



**INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH
TECHNOLOGY**

**A COMPARATION OF OMRF BRACED & SMRF RC FRAME CONSIDERING
EARTHQUAKE LOADING**

Mukesh Rai^{*1} & Prof. M.C. Paliwal²

^{*1&2}National Institute of Technical Teachers' Training & Research, Bhopal

DOI: 10.5281/zenodo.1036603

ABSTRACT

With the advancement in field of high rise construction, various types of frame arrangements have been emerged. Regular bare frame, Irregular plaza frame and Irregular stepped frame being examples of the modern high rise types are advantageous in terms of aesthetic and structural functioning. Seismic evaluation will provide a general idea about the building performance during an earthquake. In this study Special Moment Resisting Frame and Ordinary Moment Resisting Frame with bracing are considering as structural frame and comparison are made for seismic load.

The objective of this study is to investigate the seismic behaviour of the structure i.e. Ordinary Moment Resisting Frame with bracing (OMRF with bracing) & Special R C moment Resisting frame(SMRF). In this analysis, four different seismic zones are considered as well three different types of structures are used which are bare frame structure, plaza frame structure and stepped frame structure along with two types of moment resisting frames (OMRF Braced and SMRF). Hence, a total of 24 cases had been studied. For this purpose regular and irregular structure were modelled and analysis was done using STAAD.Pro software and using the Indian codes for analysis namely IS 1893:2002, IS 456: 2000. The study assumed that the buildings were located in seismic zone II, III, IV and V. Results in terms of bending moment, shear force, nodal displacement and storey displacement are taken. Relevant conclusions are drawn

KEYWORDS: Seismic Behaviour, OMRF, SMRF, model, analysis, staad.pro.

I. INTRODUCTION

The selection of a particular type of framing system depends upon two important parameters i.e. Seismic risk of the zone and the budget. The lateral forces acting on any structure are distributed according to the flexural rigidity of individual components. Indian Codes divide the entire country into four seismic zones (II, III, IV & V) depending on the seismic risks. OMRF is probably the most commonly adopted type of frame in lower seismic zones. However with increase in the seismic risks, it becomes insufficient and SMRF frames need to be adopted. A rigid frame in structural engineering is the load resisting skeleton constructed with straight or curved members interconnected by mostly rigid connections which resist movements induced at the joints of members. Its members can take bending moment, shear, and axial loads. They are of two types: Rigid-framed Structures & Braced-frames Structures The two common assumptions as to the behaviour of a building frame are that its beams are free to rotate at their connections and that its members are so connected that the angles they make with each other do not change under load. Moment-resisting frames are rectilinear assemblages of beams and columns, with the beams rigidly connected to shear, amount of reinforcement etc. Moment frames have been widely used for seismic resisting systems due to their superior deformation and energy dissipation capacities. A moment frame consists of beams and columns, which are rigidly connected. The components of a moment frame should resist both gravity and lateral load. Lateral forces are distributed according to the flexural rigidity of each component.

The main aims of the present study are as follows:

- To model structures for analyzing multi-storeyed frames having OMRF Braced and SMRF configurations.
- To carry out the analysis of the selected buildings in all seismic zone.
- To analyse regular and irregular structure and find out effective one.

- To make a comparative study with the help of results like bending moment, shear force, displacement etc.
- To provide structural engineers with a guideline on the economy aspect that could be obtained using comparative analysis of both SMRF and OMRF Braced

II. LITERATURE REVIEW

Anupam S. Hirapure et. al. (2017) In this study behaviour of the structure having various structural configurations like Ordinary moment resisting frames (OMRF), Special moment resisting frames. The poor performance of Ordinary moment resisting frame (OMRF) in past earthquakes suggested that, the special design and detailing to require arresting a ductile behaviour in seismic zones of high earthquake (zone III, IV & V). For this purpose, a G+7 storey Reinforced concrete cement (R.C.C.) regular building are analyzed for Ordinary moment resisting concrete frames (OMRCF), Special moment resisting concrete frame (SMRCF) framing configurations in seismic zone II, III & IV according to Indian codes. For Ordinary moment resisting frame (OMRF) structures the guide lines of I.S. 456-2000 and the design, detailing of reinforcement are executed as per which make the structure less tough and ductile in comparison of Special moment resisting frame (SMRF) structures. The earthquake resistant design should be based on lateral strength as well as deformability and ductility capacity of structure. For adequate toughness and ductility to resist the severe earthquake shocks without collapse, in the Special moment resisting frame (SMRF) structures beams, columns, and beam-column joints are proportioned and detailed as per IS: 13920 (2002). Thus it has been studied and observed that Special moment resisting frame (SMRF) structures behave well in earthquake than Ordinary moment resisting frames (OMRF) structures.

Sneha Meshram et. al. (2016) Reinforced concrete special moment resisting frames are used as a part of seismic force-resisting systems in buildings that are designed to resist earthquakes. Beams, columns and beam-column joints in moment frames are proportioned and detailed to resist flexural, axial and shearing actions that result as a building sways through multiple displacement cycles during strong earthquake ground shaking, Special proportioning and detailing requirements result in a frame capable of resisting strong earthquake shaking without significant loss of stiffness or strength, these moment-resisting frames are called “Special Moment Resisting Frames” because of these additional requirements, which improve the seismic resistance in comparison with less stringently detailed Intermediate and Ordinary moment resisting frames. The design criteria for Special moment resisting frames (SMRF) buildings are given in IS: 13920 (2002). In this study, the buildings are designed both as Special moment resisting frames (SMRF) and Ordinary moment resisting frames (OMRF), and their performance is compared. For this, the buildings are modeled and pushover analysis is performed in Structural analysis program 2000 (SAP 2000). The pushover curves are plotted from the analysis results and the behavior of buildings is studied for various support conditions and infill conditions. The behavior parameters are also found for each building using the values obtained from pushover curve and is investigated.

Sanjivkumar N. Harinkhede (2016) Any building when subjected to an earthquake of a certain magnitude experiences a lateral force which is produced by seismic waves. This lateral force is termed as base shear and is dependent on various parameters like zone factor, response reduction factor, natural time period and seismic weight of a building. An attempt of calculating base shear by taking into considerations combinations of ordinary moment resisting frame (OMRF), Special moment resisting frames (SMRF) and presence & absence of brick infill which also affects the value of base shear.

Jaya Prakash Kadai et. al. (2015) Moment resisting frames are commonly used as the dominant mode of lateral resisting system in seismic regions for a long time. Beams, columns, and beam-column joints in moment frames are proportioned and detailed to resist flexural, axial, and shearing actions that result as a building sways through multiple displacement cycles during strong earthquake ground shaking. Reinforced concrete special moment frames are used as part of seismic force-resisting systems in buildings that are designed to resist earthquakes. The poor performance of Ordinary moment resisting frame (OMRF) in past earthquakes suggested special design and detailing to warrant a ductile behaviour in seismic zones of high earthquake (zone III, IV & V). Thus when a large earthquake occurs, Special moment resisting frame (SMRF) which is specially detailed and is expected to have superior ductility. Special proportioning and detailing requirements result in a frame capable of resisting strong earthquake shaking without significant loss of stiffness or strength. These moment-resisting frames are called “Special Moment Resisting Frames” because of these additional requirements, which

improve the seismic resistance in comparison with less stringently detailed Intermediate and Ordinary moment resisting frames.

III. METHODOLOGY

Methodology And Selection Of Problems

This work deals with comparative study of behaviour of high rise building frames considering different geometrical configurations and response reduction factor under earthquake forces. A comparison of results in terms of moments, shear force, displacements, and storey displacement has been made. Following steps are applied in this study:-

Step-1 Selection of building geometry, bays and storey (3 geometries)

Step-2 Selection of response reduction factor (OMRF Braced and SMRF) models

Step-3 Selection of 4 zones (II,III, IV and V) seismic zones

Table 3.1 Seismic zones for all cases

Case	Model	Earthquake zones as per IS 1893 (part-1) : 2002
	RCC Structure	II, III, IV and V

Step-4 Considering of load thirteen combination

Table 3.2: Load case details

Load case no.	Load case details
1.	E.Q. IN X_DIR.
2.	E.Q. IN Z_DIR.
3.	DEAD LOAD
4.	LIVE LOAD
5.	1.5 (DL + LL)
6.	1.5 (DL + EQ_X)
7.	1.5 (DL - EQ_X)
8.	1.5 (DL + EQ_Z)
9.	1.5 (DL - EQ_Z)
10.	1.2 (DL + LL + EQ_X)
11.	1.2 (DL + LL - EQ_X)
12.	1.2 (DL + LL + EQ_Z)
13.	1.2 (DL + LL - EQ_Z)

Step-5 Modelling of building frames using STAAD.Pro software.

Step-6 In analyses different OMRF and SMRF models, seismic zones and 13 load combinations are considered.

Step-7 Comparative study of results in terms of beam forces, displacement and storey displacement

Analysis Of Building Frames

Modelling and Analysis of building frames is carried out as per following details

Modelling of building frames

Following geometries of building frames are considered for analysis-

RESPONSE REDUCTION	TYPE OF STRUCTURE	ZONE
OMRF BRACED	BARE FRAME (REGULAR STRUCTURE)	4
SMRF	BARE FRAME (REGULAR STRUCTURE)	4
OMRF BRACED	PLAZA (IRREGULAR STRUCTURE)	4
SMRF	PLAZA (IRREGULAR STRUCTURE)	4
OMRF BRACED	STEPPED (IRREGULAR STRUCTURE)	4
SMRF	STEPPED (IRREGULAR STRUCTURE)	4
TOTAL CASES		24

STAAD.Pro is used in modelling of building frames. STAAD.Pro is Structural Analysis and Design Program is a general purpose program for performing the analysis and design of a wide variety of structures. The essential 3 activities which are to be carried out to achieve this goal are -

- a. Model generation
- b. Calculations to obtain the analytical results
- c. Result verification- These are all facilitated by tools contained in the program's graphical environment.

Structural Models

Structural models for different cases are shown in Figures

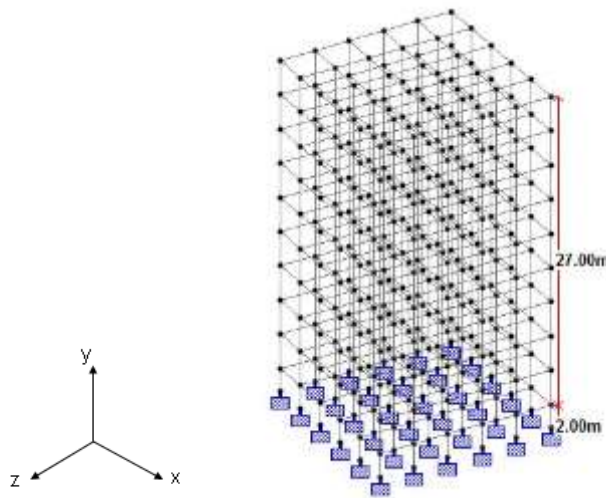


Fig. 3.1: Isometric view of regular structure

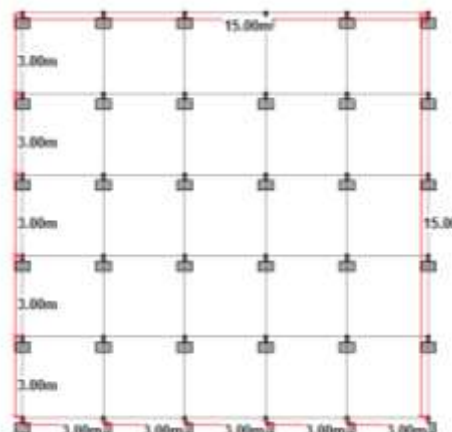


Fig. 3.2: Plan of regular structure

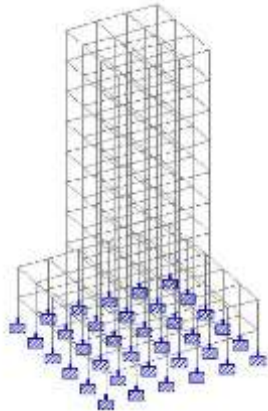


Fig. 3.3: Isometric view of irregular plaza building

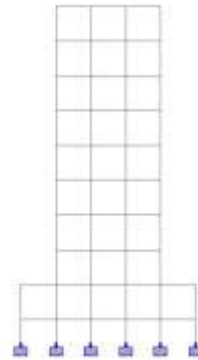


Fig. 3.4: Front view of irregular plaza

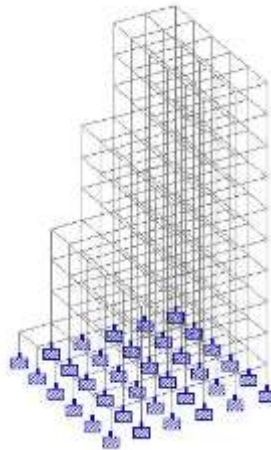


Fig. 5: Isometric view of irregular stepped building

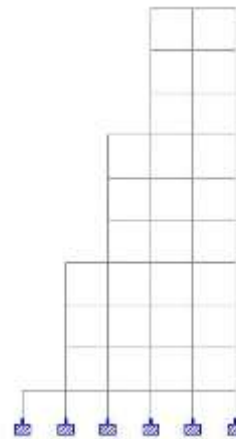


Fig. 6: Front view of irregular stepped

The column size is of 0.35 m x 0.45 m, and the beam size is 0.23 m x 0.45 m.

Material And Geomerical Properties

Following properties of material have been considered in the modelling -

Unit weight of RCC: 25 kN/m³

Unit weight of Masonry: 20 kN/m³ (Assumed)

Modulus of elasticity, of concrete: $5000\sqrt{f_{ck}}$

Poisson's ratio: 0.17

The depth of foundation is 2 m and the height of floor is 3 m.

Loading Conditions

Following loading conditions are used-

(i) **Dead Loads:** according to IS code 875 (part 1) 1987

(a) Self weight of slab

(b) Slab = 0.15 m x 25 kN/m³ = 3.75 kN/m² (slab thickness 0.15 m assumed)

Finishing load = 1 kN/m²

Total slab load = 3.75 + 1 = 4.75 kN/m²

(c) Masonry external wall Load = 0.20 m x 2.55 m x 20 kN/m³ = 10.2 kN/m

(d) Masonry internal wall Load = 0.10 m x 2.55 m x 20 kN/m³ = 5.1 kN/m

(e) Parapet wall load = $0.10 \text{ m} \times 1 \text{ m} \times 20 \text{ kN/m}^3 = 2 \text{ kN/m}$

(ii) **Live Loads:** according to IS code 875 (part-2) 1987

Live Load = 3 kN/m^2

Live Load on earthquake calculation = 0.75 kN/m^2

(iii) **Seismic Loads:** Seismic calculation according to IS code 1893 (2002)

- | | |
|---|--------------|
| 1. Seismic zone-II,III,IV,V | (Table - 2) |
| 2. Importance Factor: 1.5 | (Table - 6) |
| 3. Response Reduction Factor: | |
| OMRF: 3 | (Table - 7) |
| SMRF: 5 | (Table - 7) |
| 4. Damping: 5% | (Table - 3) |
| 5. Soil Type: Medium Soil (Assumed) | |
| 6. Period in X direction (PX): $\frac{0.09xh}{\sqrt{dx}}$ seconds | Clause 7.6.2 |
| 7. Period in Z direction (PZ): $\frac{0.09xh}{\sqrt{dz}}$ seconds | Clause 7.6.2 |

Where h = building height in meter

dx= dimension of building along X direction in meter

dz= dimension of building along Z direction in meter

Loading Diagram

Typical diagram for different types of loading conditions are shown in Fig. 3.7 to Fig. 3.10

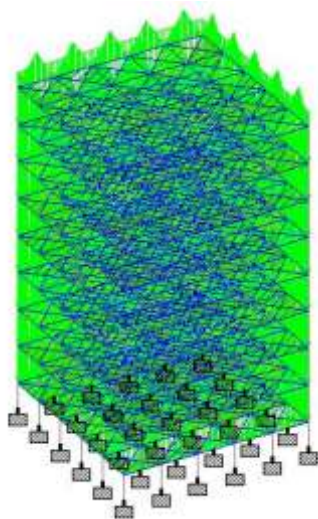


Fig. 3.7: Dead load diagram

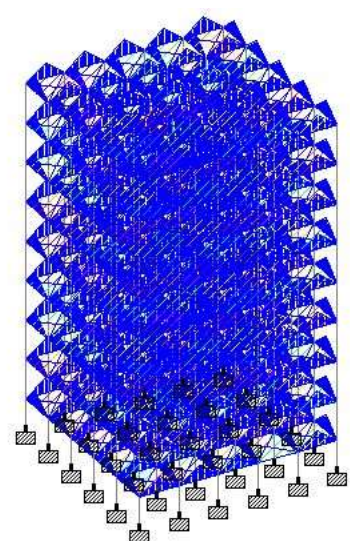


Fig. 3.8: Live load diagram

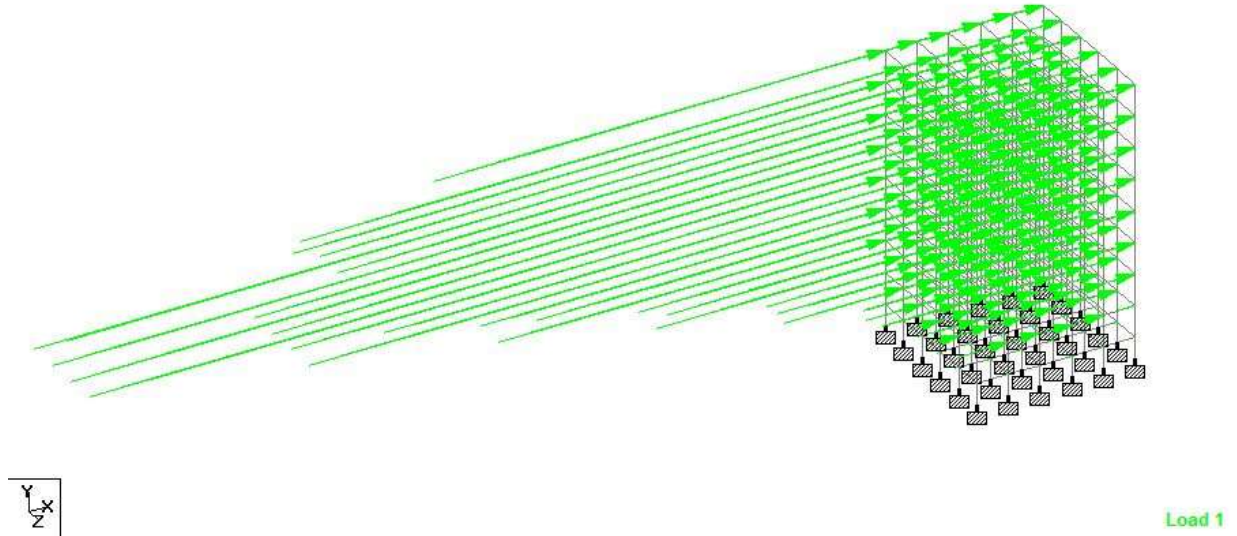


Fig. 3.9: Seismic load in X direction

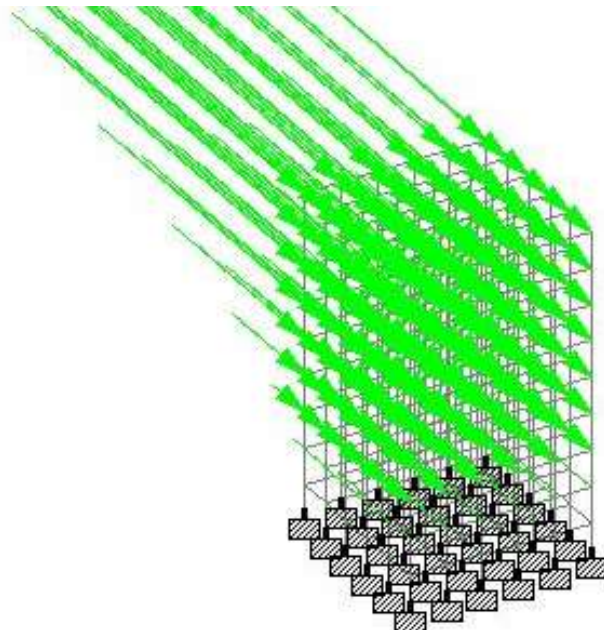


Fig. 3.10: Seismic load in Z direction

IV. RESULT ANALYSIS

Bending Moment

This maximum bending moment (kNm) in Zone II are shown in Table 4.1 and Fig. 4.1:

Table 4.1: Maximum bending moment (kNm) in Zone II

MAXIMUM BENDING MOMENT (kNm) IN ZONE II			
RF	TYPE OF STRUCTURE		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	138.1	143.6	135.5
SMRF	101.7	116.1	121.9

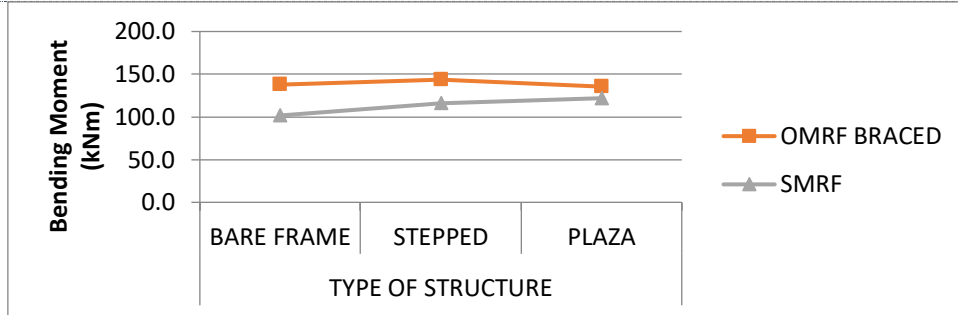


Fig. 4.1: Maximum bending moment (kNm) in Zone II

This maximum bending moment (kNm) in Zone III is shown in Table 4.2 and Fig. 4.2:

Table 4.2: Maximum bending moment (kNm) in Zone III

MAXIMUM BENDING MOMENT (kNm) IN ZONE III			
RF	TYPE OF STRUCTURE		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	212.9	202.9	221.7
SMRF	151.0	167.5	182.7

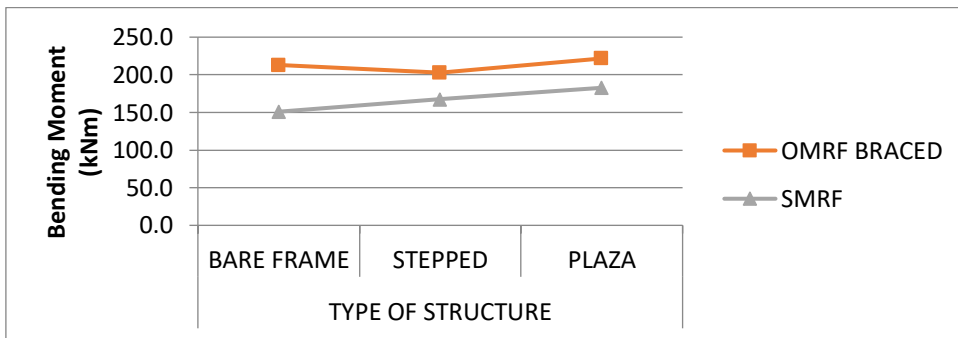


Fig. 4.2: Maximum bending moment (kNm) in Zone III

This maximum bending moment (kNm) in Zone IV is shown in Table 4.3 and Fig. 4.3:

Table 4.3: Maximum bending moment (kNm) in Zone IV

MAXIMUM BENDING MOMENT (kNm) IN ZONE IV			
RF	TYPE OF STRUCTURE		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	312.6	325.8	292.7
SMRF	217.3	235.9	263.8

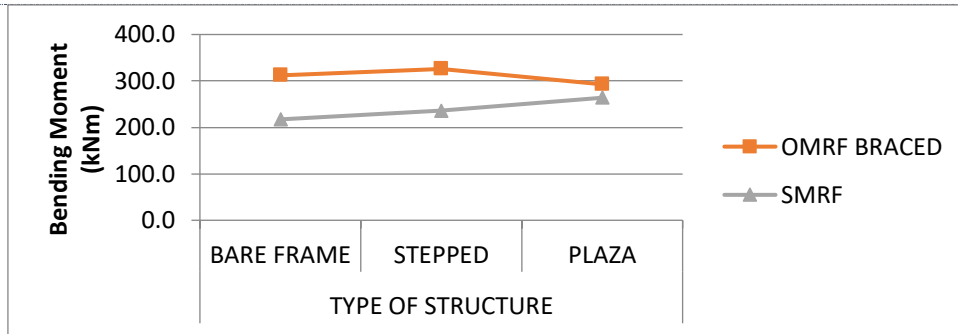


Fig. 4.3: Maximum bending moment (kNm) in Zone III

This maximum bending moment (kNm) in Zone V is shown in Table 4.4 and Fig. 4.4:

Table 4.4: Maximum bending moment (kNm) in Zone V

MAXIMUM BENDING MOMENT (kNm) IN ZONE V			
RF	TYPE OF STRUCTURE		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	462.1	481.9	427.5
SMRF	317.4	338.6	385.5

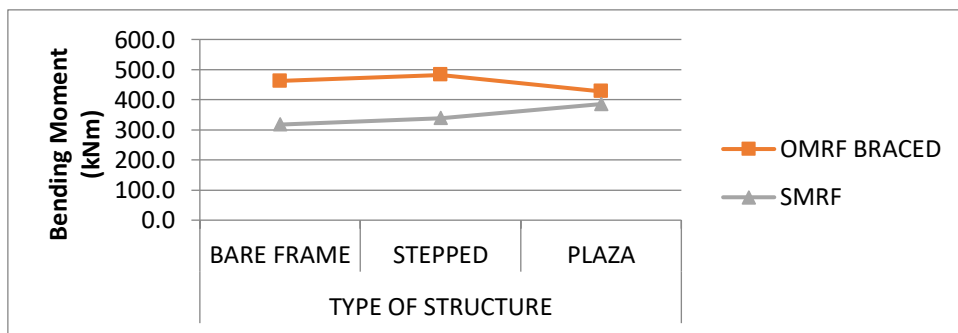


Fig. 4.4: Maximum bending moment (kNm) in Zone V

Shear Force

This maximum shear force (kN) in Zone II is shown in Table 4.5 and Fig. 4.5:

Table 4.5: Maximum shear force (kN) in Zone II

MAXIMUM SHEAR FORCE (kN) IN ZONE II			
RF	TYPE OF STRUCTURE		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	106.1	112.9	110.9
SMRF	88.4	95.7	100.2

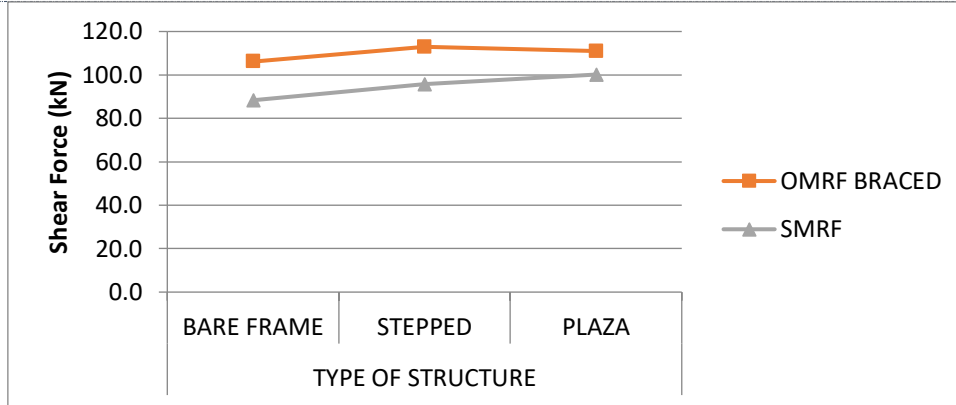


Fig. 4.5: Maximum shear force (kN) in Zone II

This maximum shear force (kN) in Zone III is shown in Table 4.6 and Fig. 4.6:

Table 4.6: Maximum shear force (kN) in Zone III

MAXIMUM SHEAR FORCE (kN) IN ZONE III			
RF	TYPE OF STRUCTURE		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	152.5	153.2	157.9
SMRF	118.4	126.6	136.9

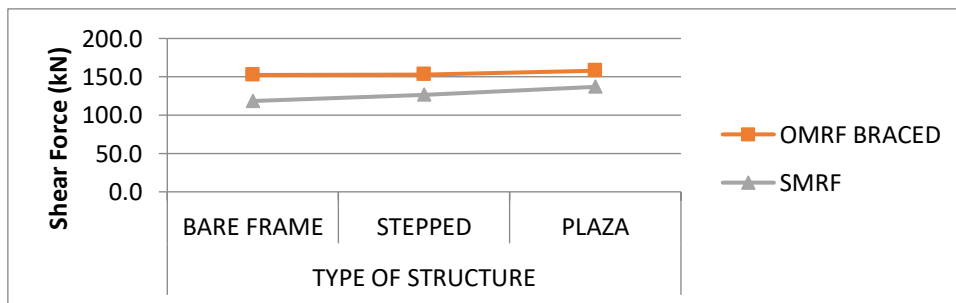


Fig. 4.6: Maximum shear force (kN) in Zone III

This maximum shear force (kN) in Zone IV is shown in Table 4.7 and Fig. 4.7:

Table 4.7: Maximum shear force (kN) in Zone IV

MAXIMUM SHEAR FORCE (kN) IN ZONE IV			
RF	TYPE OF STRUCTURE		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	214.2	222.4	209.6
SMRF	158.9	168.4	185.9

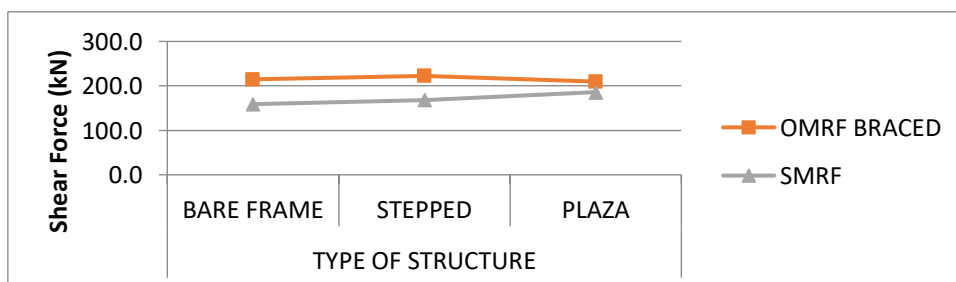


Fig. 4.7: Maximum shear force (kN) in Zone IV

This maximum shear force (kN) in Zone V is shown in Table 4.8 and Fig. 4.8:

Table 4.8: Maximum shear force (kN) in Zone V

MAXIMUM SHEAR FORCE (kN) IN ZONE V			
RF	TYPE OF STRUCTURE		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	306.9	319.2	295.9
SMRF	219.5	231.2	259.4

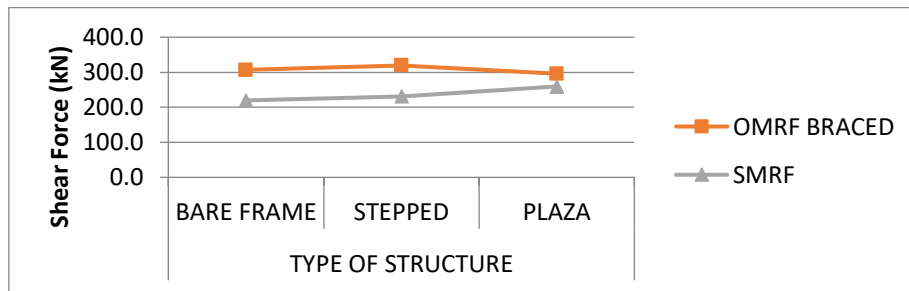


Fig. 4.8: Maximum shear force (kN) in Zone V

Maximum Nodal Displacement

The Maximum nodal displacement (mm) in Zone II at X direction is shown in Table 4.9 and Fig. 4.9:

Table 4.9: The Maximum nodal displacement (mm) in Zone II at X direction

MAXIMUM NODAL DISPLACEMENT (mm) IN ZONE II			
RF	TYPE OF STRUCTURE IN X DIRECTION		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	63.104	69.992	70.091
SMRF	51.821	52.346	58.542

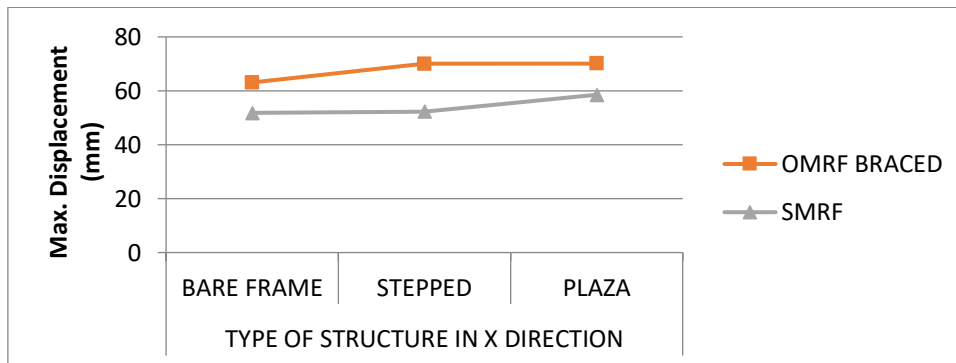


Fig.4.9: The Maximum nodal displacement (mm) in Zone II at X direction

The Maximum nodal displacement (mm) in Zone II at Z direction is shown in Table 4.10 and Fig. 4.10:

Table 4.10: The Maximum nodal displacement (mm) in Zone II at Z direction

MAXIMUM DISPLACEMENT (mm) IN ZONE II			
RF	TYPE OF STRUCTURE IN Z DIRECTION		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	63.104	64.928	70.091
SMRF	51.521	54.015	58.542

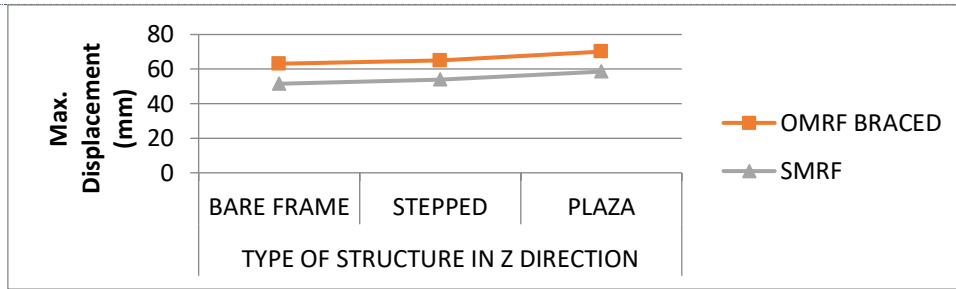


Fig.4.10: The Maximum nodal displacement (mm) in Zone II at Z direction

The Maximum nodal displacement (mm) in Zone III at X direction is shown in Table 4.11 and Fig. 4.11:

Table 4.11: The Maximum nodal displacement (mm) in Zone II at X direction

MAXIMUM NODAL DISPLACEMENT (mm) IN ZONE III			
RF	TYPE OF STRUCTURE IN X DIRECTION		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	100.922	106.852	112.107
SMRF	82.888	82.222	93.653

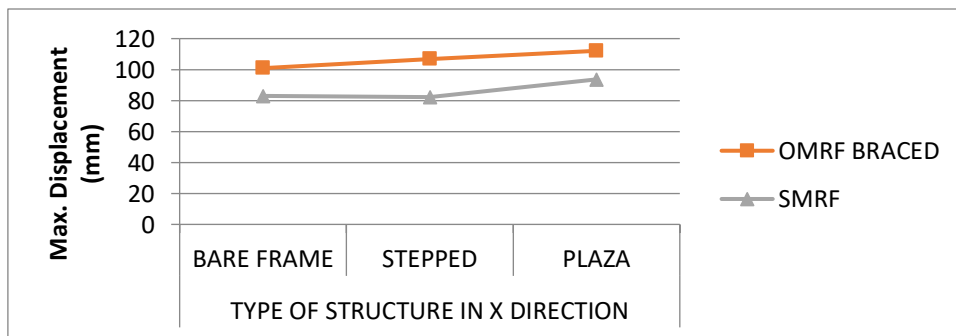


Fig.4.11: The Maximum nodal displacement (mm) in Zone III at X direction

The Maximum nodal displacement (mm) in Zone III at Z direction is shown in Table 4.12 and Fig. 4.12:

Table 4.12: The Maximum nodal displacement (mm) in Zone III at Z direction

MAXIMUM NODAL DISPLACEMENT (mm) IN ZONE III			
RF	TYPE OF STRUCTURE IN Z DIRECTION		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	100.922	103.82	112.107
SMRF	82.888	86.397	93.653

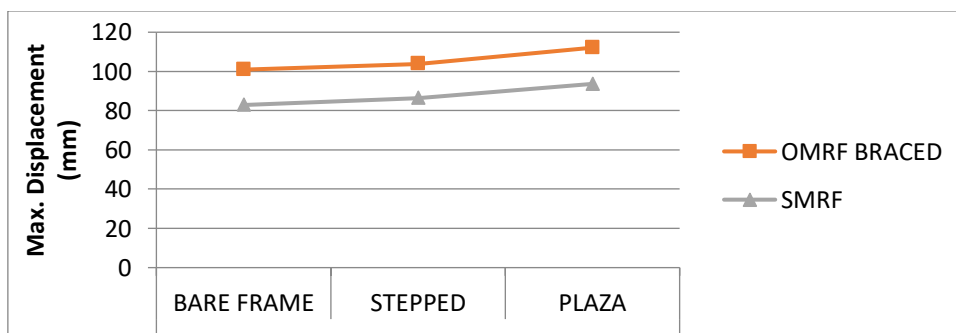


Fig.4.12: The Maximum nodal displacement (mm) in Zone III at Z direction

The Maximum nodal displacement (mm) in Zone IV at X direction is shown in Table 4.13 and Fig. 4.13:

Table 4.13: The Maximum nodal displacement (mm) in Zone IV at X direction

MAXIMUM DISPLACEMENT (mm) IN ZONE IV			
RF	TYPE OF STRUCTURE IN X DIRECTION		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	151.346	156.652	168.128
SMRF	124.31	122.058	140.468

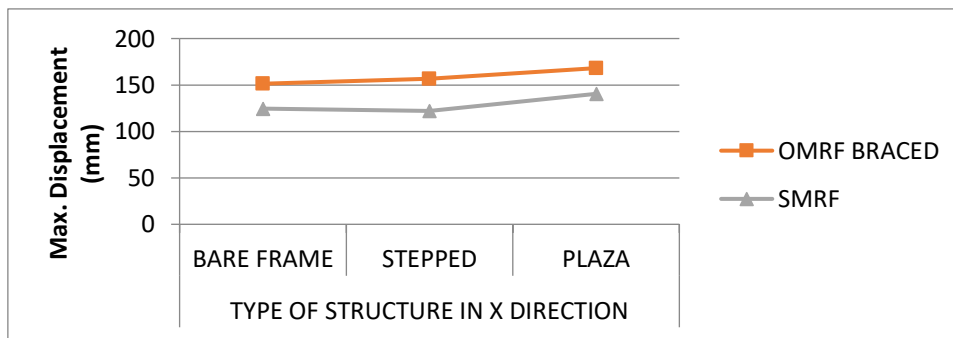


Fig.4.13: The Maximum nodal displacement (mm) in Zone IV at X direction

The Maximum nodal displacement (mm) in Zone IV at Z direction is shown in Table 4.14 and Fig. 4.14:

Table 4.14: The Maximum nodal displacement (mm) in Zone IV at Z direction

MAXIMUM NODAL DISPLACEMENT (mm) IN ZONE IV			
RF	TYPE OF STRUCTURE IN Z DIRECTION		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	151.346	155.676	168.128
SMRF	124.31	129.574	140.468

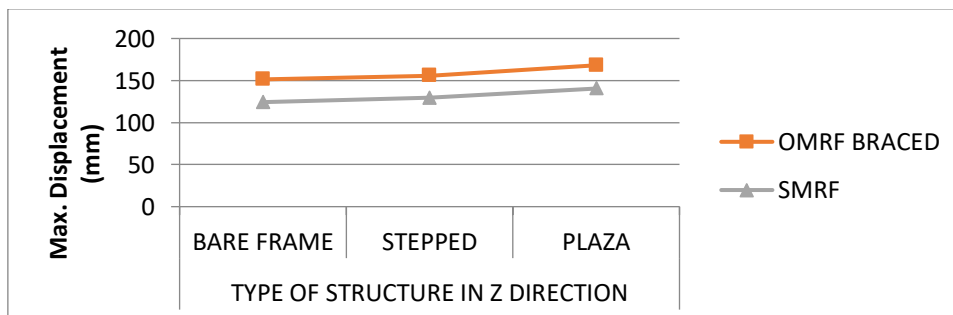


Fig.4.14: The Maximum nodal displacement (mm) in Zone IV at Z direction

The Maximum nodal displacement (mm) in Zone V at X direction is shown in Table 4.15 and Fig. 4.15:

Table 4.15: The Maximum nodal displacement (mm) in Zone V at X direction

MAXIMUM NODAL DISPLACEMENT (mm) IN ZONE V			
RF	TYPE OF STRUCTURE IN X DIRECTION		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	226.982	231.368	252.161
SMRF	186.444	181.81	210.691

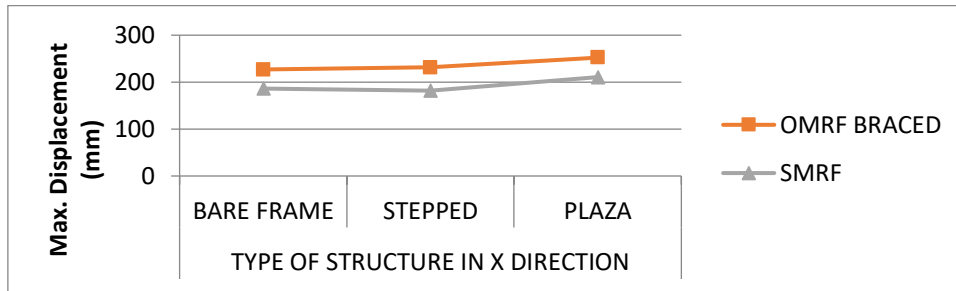


Fig.4.15: The Maximum nodal displacement (mm) in Zone V at X direction

The Maximum nodal displacement (mm) in Zone V at Z direction is shown in Table 4.16 and Fig. 4.16:

Table 4.16: The Maximum nodal displacement (mm) in Zone V at Z direction

MAXIMUM NODAL DISPLACEMENT (mm) IN ZONE V			
RF	TYPE OF STRUCTURE IN Z DIRECTION		
	BARE FRAME	STEPPED	PLAZA
OMRF BRACED	226.982	223.459	252.161
SMRF	186.44	194.339	210.691

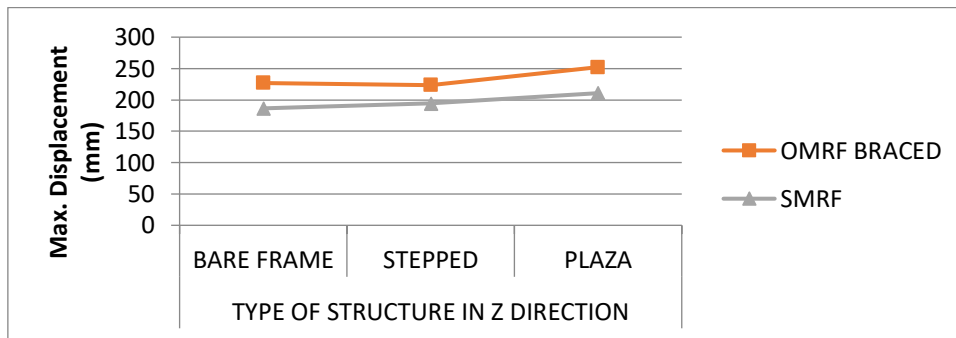


Fig.4.16: The Maximum nodal displacement (mm) in Zone V at Z direction

V. CONCLUSION

Here in this work OMRF braced (ordinary moment resisting frame bracing at lintel level) and SMRF (special moment resisting frame) was analysed with all seismic zone considering various regular and irregular structures. The relevant conclusion drawn with help of analysis data are:

Bending Moments

- It was observed that maximum bending moment in irregular plaza building and minimum in regular bare frame building.
- The rate of increase in bending moment is increases as the seismic zone intensity increases.
- The special moment resisting frame is more efficient than ordinary moment resisting braced type frame and SMRF reduces moments means reduces area of steel.
- While observing nature of graph found same in all seismic zone it was clear that bare frame is first best, stepped is second best and plaza building is critical.
- SMRF provides better detailing than OMRF structures.

Shear Forces

- It was observed that maximum shear force in irregular plaza building and minimum in regular bare frame building.
- The rate of increase in shear force is increases as the seismic zone intensity increases.
- The special moment resisting frame is more efficient than ordinary moment resisting braced types frame and SMRF reduces shear forces means reduces shear reinforcement.

- d. While observing nature of graph found same in all seismic zone it is clear that bare frame is first best, stepped is second best and plaza building is critical.
- e. Less shear force means less shear stress because shear stress is directly proportional to shear force.

Maximum Nodal Displacements

- a. It was observed that maximum nodal displacement in irregular plaza building and minimum in regular bare frame building.
- b. The rate of increase in nodal displacement increases as the seismic zone intensity increases.
- c. Maximum nodal displacement is almost same in both direction (X and Z direction).
- d. The special moment resisting frame is more efficient than ordinary moment resisting types frame and SMRF reduces nodal displacement means reduction in size of section.
- e. While observing nature of graph found same in all seismic zone it is clear that bare frame is first best, stepped is second best and plaza building is critical

VI. REFERENCES

- [1] SivaPrasad G.V.S., Adishesu S. "A Comparative Study Of OMRF & SMRF Structural System For Tall & High Rise Buildings Subjected To Seismic Load", IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308
- [2] Parmar Kiran, Dhankot Mazhar, "Comparative study between dual systems for lateral load resistance in buildings of variable heights", JIKRCE, ISSN: 0975 – 6760, Vol. – 02, ISSUE – 02, 2013
- [3] Najif Ismail "Comparative studies of IMRF and SMRF in moderate seismic zones"
- [4] Chippa Ambika, Nampalli Prerana, "Analysis and Design of R.C. Moment Resisting Frames with and without", IJISSET - International Journal of Innovative Science, Engineering & Technology, Vol. 1 Issue 6, August 2014. Shear Wall for Different Seismic Parameters
- [5] IS 456: 2000 Plain and Reinforced Concrete- Code of Practice
- [6] IS 1893:2002 Part-I
- [7] IS 13920:1993- Ductile Detailing of Reinforced Concrete Structure subject to Seismic Force- Code of practice
- [8] Mario Paz "Dynamics of Structures book"
- [9] Aggarwal & Shrikhande" Earthquake Resistant Design book".

CITE AN ARTICLE

Rai, M., & Paliwal, M. (2017). A COMPARISON OF OMRF BRACED & SMRF RC FRAME CONSIDERING EARTHQUAKE LOADING. INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY, 6(10), 587-601.