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# A COMPARATION OF OMRF BRACED & OMRF NON BRACED RC FRAME CONSIDERING EARTHQUAKE LOADING

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## 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 Ordinary Moment Resisting Frame with bracing and Ordinary Moment Resisting Frame 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) & Ordinary Moment Resisting Frame non braced (OMRF). 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 OMRF). 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, OMRF Braced, 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 OMRF 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.

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- 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 OMRF 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

### 1. 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 OMRF) 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 OMRF Braced and OMRF models, seismic zones and 13 load combinations are considered.
**Step-7** Comparative study of results in terms of beam forces, displacement and storey displacement

### 2. 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-

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| RESPONSE REDUCTION | TYPE OF STRUCTURE | ZONE |
|---|---|---|
| OMRF BRACED | BARE FRAME (REGULAR STRUCTURE) | 4 |
| OMRF | BARE FRAME (REGULAR STRUCTURE) | 4 |
| OMRF BRACED | PLAZA (IRREGULAR STRUCTURE) | 4 |
| OMRF | PLAZA (IRREGULAR STRUCTURE) | 4 |
| OMRF BRACED | STEPPED (IRREGULAR STRUCTURE) | 4 |
| OMRF | 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

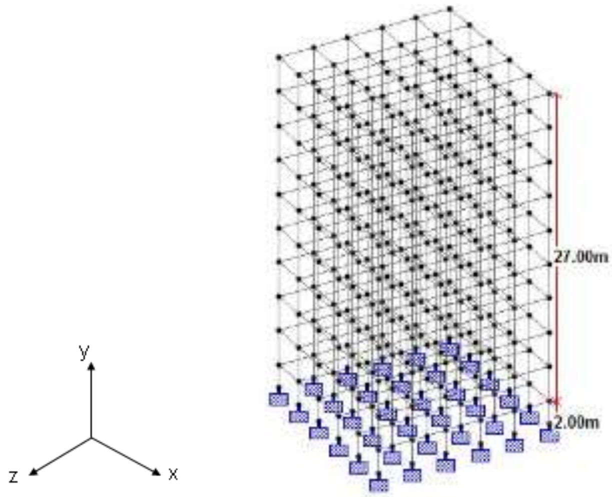


***Fig. 3.1: Isometric view of regular structure***

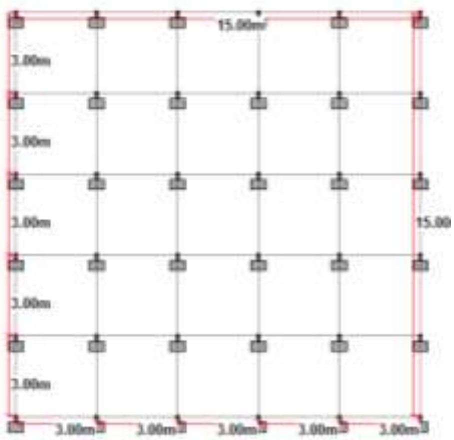


***Fig. 3.2: Plan of regular structure***

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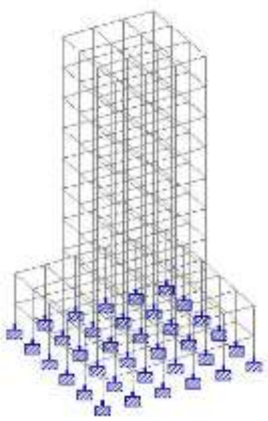

*Fig. 3.3: Isometric view of irregular plaza building*

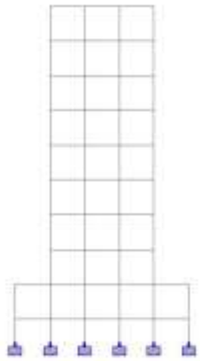

*Fig. 3.4: Front view of irregular plaza*

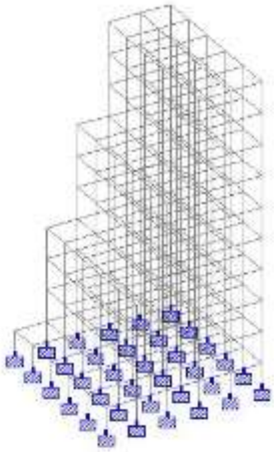

*Fig. 5: Isometric view of irregular stepped building*

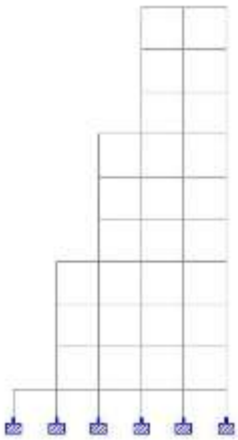

*Fig. 6: Front view of irregular stepped*

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

### 3. Material And Geomerical Properties

Following properties of material have been considered in the modelling -
Unit weight of RCC: 25 kN/$m^3$
Unit weight of Masonry: 20 kN/$m^3$ (Assumed)
Modulus of elasticity, of concrete: $5000\sqrt{fck}$
Poisson's ratio: 0.17
The depth of foundation is 2 m and the height of floor is 3 m.

### 4. 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/$m^3$ = 3.75 kN/$m^2$ (slab thickness 0.15 m assumed)

Finishing load = 1 kN/$m^2$
Total slab load = 3.75 + 1 = 4.75 kN/$m^2$
(c) Masonry external wall Load = 0.20 m x 2.55 m x 20 kN/$m^3$ = 10.2 kN/m
(d) Masonry internal wall Load = 0.10 m x 2.55 m x 20 kN/$m^3$ = 5.1 kN/m
(e) Parapet wall load = 0.10 m x 1 m x 20 kN/$m^3$ = 2 kN/m

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(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:
3.1 OMRF: 3 (Table - 7)
3.2 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

## 5. Loading Diagram

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

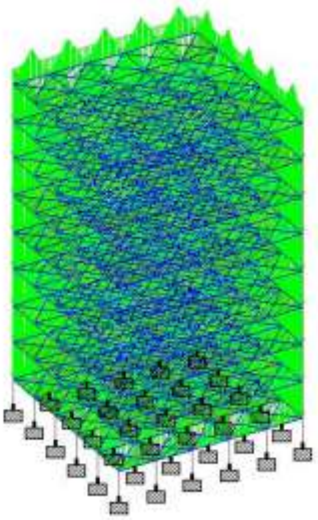

*Fig. 3.7: Dead load diagram*

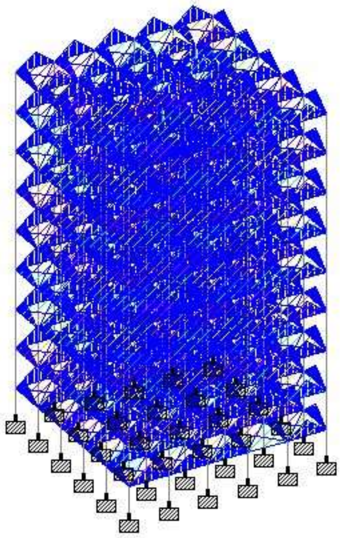

*Fig. 3.8: Live load diagram*

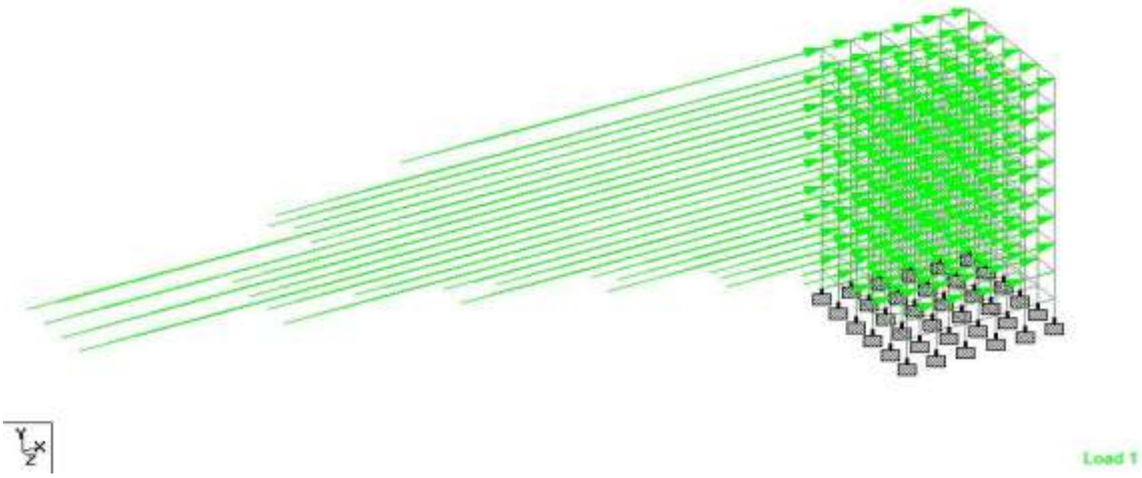


*Fig. 3.9: Seismic load in X direction*

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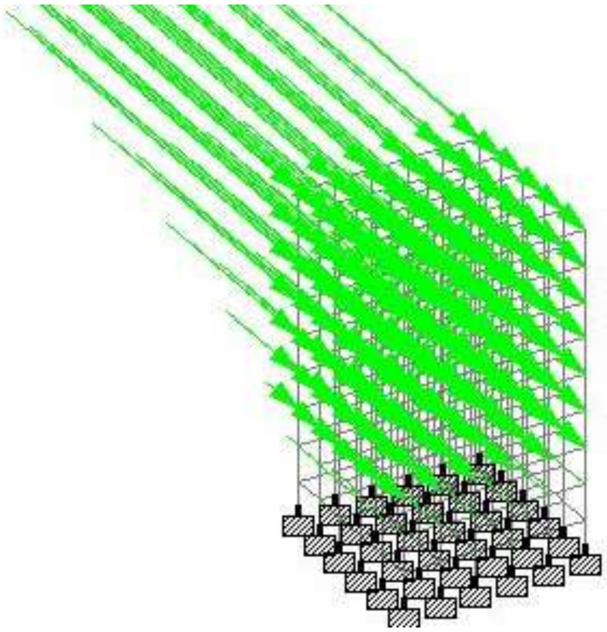

*Fig. 3.10: Seismic load in Z direction*

## IV. RESULT ANALYSIS

### 1. 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 | 156.5 | 173.2 | 189.5 |
| OMRF BRACED | 138.1 | 143.6 | 135.5 |

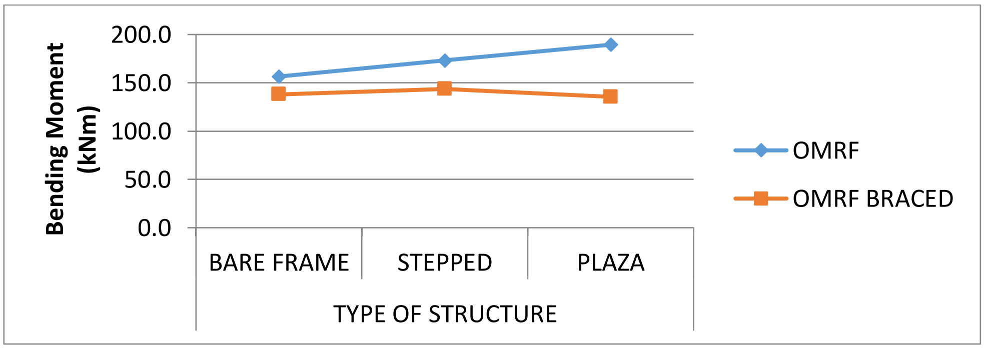


*Fig. 4.1: Maximum bending moment (kNm) in Zone II*

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

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*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 | 239.5 | 258.7 | 290.9 |
| OMRF BRACED | 212.9 | 202.9 | 221.7 |

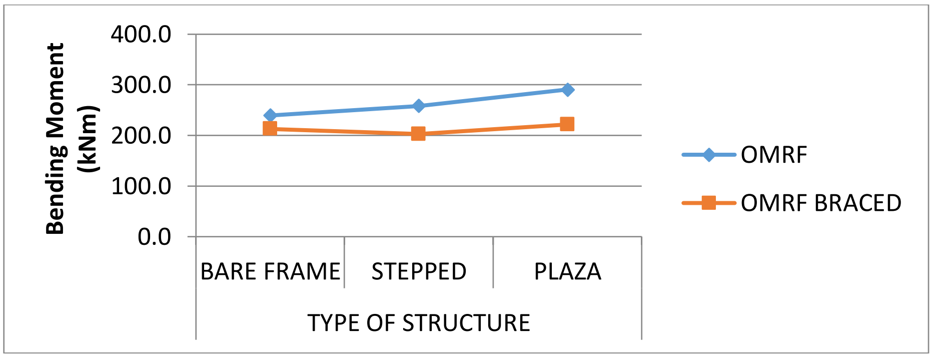


*Fig. 4.2: Maximum bending moment (kNm) in Zone III*

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 | 350.8 | 372.8 | 426.0 |
| OMRF BRACED | 312.6 | 325.8 | 292.7 |

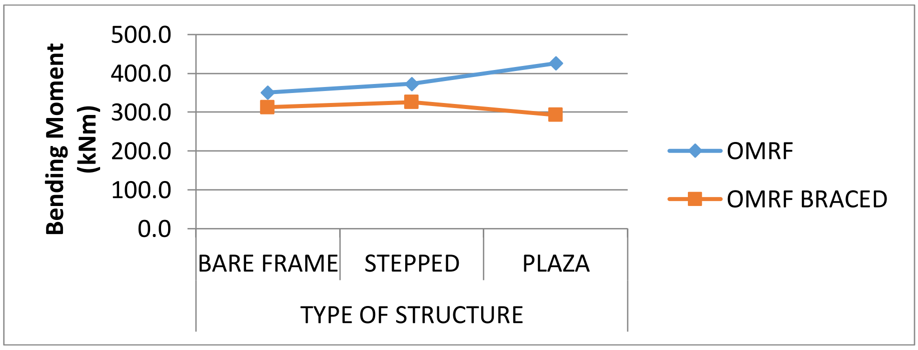


*Fig. 4.3: Maximum bending moment (kNm) in Zone III*

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 | 517.8 | 543.9 | 628.7 |
| OMRF BRACED | 462.1 | 481.9 | 427.5 |

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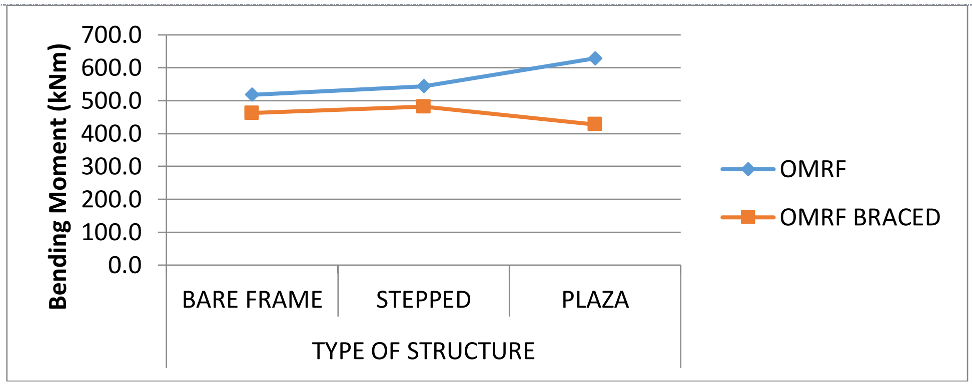


*Fig. 4.4: Maximum bending moment (kNm) in Zone V*

**2. 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 | 121.8 | 130.1 | 141.0 |
| OMRF BRACED | 106.1 | 112.9 | 110.9 |

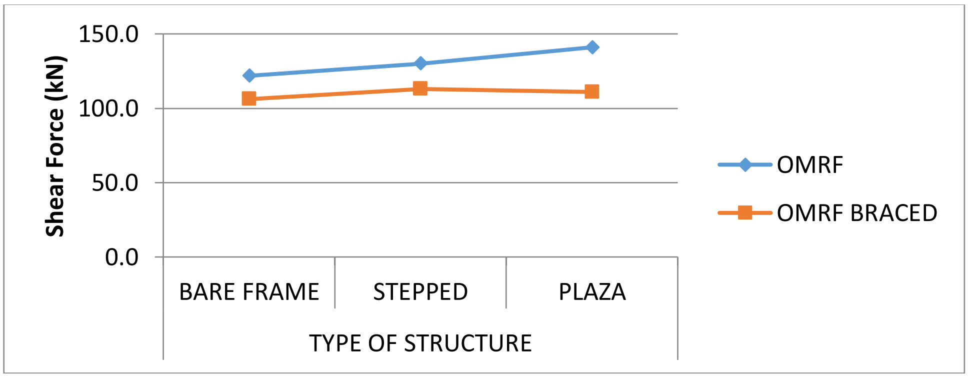


*Fig. 4.5: Maximum shear force (kN) in Zone II*

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 IIIMAXIMUM SHEAR FORCE (kN) IN ZONE III | | | |
|---|---|---|---|
| RF | TYPE OF STRUCTURE | | |
| | BARE FRAME | STEPPED | PLAZA |
| OMRF | 172.4 | 182.4 | 202.3 |
| OMRF BRACED | 152.5 | 153.2 | 157.9 |

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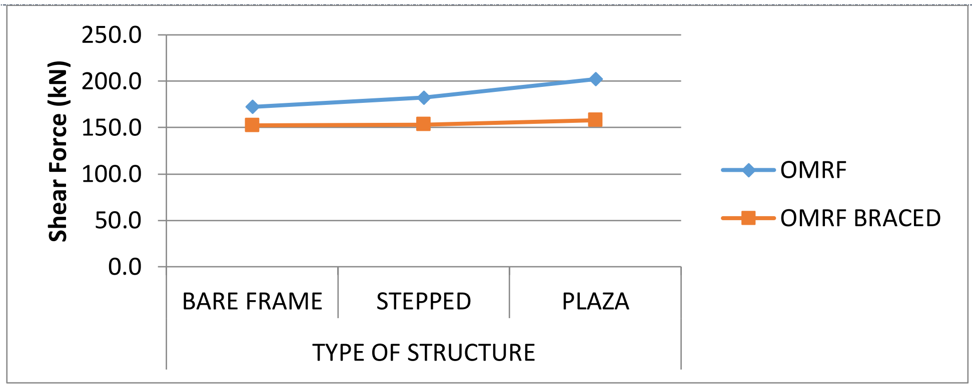


***Fig. 4.6: Maximum shear force (kN) in Zone III***

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** | 239.8 | 252.1 | 283.9 |
| **OMRF BRACED** | 214.2 | 222.4 | 209.6 |

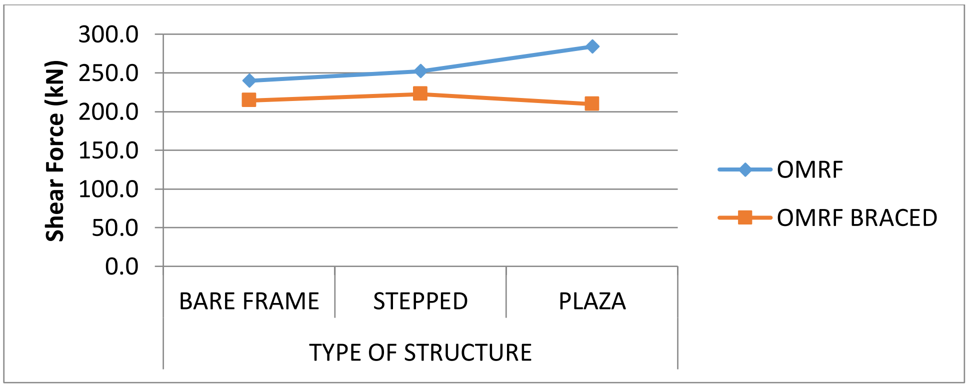


***Fig. 4.7: Maximum shear force (kN) in Zone IV***

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 | 340.8 | 358.4 | 406.4 |
| OMRF BRACED | 306.9 | 319.2 | 295.9 |

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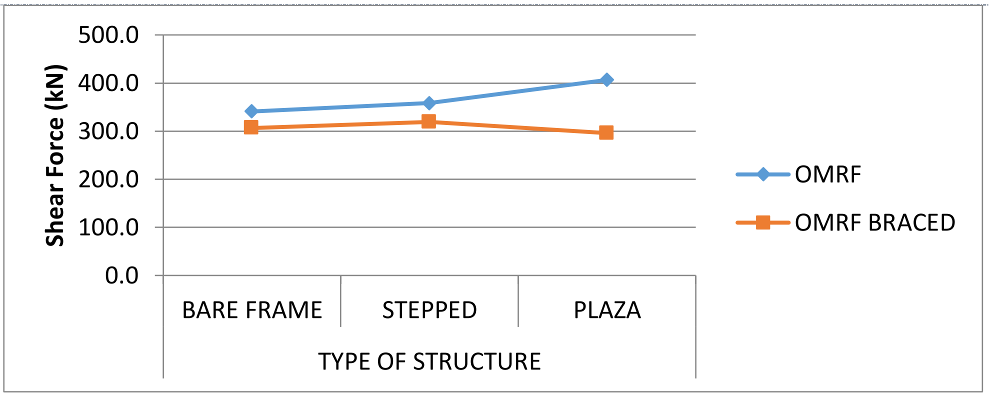


*Fig. 4.8: Maximum shear force (kN) in Zone V*

**3. 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 | 86.34 | 85.542 | 97.554 |
| OMRF BRACED | 63.104 | 69.992 | 70.091 |

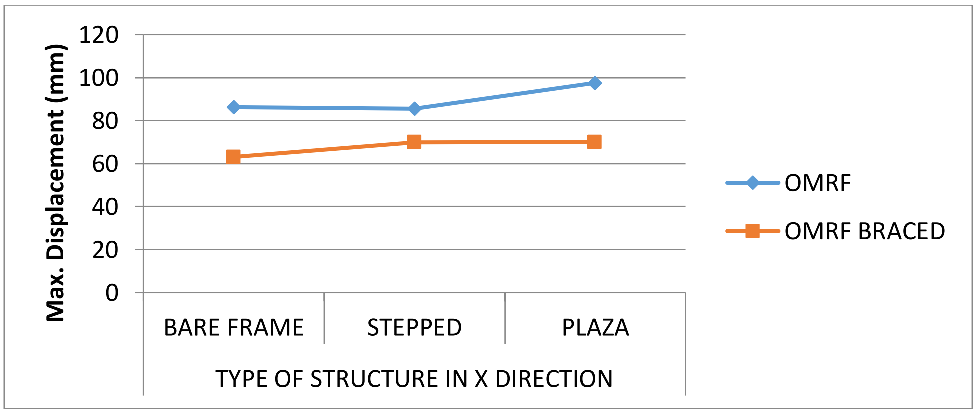


*Fig.4.9: The Maximum nodal displacement (mm) in Zone II at X direction*

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 | 86.34 | 89.995 | 97.554 |
| OMRF BRACED | 63.104 | 64.928 | 70.091 |

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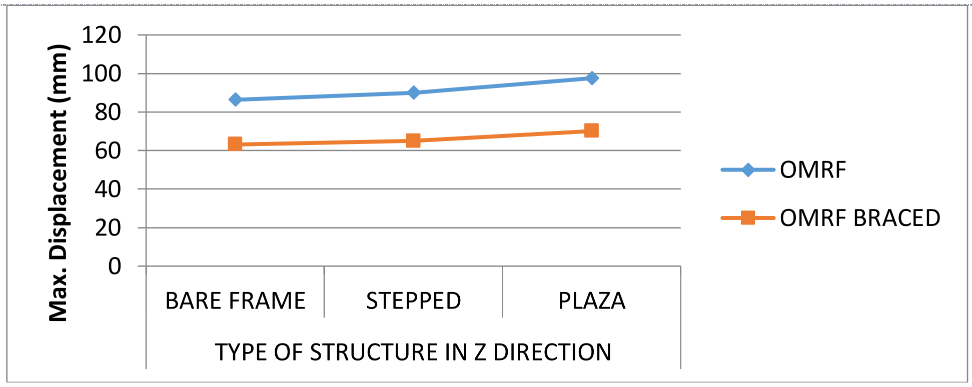


***Fig.4.10: The Maximum nodal displacement (mm) in Zone II at Z direction***

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** | 138.118 | 135.336 | 156.073 |
| **OMRF BRACED** | 100.922 | 106.852 | 112.107 |

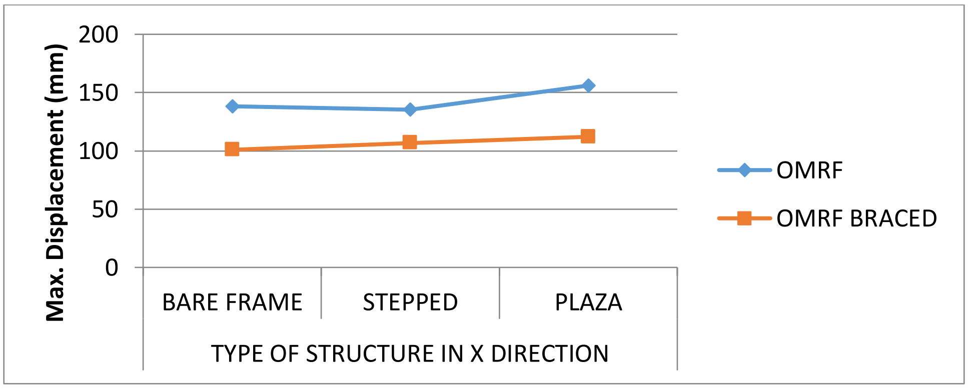


***Fig.4.11: The Maximum nodal displacement (mm) in Zone III at X direction***

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** | 138.118 | 143.996 | 156.073 |
| **OMRF BRACED** | 100.922 | 103.82 | 112.107 |

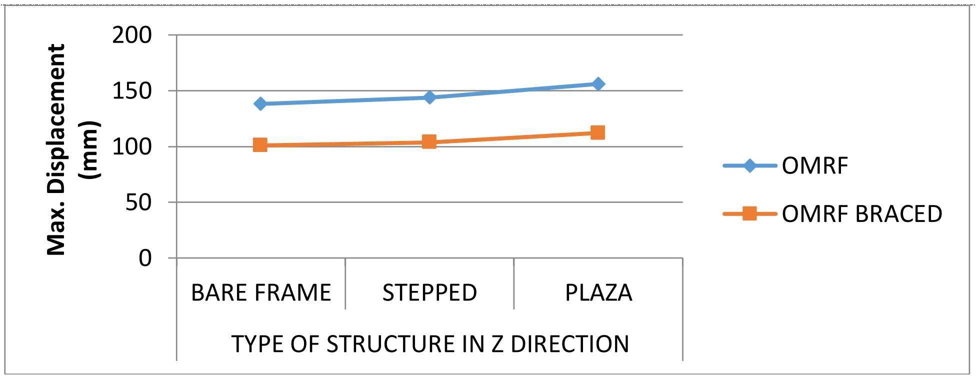


***Fig.4.12: The Maximum nodal displacement (mm) in Zone III at Z direction***

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** | 207.156 | 201.728 | 234.099 |
| **OMRF BRACED** | 151.346 | 156.652 | 168.128 |

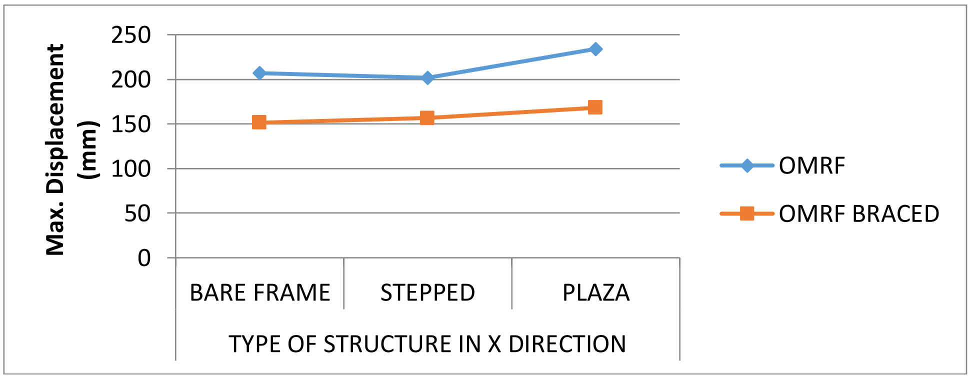


***Fig.4.13: The Maximum nodal displacement (mm) in Zone IV at X direction***

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** | 207.156 | 215.928 | 234.099 |
| **OMRF BRACED** | 151.346 | 155.676 | 168.128 |

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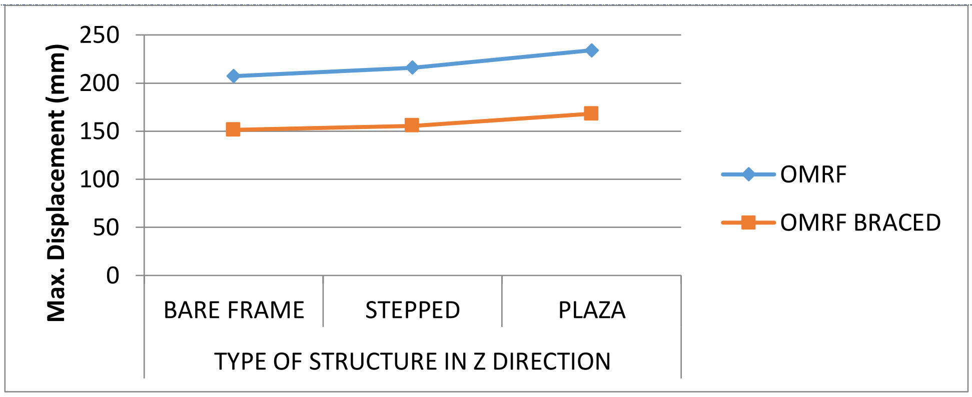


***Fig.4.14: The Maximum nodal displacement (mm) in Zone IV at Z direction***

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** | 310.712 | 301.326 | 310.712 |
| **OMRF BRACED** | 226.982 | 231.368 | 252.161 |

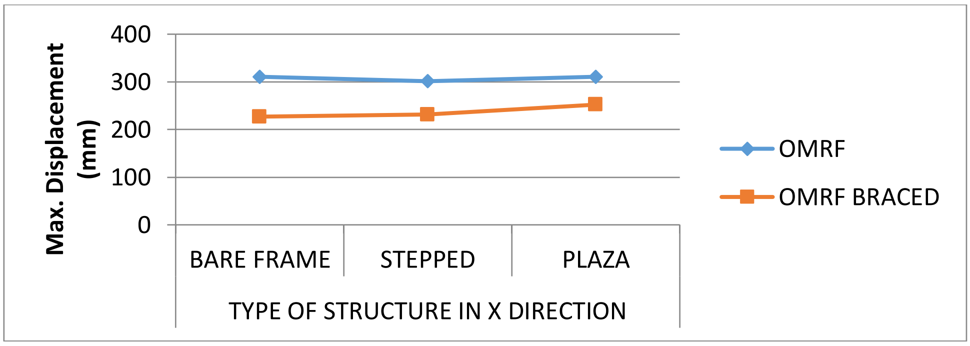


***Fig.4.15: The Maximum nodal displacement (mm) in Zone V at X direction***

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** | 310.712 | 323.87 | 351.136 |
| **OMRF BRACED** | 226.982 | 223.459 | 252.161 |

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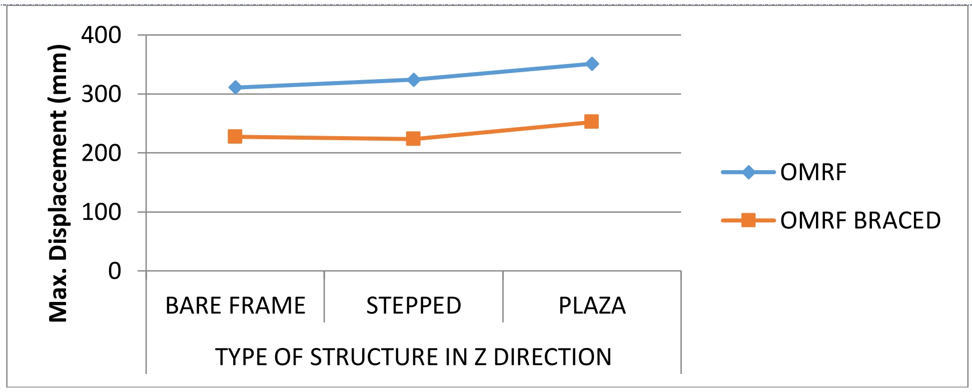


***Fig.4.16: The Maximum nodal displacement (mm) in Zone V at Z direction***

## V. CONCLUSION

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

**1. Bending Moments**

a. It was observed that maximum bending moment in irregular plaza building and minimum in regular bare frame building.
b. The rate of increase in bending moment is increases as the seismic zone intensity increases.
c. The ordinary moment resisting frame braced at lintel level is more efficient than ordinary moment resisting type frame and reduces moments means reduces area of steel.
d. 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.
e. OMRF braced provides better detailing than OMRF structures.

**2. Shear Forces**

a. It was observed that maximum shear force in irregular plaza building and minimum in regular bare frame building.
b. The rate of increase in shear force is increases as the seismic zone intensity increases.
c. The ordinary moment resisting frame braced at lintel is more efficient than ordinary moment resisting types frame and 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 in directly proportional to shear force.

**3. Maximumn 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 is increases as the seismic zone intensity increases.
c. Maximum nodal displacement is almost same in both direction (X and Z direction).
d. The ordinary moment resisting frame braced at lintel level is more efficient than ordinary moment resisting types frame and 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.

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