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# Computation of 'R' Factor for SMRF and OMRF Frame Using Nonlinear Time History Analysis

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***Abstract: The building vulnerability to seismic hazards is higher in developing nations with high seismicity than in developed countries. This is primarily due to a scarcity of seismic design concepts that are suited for the kind of structural systems and procedures used in such areas. Many developing countries use the well-developed seismic design codes used in the United States (US) or Europe as R factors. These R factors are unjust because they give a skewed picture of the structural techniques applied in developing countries. As a result, true R factors for the diverse structural systems employed by these countries are urgently required. The R factor of reinforced concrete (RC) moment resistant frames (MRFs) in India was determined using nonlinear time history analysis (NLTHA). To investigate the effect of these parameters on R factor, a parametric study involving RC SMRF and OMRF frames with varying zone and dimensional properties was done. Parameters such as tale drift, displacement, and base shear will be derived from OMRF and SMRF frame studies, and the computed response reduction factor will be compared to IS1893From the analysis results it was found out that Over strength and Response modification factor is decreasing up to 25% as increasing the height of the building and is also decreasing up to 30% from Seismic Zone II to Zone V.***
***Keywords: Response Reduction Factor, Ductility Factor, Redundancy Factor, Over Strength Factor, Damping Factor, NLTHA***

## I. INTRODUCTION

Many developing nations' R factors are based on well-developed seismic design rules used in the United States and Europe. These developing countries face more severe seismic risk than developed nations, but they lack the technology to build structures in accordance with seismic norms. India is an example of a developing nation that confronts a significant seismic risk because to its proximity to a major fault zone. India will be used as an example of other emerging countries with similar seismic susceptibility in this research. India has adopted earthquake resistant provisions based on the United States' code of practice. Because of the various levels of seismic danger and building inventory in India, structures are vulnerable in different ways than those in the United States. As a result, it is acceptable to conclude that structures in India are more vulnerable to earthquakes than those in affluent countries. This is due to a lack of earthquake design principles appropriate for the types of buildings and construction processes employed in India. As a result, using R factors estimated for the United States provides an inaccurate representation of the structural techniques used in India, and is therefore considered unrealistic. R factors recommended by US seismic design provisions are unreliable and can result in overestimation of R factor values.

### *1) Formulation of 'R' Factor*

The response modification factor is the factor that should be used to lower the actual base shear force in order to acquire the design lateral force during DBE shaking.

$$R = R_s \, R_\mu \, R_R \, R_\xi$$

The response modification factor (R) is primarily determined by the following factors:

### *2) Overstrength Factor*

The significance of structural overstrength in preventing building collapse is critical. The overstrength factor (Rs) is the ratio of actual lateral strength to planned lateral strength.

$$\text{Over strength factor}(R_s) = V_y / V_d$$

### *3) Ductility Factor*

The ductility reduction factor ($R_\mu$) is a factor that decreases the elastic force demand to the level of the structure's idealized yield strength, and it can be written as the following equation.

$$R_\mu = V_e / V_y$$

If the structure stays elastic, Ve is the maximum base shear coefficient. The Rμ factor takes advantage of the energy dissipation ability of well planned and well-detailed structures and, as a result, is principally determined by the structure's global ductility requirement (is the ratio between maximum roof displacement and yield roof displacement).

*4) Redundancy Factor*

Structures with a large number of vertical components are classified as redundant structural systems. ASCE 7:2005 carefully indicated a $R_R$ of 1. The redundancy factor is assumed to be 1 in this study (as per ATC-19, Table 4.3)

$$R_R = Vu/ Vy$$

*5) Damping Factor*

For buildings with additional energy dissipation (viscous damping) devices, the damping factor R is utilised. For structures without such devices, the damping factor is assumed to be one. The damping factor is assumed to be 1 in this investigation.

## II. LITERATURE REVIEW

*Mussa Mahmoudi and Mohammad Ghasem Abdi,* [1] studied Evaluating response modification factors of TADAS frames. This work compares the R factor for SMRF with and without T-SMRF. They conduct pushover analysis. They use TADAS devices to test Rs, R, and response modification factors in specific moment resisting frames. They came to the conclusion that T-SMRF response modification factors were higher than SMRF response modification factors. It was also discovered that the number of stories a building has on the response modification elements has a bigger impact

*Gomatesh S. Patil and Vishal D. Sakhare,* [2] this research shows the actual value of response reduction factor (R) for light weight infill. Static nonlinear (pushover) analysis is used in this analysis, which is carried out by ETABS. The Applied Technology Council (ATC)-19 approach is used to calculate the Response reduction factor (R). The R factor falls when clay burned bricks are utilised and raises when light weight infill material is employed.

*P. Pravin Venkat Rao and L. M. Gupta,* [3] the Indian code does not provide any deterministic values of ductility reduction factor and overstrength factor to be employed in the design. Using nonlinear static (pushover) analysis, a total of 12 steel moment resistant frames with various seismic zones and stories were investigated and developed in this work. They found that three buildings of various heights had a 63 percent higher average over strength in Zone-II than in Zone-V.

*Prashant R. Barbude, Amol S. Jadhav, Dr.T.N.Boob,* [4] These studies focused on estimating the seismic response reduction factor for a dual system of reinforced concrete SMRF and shear walls using non-linear static pushover analysis. The frames are designed utilising Indian seismic and RC design requirements and are subjected to two separate lateral load patterns. The exact values of the Response reduction factor have been calculated using the push over curve obtained between base shear and roof displacement. Following the investigation, it was discovered that the response reduction factor is influenced by four primary factors: strength, ductility, redundancy, and damping

*Kruti Tamboli, J. A. Amin,* [5] Using nonlinear static pushover analysis, the response reduction factor and ductility of an RC braced frame are evaluated in this study. The study looked at RC frames with X bracing at the centre bay, RC frames with X bracing at alternate bays, and shear walls at the canter and alternate bays. They conclude that the types and patterns of bracing systems have a significant impact on the response reduction factor of an RC frame. When compared to the RC frame with bracing/shear wall in the centre bay and the bare RC frame, providing bracing/shear wall in alternate bays enhances the values of responses reduction factor by almost 1.88 to 2.2 and 3.75 to 3.9 times, respectively.

## III.OBJECTIVE AND SCOPE OF WORK

*A. Object*

1) Parameter under study are : Varying height, zone factor and plan irregularity
2) The time history under study are : Berlongfer Station , Diphu Station and Silchar Station
3) Output parameter under study are : storey displacement , base shear, storey drift
4) Calculation of Rs , Rμ and $R_R$ by using FEMA695 and ATC19
5) Computation of "R" factor and compare with IS1893:2016

*B. Scope Of Work*

1) To study SAP2000 software and perform validation procedure.
2) To analyze these models by dynamic analysis such as time history analysis.

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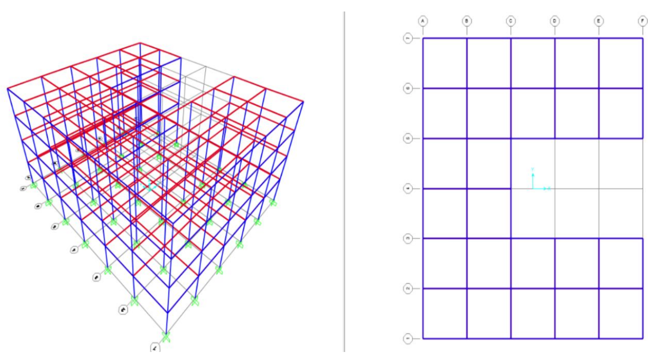
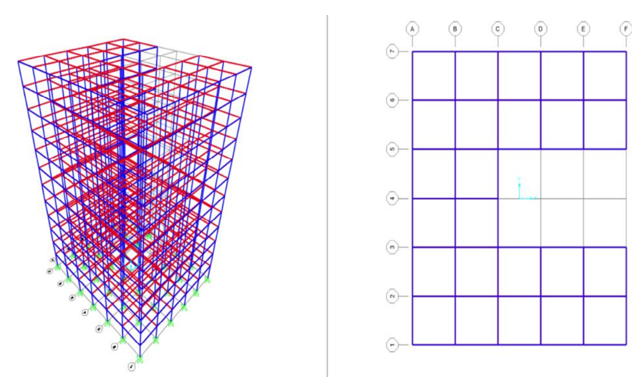
3) Total 3 Nonlinear time history analysis shall to be conducted considering different earthquake ground motion.
4) Parameter such as varying height, zone factor, plan irregularity will be carried used for nonlinear analysis.
5) Shape of Building
   1) C shape 2) L shape Rectangular shape
6) Storey of Building
   1) 4 storey 2) 12 storey
7) Seismic Zone
   1) Zone II 2)Zone V
8) To use of nonlinear time history result to evaluate 'R' value
9) Learning of SAP2000 software
10) To validate the model with reference

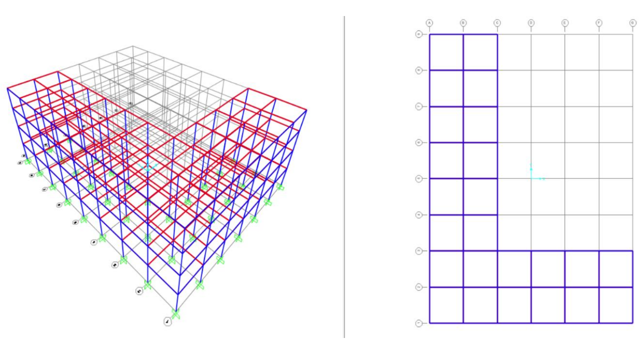
| Details of Building and structure elements | |
|---|---|
| Building type | Residential |
| Number of Storey | 4 |
| | 12 |
| Shape of Building | C-shape |
| | L-shape |
| | Rectangle shape |
| length of bay in x-direction (m) | 4 |
| length of bay in y-direction (m) | 4 |
| Floor height (m) | 3 |
| Beam section (mm × mm) | 500 X 500 |
| Column section (mm × mm) | 700 X 700 |
| Slab thickness(mm) | 200 |
| Base Connectivity | Fixed |



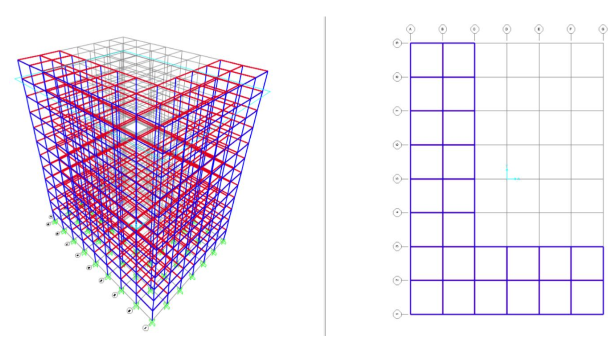
4 storey C shape building



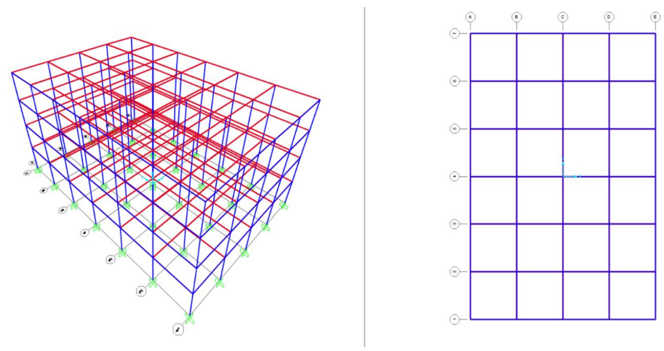
12 storey C shape building



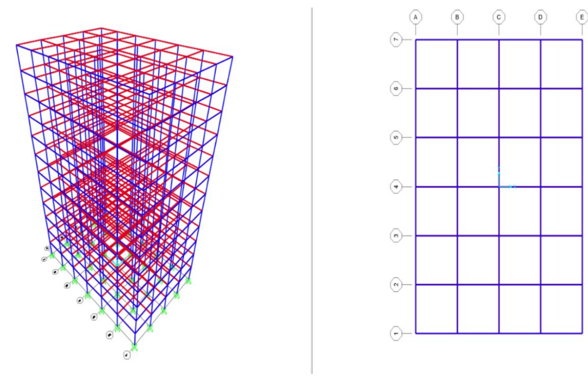
4 storey L shape building



12 storey L shape building

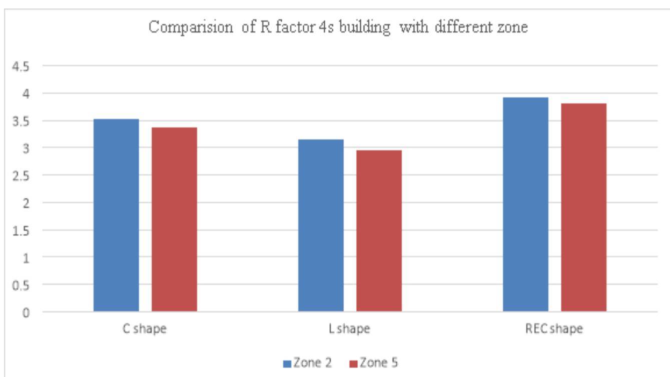


4 storey REC shape building

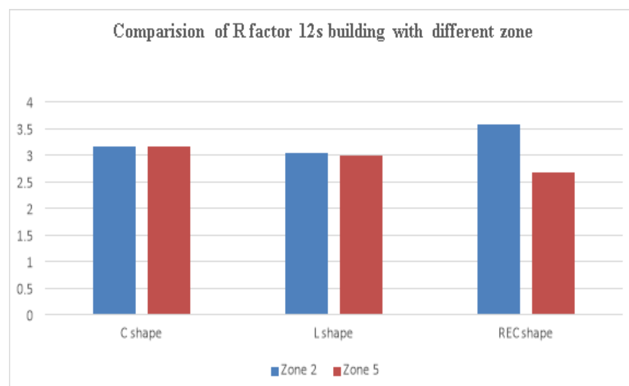


12 storey REC shape building

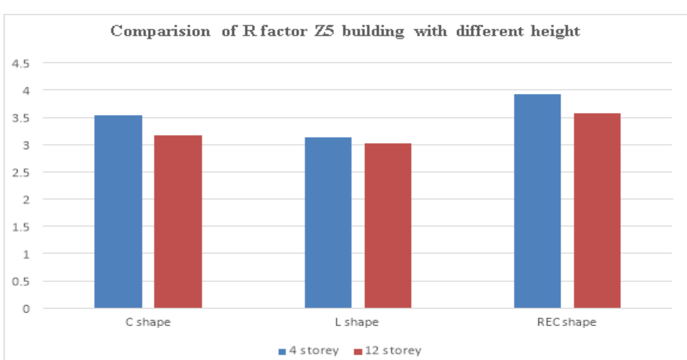
## IV. RESULT AND DISCUSSION



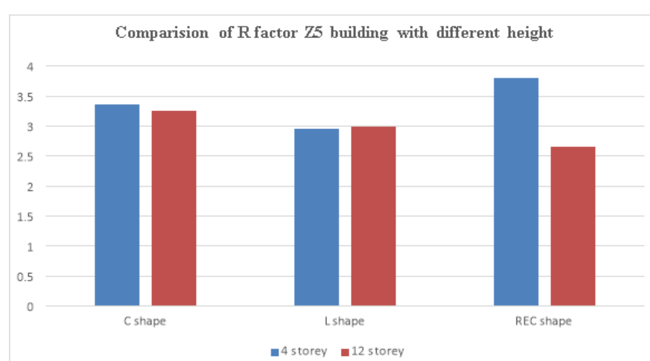

Comparison of R factor of 4 storey OMRF building




Comparison of R factor of 12 storey OMRF building




Comparison of R factor of Zone 2 OMRF building




Comparison of R factor of Zone 5 OMRF buildig

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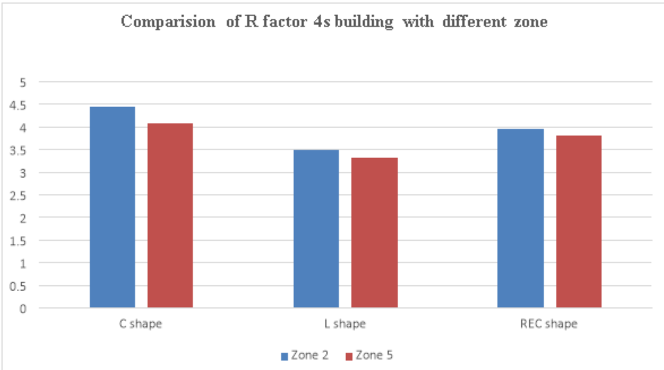
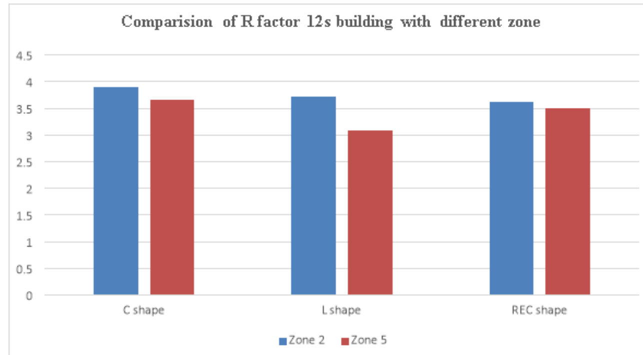
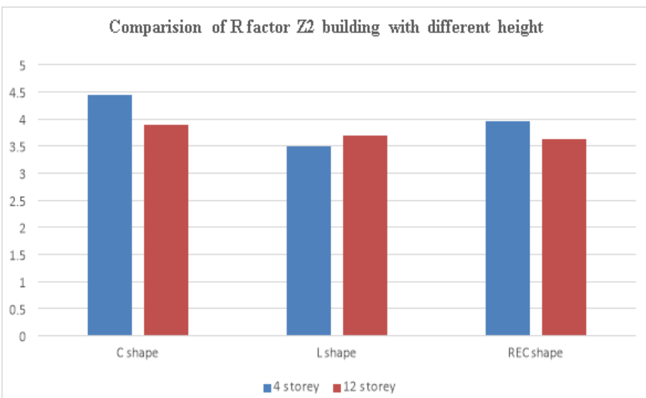


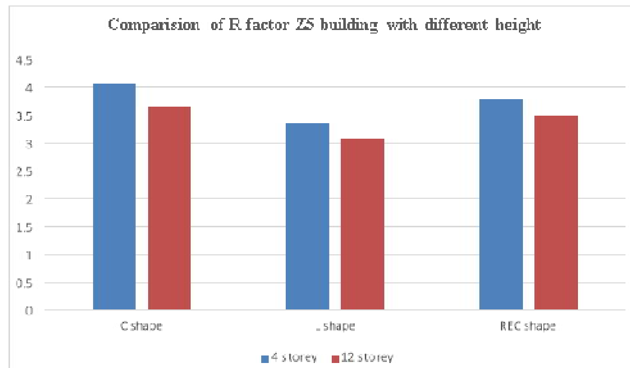

Comparison of R factor of 4 storey SMRF buildig




Comparison of R factor of 12 storey SMRF building




Comparison of R factor of 4 storey SMRF building




Comparison of R factor of 12 storey SMRF building

| Model | Response reduction factor calculated | Response reduction factor as per IS1893:2016 | Response reduction factor calculated | Response factor as per IS1893:2016 |
|---|---|---|---|---|
| 4S-ZON 2-C SHAPE | 3.53 | 3 | 4.45 | 5 |
| 4S-ZON 5-C SHAPE | 3.36 | 3 | 4.07 | 5 |
| 12S-ZON 2-C SHAPE | 3.16 | 3 | 3.9 | 5 |
| 12S-ZON 5-C SHAPE | 3.25 | 3 | 3.67 | 5 |
| | | | | |
| 4S-ZON 2-L SHAPE | 3.14 | 3 | 3.5 | 5 |
| 4S-ZON 5-L SHAPE | 2.95 | 3 | 3.31 | 5 |
| 12S-ZON 2-L SHAPE | 3.03 | 3 | 3.73 | 5 |
| 12S-ZON 5-L SHAPE | 2.99 | 3 | 3.08 | 5 |
| | | | | |
| 4S-ZON 2-REC SHAPE | 3.92 | 3 | 3.95 | 5 |
| 4S-ZON 5-REC SHAPE | 3.80 | 3 | 3.8 | 5 |
| 12S-ZON 2-REC SHAPE | 3.57 | 3 | 3.62 | 5 |
| 12S-ZON 5-REC SHAPE | 2.66 | 3 | 3.5 | 5 |

## V. RESULT AND DISCUSSION

In nonlinear time history analysis, it has been that, response reduction factor has been decreased by 5-25% with increase number storey and it decrees 5-30% with increase zone

## VI. CONCLUSION

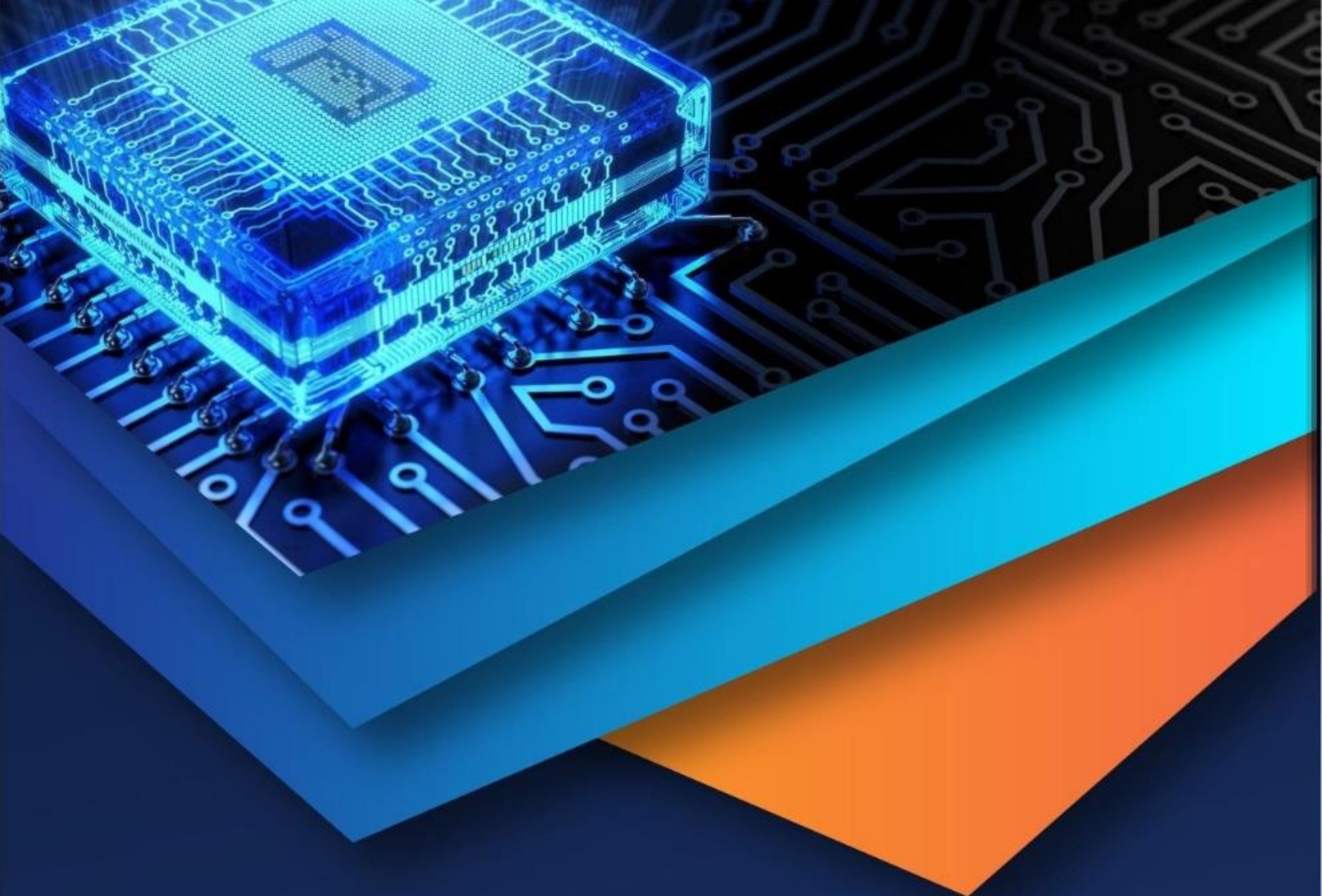
1) SMRF buildings have been found to attract 39 percent to 40 percent less base shear than OMRF buildings
2) The over-strength factor varies depending on seismic zones and the natural time period of the building frames
3) The structures modelled and analysed for low seismic zones provide high over-strength factor as compare to higher seismic zone
4) The over strength factor is decrease as the number of stories increase
5) For short time period buildings in all seismic zones, the Ductility factor is constant
6) As the seismic zone increases from Zone 2 to Zone 5, the overall seismic response reduction factor, which is dependent on over-strength and ductility factors, reduces rapidly
7) The height of the building has a significant impact on the response reduction factor. It decreases as the height of the building rises
8) The SMRF frame has a higher over strength and ductility factor than the OMRF frame
9) The response reduction factors determined for SMRF frame buildings are found to be lower than IS 1893: 2002 which is 5. These parameters, however, are slightly greater in the case of OMRF frame buildings than those specified by IS 1893: 200214, which is 3

## VII. FUTURE SCOPE OF WORK

1) Determine Response reduction factor using Non-linear analysis of the building considering the effect of infill wall
2) Effect of Tsunami on Response reduction factor
3) Effect of SSI on Response Reduction Factor
4) In this study building situated on plain ground, so in future same models were analysing to kept the building on sloping ground
5) In this work plan irregularity was considered only may also incorporating another types of irregularity

## REFERENCES

[1] Mussa Mahmoudi and Mohammad Ghasem Abdi "Evaluating response modification factors of TADAS frames" Journal of Constructional steel Research 2011
[2] Gomatesh S. Patil and Vishal D. Sakhare 'Effect of Response Reduction Factor on R.CBuilding with Different Infill Material" International Research Journal of Engineering and Technology Vol.06 2019
[3] P. Pravin Venkat Rao and L. M. Gupta " Effect of Seismic Zone and Story Height on Response Reduction Factor for SMRF Designed According to IS 1893(Part-1):2002" J.Inst.Eng.India.Ser.A 2016
[4] Somayeh Sharifi, Hamid Toopchi Nezhad " Seismic Response Modification Factor of RC-Frame Structures Based on Limit State Design" International Journal of Civil Engineering 2017
[5] H. Abdi and F. Hejazi " Response Modification Factor for Steel Structure Equipped with Viscous Damper Device" International Journal of Steel Structures 2015
[6] Fatemeh Aliakbari and Hashem Shariatmadar " Seismic response modification factor for steel slit panel-frames" Engineering Structures 2018
[7] Arjun Sil,Gourab Das and Ritam Hait "Characteristics of FBD and DDBD technique for SMRF buildings designed for seismic zone V in India" Journal of Building Pathology and Rehabitation 2019
[8] Kashyap N. Patel and Jignesh A. Amin "Performance-based assessment of response reduction factor of RC-elevated water tank considering soil flexibility: a case study" International Journal of Advanced Structural Engineering 2018
[9] Jinkoo Kim and Hyunhoon Choi "Response modification factors of chevron-braced frames" Engineering Structures 2004
[10] Samir K. Prajapati and Jignesh A. Amin "Seismic assessment of RC frame building designed using gross and cracked section as per Indian standards" Asian Journal of Civil Engineering 2019
[11] Mohssen Izadinia a, Mohammad Ali Rahgozar b, Omid Mohammadrezaei "Response modification factor for steel moment-resisting frames by different pushover analysis methods" Journal of Constructional steel Research 2013
[12] H Chaulagain a, H. Rodrigues a, J. Jara b, E. Spacone c, H. Varum "Seismic response of current RC buildings in Nepal" Engineering Structures 2012
[13] Swajit Singh Goud and R Pradeep Kumar " Rationalizing Response Reduction Factor (R) for better Performance of Reinforced Concrete Framed Buildings" Research Advances In Civil Engineering 2015



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