ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105

International Journal on Recent Researches In Science, Engineering & Technology
(Division of Computer Science and Engineering)
A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. It is an absolutely free (No processing charges, No publishing charges etc) Journal Indexed in JIR, DIIF and SJIF.
Research Paper
Available online at: www.jrrset.com

Volume 5, Issue 7, July 2017.

JIR IF : 2.54
DIIF IF : 1.46
SJIF IF : 1.329

EVALUATION OF SEISMIC RESPONSE REDUCTION FACTOR FOR RC AND STEEL STRUCTURES

Archana R, Swethamol Shaji, Gayathri Thampi
Assistant Professors, Department of Civil Engineering, Sri Vellappally Natesan College of Engineering, Kerala, India

Abstract

The response reduction factor reflects the capacity of structure to dissipate energy through inelastic behavior. It is the factor by which the actual base shear force that would be generated if the structure were to remain elastic during its response to the Design Basis Earthquake (DBE) shaking, shall be reduced to obtain the design lateral force. The actual intensity of earthquake is reduced by a factor called response reduction factor. The value of R depends on ductility factor, strength factor, structural redundancy and damping. In present work efforts has been made in estimating the actual value response reduction factor (R-factor) of RC and steel frame having irregularity in elevation and as well as in plan by using non-linear static analysis and compare it with a regular structure and codal values. In this work response reduction factor of regular and irregular RC and steel frame for zone V and hard soil type is determined.
.

Keywords: Base shear, Response Reduction, Damping, Ductility Factor, Lateral Force

1. Introduction

The response reduction factor reflects the capacity of structure to dissipate energy through inelastic behavior. It is the factor by which the actual base shear force that would be generated if the structure were to remain elastic during its response to the Design Basis Earthquake (DBE) shaking, shall be reduced to obtain the design lateral force. In present work efforts has been made in estimating the actual value response reduction factor (R-factor) of RC and steel frame having irregularity in elevation and as well as in plan by using non-linear static analysis. Also it is compared it with regular structure and codal values. In this work response reduction factor of regular and irregular RC and steel frame for zone V and hard soil type is determined.

2. Objective

- To determine the response reduction factor for regular RC and steel frame by using non-linear static analysis.
- To determine the response reduction factor for irregular RC and steel frame by using non-linear static analysis.
- To compare the obtained result with codal value.

3. Methodology

Capacity spectrum and pushover analysis is adopted for the analysis of RC and Steel frame.

4. Analysis of regular rc and steel frame

Analysis of regular frame is done by ETABS software. The analysis is done by following steps such as modeling , load distribution, and finally analysing.

4.1 Modelling of Building

The software ETABS has been used for the modelling. ETABS is an engineering software product that caters to multi-story building analysis and design. Basic or advanced systems under static or dynamic conditions may be evaluated using ETABS.

4.2. Building Plan and Dimensional Details of Building Model

An RC and steel framed buildings of 10 storeys with plan dimension 24m× 30m is considered for analysis.

Table 1. Dimensional Details of RC Building Model

Type of structure	Multi Storied RC Rigid jointed Plane Frame
Materials	Concrete (M25) Steel Reinforcement (Fe415)
Number of stories	G+10
Poisson's ratio	0.15
Grade of steel	Fe 415
Density of RCC	$25kN/m^3$
Thickness of slab	200 mm
Size of Beams	300×500 mm
Dimension of column	600×600 mm
Height of each floor	3m
Length of each bay in X-direction	4m
Length of each bay in Y-direction	5m

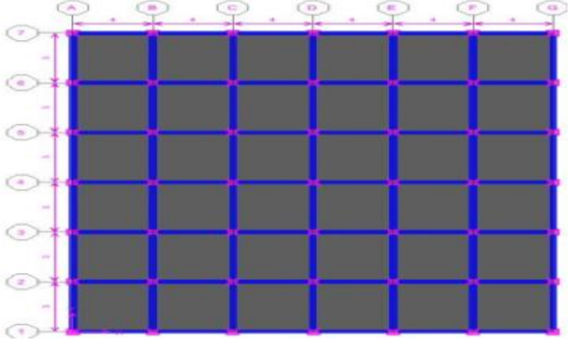


Figure 1. Plan of Regular RC Frame Building

Table 2. Dimensional Details of Steel Building Model

Type of structure	Steel moment resisting frame
Materials	Steel structure (Fe 250)
Number of stories	G+10
Poisson's ratio	0.15
Density of steel	76. 81kN/m^3
Thickness of deck	200 mm
Size of Beams	IS HB 400
Dimension of column	ISHB 450
Height of each floor	3m
Length of each bay in X-direction	4m
Length of each bay in Y-direction	5m

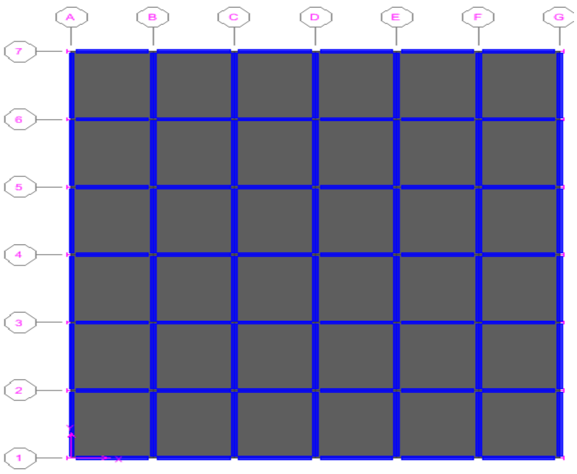


Figure 2. Plan of Regular Steel Frame Building

Table 3. Dead Load Data

Super imposed dead load	3kN/m^2

Table 4. Earthquake Load Data

.

Seismic zone	IV
Soil Type	Hardsoil (Type -1)
Zone Factor ,Z	0.36
Importance factor ,I	1
Response reduction factor, R	5
Damping Ratio	5%

4.3 Analysis

The RC and steel frame buildings were analysed by using pushover analysis and capacity spectrum.

4.4 Results and Discussions

Modal analysis is used for the preliminary analysis. The study is about response reduction factor of RC and steel framed buildings were computed by pushover analysis.

The value of performance point is obtained from pushover curve. The value of maximum storey displacement is obtained from response of lateral forces. They were computed in Table 5.

Table 5. Performance point and storey displacement

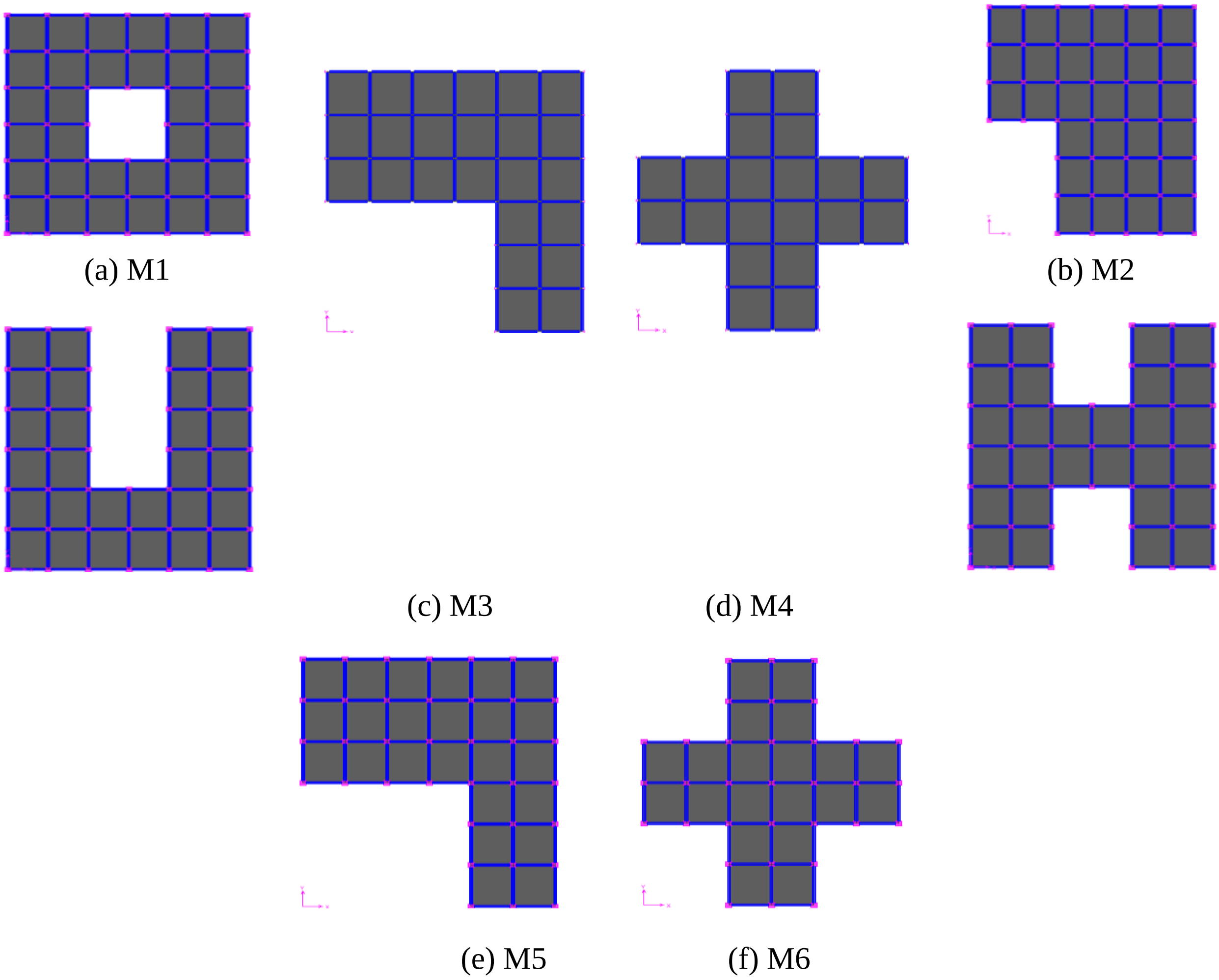
Building Model	**Performance Point**	**Storey Displacement**
RC Frame	8360.11	0.53
Steel Frame	6540.85	0.64

5. ANALYSIS OF IRREGULAR RC AND STEEL FRAME

Analysis of regular frame is done by ETABS software. The analysis is done by following steps such as modeling , load distribution, and finally analysing.

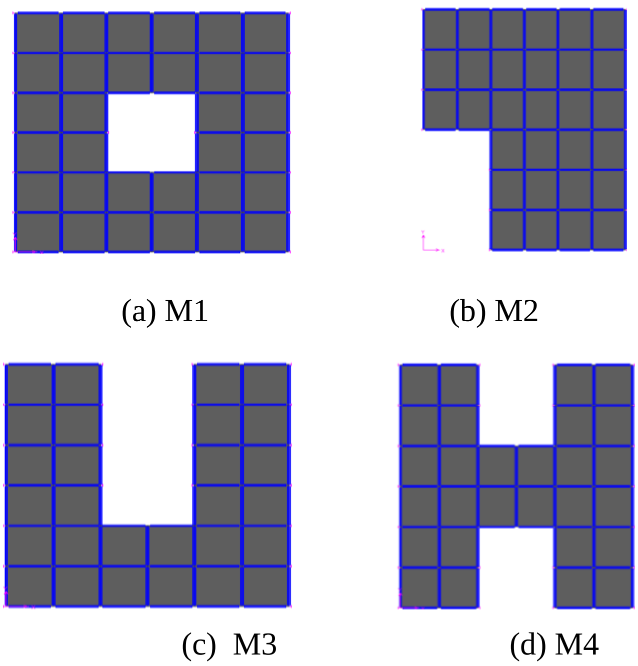
5.1 Building Plan and Dimensional Details

The details and dimension of building model were given in Table 1 and 2. Loading details are same as regular building and were given in Table 3 and 4.



(a) M1 (b) M2 (c) M3 (d) M4 (e) M5 (f) M6

Figure 3. Plan of Irregular RC Frame Buildings



(a) M1 (b) M2 (c) M3 (d) M4

Figure 4. Plan of Irregular Steel Frame Buildings

Table 6. Percentage Irregularity

Model Designation	Percentage Irregularity
M1	11.1 %
M2	16.67 %
M3	23.1 %
M4	26.3%
M5	33.3%
M6	44.4 %

5.2 Analysis

The value of performance point is obtained from pushover curve. The value of maximum storey displacement is obtained from response of lateral forces. They were computed in Table 7.

Table 7. Performance Point and Storey Displacement

Model Designation	Performance Point		Storey Displacement	
	RC	***Steel***	***RC***	***Steel***
M1	6208.3	6022.96	0.54	0.65
M2	6097.8	5943.42	0.54	0.66
M3	5857.3	5524.84	0.54	0.67
M4	5520.5	5140.62	0.55	0.69
M5	5383.7	4526.81	0.55	0.71
M6	5224.6	4143.18	0.56	0.72

6. ESTIMATION OF RESPONSE REDUCTION FACTOR

The response reduction factor is expressed in terms of over-strength, ductility, redundancy and damping of structure. Mathematically it can be written as:

$$R = R_S \times R_\mu \times R_R$$

Where ,

R_S= Strength factor,

R_μ= Ductility factor and

R_R = Redundancy factor.

Response reduction factor for RC and steel structure is 5 as per code IS 1893:2002.

6.1 Estimation of Overstrength Factor

Overstrength factor of irregularities in plan and elevation and also regular RC and steel frame were estimated. Performance point of models was listed in Table 8.

$$R_S = \frac{\text{Performance point}}{\text{EQ Calculation}}$$

Table 8. Overstrength Factor of Model

Model Designation	RC	Steel
SYM	3.45	3.41
M1	2.56	3.14
M2	2.52	3.10
M3	2.42	2.88
M4	2.28	2.68
M5	2.22	2.36
M6	2.16	2.16

6.2 Estimation of Ductility Reduction Factor

Ductility reduction factor with respect to plan and elevation irregularity along with regular structure is estimated.

Ductility reduction factor

$$R_\mu = \frac{\Delta \max}{\Delta}$$

$$\Delta \max = 0.004 \times h$$

$$= 1.2 \text{ mm}$$

Table 9. Ductility Reduction Factor of Model

Model Designation	RC	Steel
SYM	2.26	1.89
M1	2.22	1.85
M2	2.22	1.82
M3	2.22	1.79
M4	2.18	1.74
M5	2.18	1.69
M6	2.14	1.67

6.3. Estimation of Response Reduction Factor

Response reduction factor with respect to plan and vertical irregularity along with regular structure are estimated. The R value is estimated as per equation is shown in Table 10.

Table 10. Response Reduction Factor of Models

Model Designation	RC	Steel
SYM	7.2	6.45
M1	6.43	5.93
M2	5.89	5.64
M3	5.39	5.16
M4	4.98	4.66
M5	4.72	4.21
M6	4.37	3.84

7. Results and Discussions

The result obtained during the modal analysis of regular and irregular RC and steel frame building is compared with codal value. The comparison of response reduction factor is shown in Table 11.

Table 11. Comparison of R Factor with Codal Value

Model Designation	RC	Steel
SYM	35.9	31.1
M1	26.3	20.9
M2	21.6	19.3
M3	13.1	10.1
M4	9.80	6.3
M5	3.2	2.2
M6	7.6	0.8

From the nonlinear static pushover analysis R factor of a regular RC frame is 35.9 % greater than those specified in the IS 1893. R value of horizontal irregular frame is found to be 26.3% greater than to 7.6% less than that of codal value.

R factor of a regular steel frame is 31.1 % greater than those specified in the IS 1893. R value of horizontal irregular frame is found to be 20.9% greater than to 0.8 less than that of codal value.

Table 12. Comparison of R Factor for RC and Steel

Model Designation	RC	Steel
SYM	7.2	6.45
M1	6.43	5.93
M2	5.89	5.64
M3	5.39	5.16
M4	4.98	4.66
M5	4.72	4.21
M6	4.37	3.84

R- Factor of regular frame is greater than irregular frame. As the percentage of horizontal irregularity increases, R-factor goes on decreasing. R - Factor of RC frame is greater than steel frame.

8. CONCLUSIONS

Following conclusions can be made from the analysis:

- R factor of a regular RC frame is 35.9% greater than those specified in the IS 1893.
- R factor of a regular steel frame is 31.1% greater than those specified in the IS 1893.
- R value of horizontal irregular RC frame is found to be 26.3% greater than to 7.6 % less than that of codal value.
- R value of horizontal irregular steel frame is found to be 20.9% greater than to 0.8 % less than that of codal value.
- R value of regular RC and steel frame is greater than that of irregular RC and steel frames.
- R value of RC frame is greater than that of steel frame.

REFERENCES

1. A. Kheyroddin et.al., (2012), "Static and dynamic analysis of a reinforced concrete flat slab frame building for progressive collapse", Engineering Structures, Vol. 40, Pp. 205.

2. Bholebhavi Rahul D et.al., (2016), "Performance Evaluation of Flat Slab with Storey Height Variation using Pushover Analysis", International Journal of Engineering Research ISSN:2319-6890(online),2347-5013(print), Vol. 5 (3), Pp. 639-643.

3. M. A. Shayanfaret.al., "Comparative study of Seismic Performance of multistoried R.C.C buildings with Flat slab & Grid slab", International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161.

4. Neha P. Modakwar et.al., (2014), "Progressive Collapse Analysis of RC Buildings using Linear Static and Linear Dynamic Method", International Journal of Engineering Research & Technology (IJERT), Vol. 3 (8), ISSN: 2278-0181.

5. Tia Toby et.al., (2014), "Progressive collapse analysis of RC buildings using Non-linear static and non-linear dynamic method", International Journal of Emerging Technology and Advanced Engineering, Vol. 4 (9), ISSN 2250-2459.

6. Y. S. Salem et.al., (2013), "Performance of Flat Slab Structure Using Pushover Analysis", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Vol. 8 (3), Pp. 41-44.