Concrete Moment Resisting Frames In Developing Countries".
2. Apurba Mondal, Siddhartha Ghosh, G.R. Reddy:- "Performance-based evaluation of the response reduction factor for ductile RC frames" Elsevier-2013.

3. Hemchandra Chaulagain, Hugo Rodrigues, Enrico Spacone, Ramesh Guragain, Radhakrishna Mallik and Humberto Varum:- “Response reduction factor of irregular RC buildings in Kathmandu valley” Earthquake Engineering and Engineering Vibration September 2014, Vol. 13, Issue 3, pp 455–470.
4. Indian standard code – IS 1893 : 2016 & IS 875 part 1-3.
5. Krawinkler H and Nassar A (1992):- “Seismic design based on ductility and cumulative damage demands and capacities, Nonlinear Seismic Analysis and Design of Reinforced Concrete Buildings”, Elsevier Applied Science, 95-104.
6. Minnu M. M. (MAY-2014):- “Evaluation of Response Reduction Factors for Moment Resisting RC Frames” M.Tech Thesis, NIT Rourkela.
7. Miranda and Bertero (1994):- “Evaluation of Strength Reduction Factors for Earthquake-Resistant Design”.
8. Monika Dagliya, Vivek Kumar Goud:- “Composite Truss- A new Approach to Composite Framing Structures” Volume 2, Issue 3, March 2013, ISSN - 2250-1991.
9. N. Subramanian:- Design of Steel Structure, Oxford University Publication.
10. Park R. (1988):- “Ductility evaluation from laboratory and analytical testing” Proceedings of the 9th World Conference on earthquake Engineering, Tokyo, Japan Vol.VIII, pp.605-616.
11. Podudolu Rani, D Rambabu:- “Determination of moment resisting RC frames of response reduction factors” International Journal of Advance Research in Science and Engineering, Vol. 7, Issue 6, June 2018.
12. Rahul Pandey:- “Comparative Seismic Analysis of RCC, Steel & Steel-Concrete Composite Frame” Department of Civil engineering National Institute of technology Rourkela, 2014.
13. S. A. Raji, K. K. Abdulraheem, R. O. Rahmon, A. A. Adelowo:- “Design Of A Composite Truss System In A Multistorey Building” Journal of Multidisciplinary Engineering Science and Technology (JMEST) ISSN: 2458-9403 Vol. 4 Issue 3, March– 2017.
14. Shaikh Muffassir , L.G. Kalurkar:- “Study of wind analysis of multi-story composite structure for plan irregularity” International Journal of Advance Research in Science and Engineering, Vol. 7, Issue 6, June 2018.
15. Varghese Basil Alexander, Dominic Ashwin W, Anand N, Jayalin D:- “Studies on Effect of Lateral Force on Different Types of Composite Building Frame Systems” International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-7, Issue-6, March 2019.