A Comparative Analysis of OMRF And SMRF Structures In Different Seismic Zones

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Abstract- *In this thesis a comparison of Moment Resisting RC Frames for Regular and Irregular buildings in all the four seismic zones is carried out. The different moment resisting frames considered are Ordinary Moment Resisting Frame (OMRF) and Special Moment Resisting Frame (SMRF).Comparisons are made for the behaviorof building frames considering different elevation irregularity and response reduction factor under earthquake forces. For this purpose, the three buildings of different configurations considered are a regular bare-frame block structure, an irregular stepped structure and an irregular plaza structure. For the same plan area and same height a comparison is done for different buildings. The base area is 15m x 15m of G+8 storey buildings. The overall height of the buildings is taken to be 27m.The building frames are made of 5 equal bays along both the axis. Thirteen different load combinations are considered as per IS 456:2000.The method of analysis used is Equivalent Static Code Method. Analysis was done using STAAD.Pro software using Indian Standards. And the codes used for reference are IS 1893 (PART 1):2002, IS 456:2000, IS 875 (PART 1):1987, IS 875 (PART2):1987 and IS 13920:1993.The parameters computed and compared are shear force, bending moment, maximum deformation and storeydeformation . In all 24 models are made and analysis is done to bring out the results i.e., adoptability of suitable moment resisting frame as well as type of building configuration.*

The results show a close competition between regular bare-frame and irregular stepped frame, though irregular plaza frame showed higher values. OMRF showed higher values as compared to SMRF.

I. INTRODUCTION

The choice of a particular kind of framing system is influenced by two key factors: the zone's seismic risk and the budget. The flexural stiffness of individual components determines the distribution of lateral forces applied to any structure. According to the earthquake dangers, Indian Codes divide the nation into four seismic zones (II, III, IV, and V). In relatively low seismic zones, the OMRF is perhaps the most widely used form of the frame. However, as earthquake threats rise, it becomes insufficient, necessitating the use of SMRF frames. Moment-resisting frames are rectilinear assemblages of beams and columns rigidly coupled to shear, reinforcement, and other factors. Because of their superior deformation and energy absorption characteristics, moment frames have been widely used for seismic resisting systems. A moment frame's components should be able to withstand both gravity and lateral loads. The flexural stiffness for every component determines how lateral forces are distributed.

Under seismic loads, regular buildings are thought to perform far better than irregular buildings. This is what the codes have been urging us to do all along. In the construction of buildings, irregularities are unavoidable. As competition has intensified, so have aesthetic demands. It is preferable to combine strength and beauty. As a result, a thorough investigation into the structural behaviour of structures with irregularities under seismic loading is required for proper design and improved performance.

Earthquake Magnitude and Intensity

An earthquake, thus, is literally described as an episode of intense seismic energy generation. Richter scales are commonly employed as magnitudes scales. Trace deformation of surface-wave seismograms is the most important parameter in determining the magnitude of an earthquake. Magnitudes estimated from body wave components of seismograms are widely used to refine magnitude estimations due to this property. But, for the purposes of reporting, the outcome is almost always reported as equivalent Richter magnitude. When it comes to measuring the magnitude of an earthquake, there is a direct correlation between the quantity of energy emitted (E) and the Richter magnitude (M).

$$\log_{10} E = 11.4 + \boldsymbol{1.5M}$$

The intensity of an earthquake is a subjective assessment of its perceived local impacts, and it is determined by peak acceleration, duration, and velocity. The modified Mercalli scale (MM) is the most extensively used, having been established by Mercalli in 1902, amended by Wood and Neuman in 1931, and revised by Richter in 1958.

EFFECTS OF EARTHQUAKES

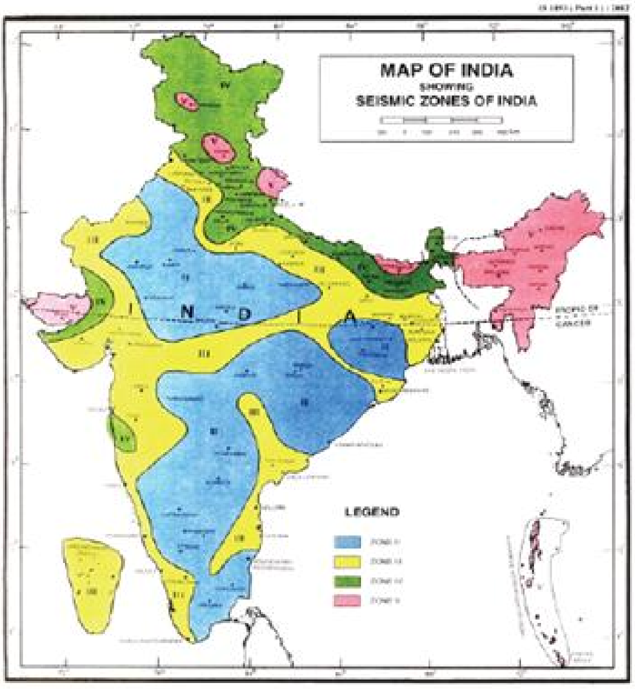
Earthquakes have significant effects on structures, humans, the environment, and animals. We commonly associate earthquake impacts with negative adjectives such as unpleasant, frightening, irritating, and loss. Earthquakes, on the other hand, can have a favourable impact.

Destructive Effects of Earthquakes –

1. At or around the epicentre, earthquakes cause buildings, bridges, and other infrastructure to collapse. Many people and animals are slain and buried beneath the surface.
2. Rails have been folded, and underground wires have been severed. In huge cities, fires are unavoidable.
3. Tsunamis are sea waves that are caused by earthquakes.
4. Earthquakes cause fractures and fissures in the ground.
5. Earthquakes generate landslides, avalanches, and landmass denudation.
6. Earthquakes can sometimes block valleys, forming undesirable lakes or rerouting river flows, resulting in catastrophic scenarios.
7. It has psychological consequences that might take years, if not a lifetime, to overcome.

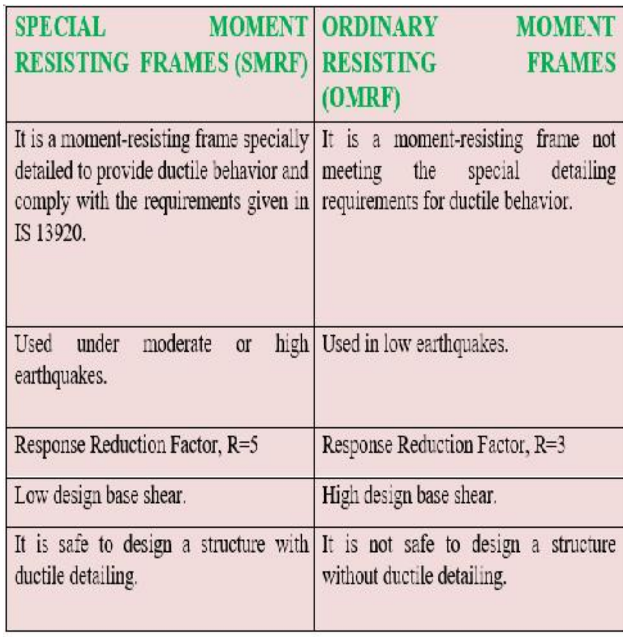
Constructive Effects of Earthquakes –

1. Earthquakes can sometimes result in the production of beneficial hot springs.
2. Earthquakes occasionally submerge coastal land, resulting in the construction of inlets, bays, and gulfs that aid in the development of fishing and shipping. They open up new communication channels.
3. It can trigger the emergence of beaches and the emergence of productive shorelines from the water.



STRUCTURAL FRAME SYSTEMS

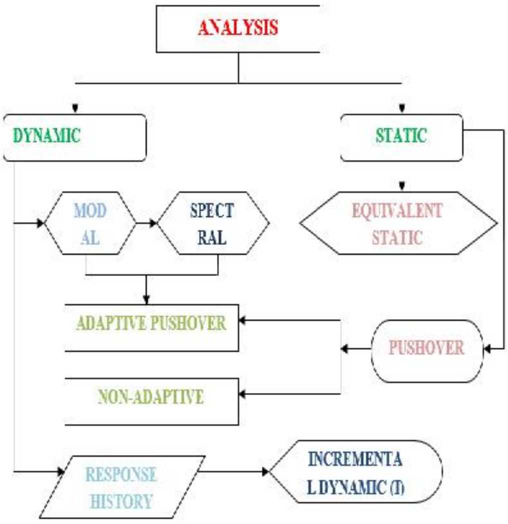
STRUCTURAL FRAME SYSTEMS



SPECIAL MOMENT RESISTING FRAMES (SMRF)	ORDINARY MOMENT RESISTING FRAMES (OMRF)
It is a moment-resisting frame specially detailed to provide ductile behavior and comply with the requirements given in IS 13920.	It is a moment-resisting frame not meeting the special detailing requirements for ductile behavior.
Used under moderate or high earthquakes.	Used in low earthquakes.
Response Reduction Factor, R=5	Response Reduction Factor, R=3
Low design base shear.	High design base shear.
It is safe to design a structure with ductile detailing.	It is not safe to design a structure without ductile detailing.

METHODS OF SEISMIC ANALYSIS

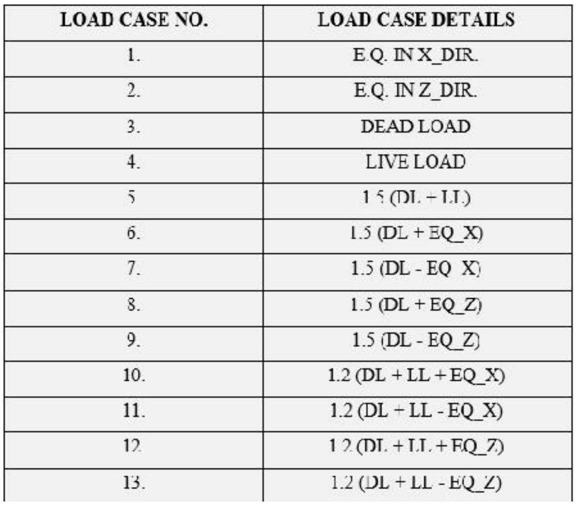
Seismic analysis has recently seen a major growth in both research and practise because of the increased availability of reliable and user-friendly software, as well as fast computers. Flowchart illustrating some of these structural building analysis techniques:



Key: E = elastic analysis; I = inelastic analysis.

METHOD ADOPTED IN THE ANALYSIS WORK

- Method of Dynamic Analysis
- Method of Static Analysis
- We prepared a G+8 storey building challenge.
- We use a reduced coding way to perform equivalent static analysis on the construction.
- In order to analyse the structures using the simplified code method, the following procedures were taken:
- Geometry, bays, and storeys of the building (3 geometries).
- Model selection for response reduction factors (OMRF and SMRF) according to IS 1893 (PART 1):2002 Table 7.
- Using Table 2 of IS 1893 (PART 1):2002, select four seismic zones (II, III, IV, and V).
- Importance factor selection according to IS 1893 (PART 1):2002 Table 6.
- Based on IS 456:2000 and IS 1893 (PART 1):2002, consider thirteen load combinations.



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)

PROBLEM DISCRIPTION

A comparative analysis of the behaviour of multi-story building frames under earthquake stresses is carried out in this thesis work, taking into account varied vertical geometrical configurations and response reduction factors. The results are then compared in terms of moments, shear force,deformation s, and storey deformation. The analysis is carried out in accordance with IS 1893 (PART 1):2002.

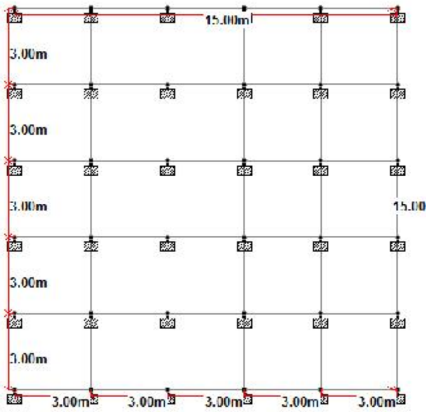
In medium soil, a G+8 storey reinforced concrete building with various configurations has a base plan of 15m x 15m and a height of 27m.

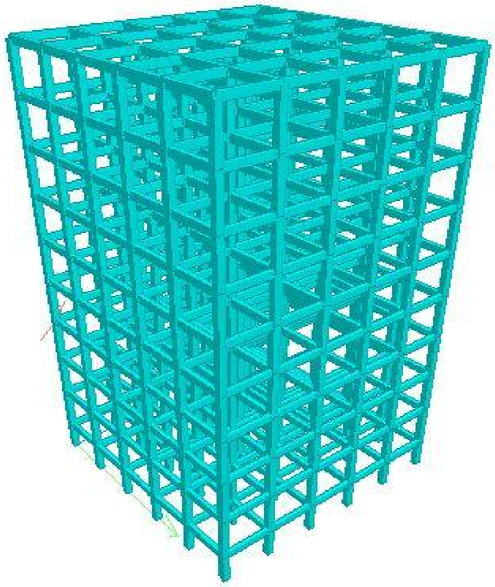
A standard bare-frame, an irregular plaza, and an irregular stepping building are among the several forms examined.

M20 is the concrete grade, and Fe 415 is the steel grade.

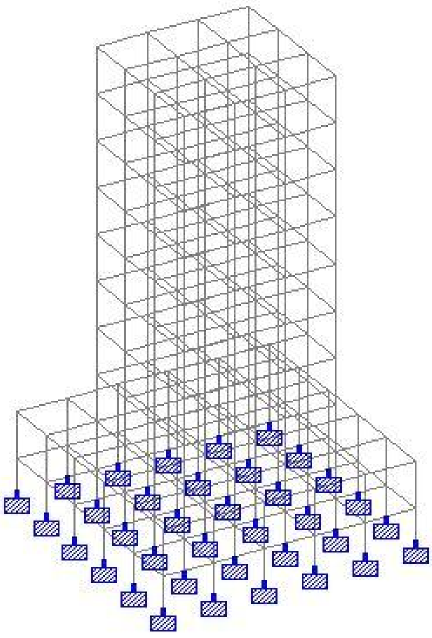
- The column is 0.35m x 0.45m in size, and the beam is 0.23m x 0.45m in size.
- R.C.C. unit weight: 25kN/m3 according to Table 1 (page 6) of IS 875 (PART 1):1987.
- Masonry unit weight: 20kN/m3 according to Table 1 (page 8) of IS 875 (PART 1):1987.
- According to IS 456:2000, the modulus of elasticity for concrete is Ec: 5000fck.
- Concrete's Poison Ratio is 0.17.
- The slab's thickness is 150mm.
- The base is 2 metres deep, and the floor is 3 metres high.
- All of the cases are presumptively supported.

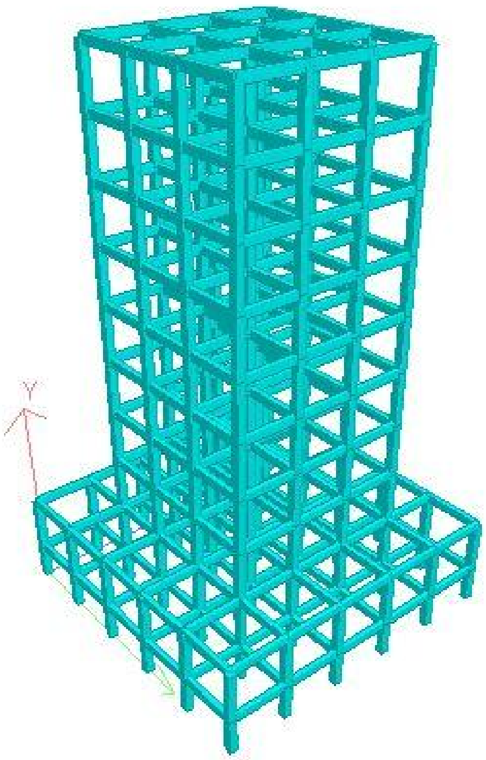
CASES	**STRUCTURE**	**SEISMIC ZONE**	**RESPONSE REDUCTION FACTOR**
CASE 1	REGULAR (BARE FRAME)	ZONE - II	OMRF
CASE 2	REGULAR (BARE FRAME)	ZONE - III	OMRF
CASE 3	REGULAR (BARE FRAME)	ZONE - IV	OMRF
CASE 4	REGULAR (BARE FRAME)	ZONE - V	OMRF
CASE 5	REGULAR (BARE FRAME)	ZONE - II	SMRF
CASE 6	REGULAR (BARE FRAME)	ZONE - III	SMRF
CASE 7	REGULAR (BARE FRAME)	ZONE - IV	SMRF
CASE 8	REGULAR (BARE FRAME)	ZONE - V	SMRF
CASE 9	IRREGULAR (PLAZA FRAME)	ZONE - II	OMRF
CASE 10	IRREGULAR (PLAZA FRAME)	ZONE - III	OMRF
CASE 11	IRREGULAR (PLAZA FRAME)	ZONE - IV	OMRF
CASE 12	IRREGULAR (PLAZA FRAME)	ZONE - V	OMRF
CASE 13	IRREGULAR (PLAZA FRAME)	ZONE - II	SMRF
CASE 14	IRREGULAR (PLAZA FRAME)	ZONE - III	SMRF
CASE 15	IRREGULAR (PLAZA FRAME)	ZONE - IV	SMRF
CASE 16	IRREGULAR (PLAZA FRAME)	ZONE - V	SMRF
CASE 17	IRREGULAR (STEPPED FRAME)	ZONE - II	OMRF
CASE 18	IRREGULAR (STEPPED FRAME)	ZONE - III	OMRF
CASE 19	IRREGULAR (STEPPED FRAME)	ZONE - IV	OMRF
CASE 20	IRREGULAR (STEPPED FRAME)	ZONE - V	OMRF
CASE 21	IRREGULAR (STEPPED FRAME)	ZONE - II	SMRF
CASE 22	IRREGULAR (STEPPED FRAME)	ZONE - III	SMRF
CASE 23	IRREGULAR (STEPPED FRAME)	ZONE - IV	SMRF
CASE 24	IRREGULAR (STEPPED FRAME)	ZONE - V	SMRF



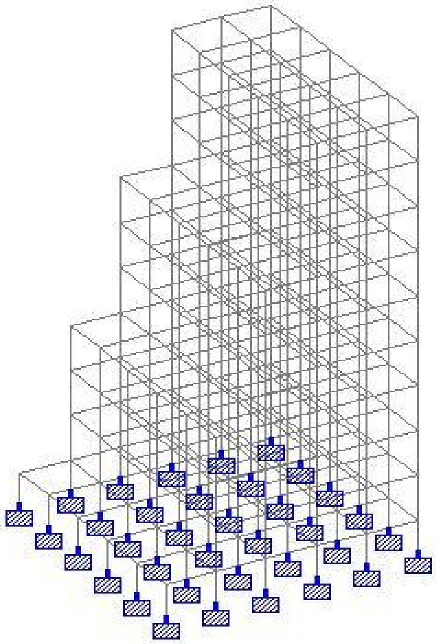


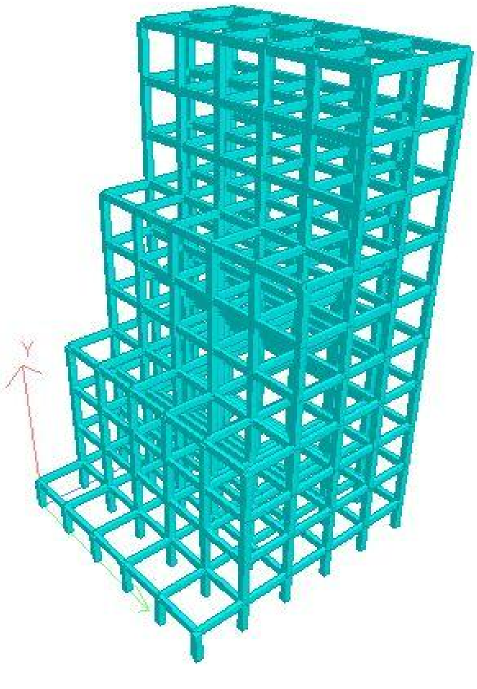
COMMON BASE PLANFIGURE 18: 3D VIEW OF REGULAR BARE-FRAME STRUCTURE





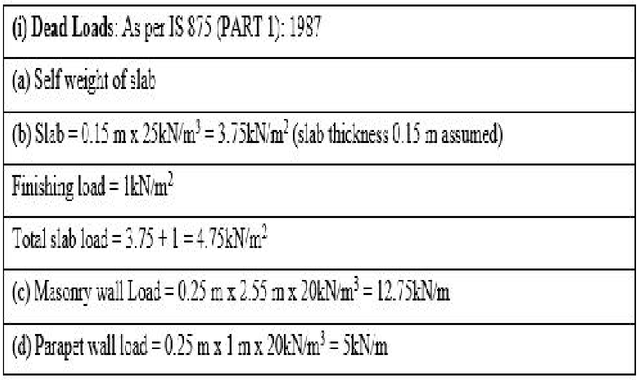
3D VIEW OF IRREGULAR PLAZA STRUCTURE



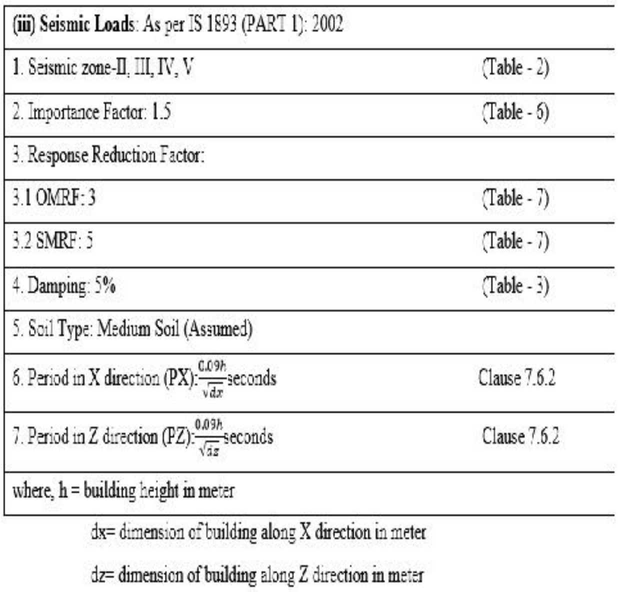


3D VIEW OF IRREGULAR STEPPED STRUCTURE

ANALYSIS BY SIMPLIFIED CODE METHOD



(i) Dead Loads: As per IS 875 (PART 1): 1987
(a) Self weight of slab
(b) Slab = 0.15 m x 25kN/m^3 = 3.75kN/m^2 (slab thickness 0.15 m assumed)
Finishing load = 1kN/m^2
Total slab load = 3.75 + 1 = 4.75kN/m^2
(c) Masonry wall Load = 0.25 m x 2.55 m x 20kN/m^3 = 12.75kN/m
(d) Parapet wall load = 0.25 m x 1 m x 20kN/m^3 = 5kN/m



(iii) Seismic Loads: As per IS 1893 (PART 1): 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): $\frac{0.09h}{\sqrt{dx}}$ seconds	Clause 7.6.2
7. Period in Z direction (PZ): $\frac{0.09h}{\sqrt{dz}}$ seconds	Clause 7.6.2
where, h = building height in meter	

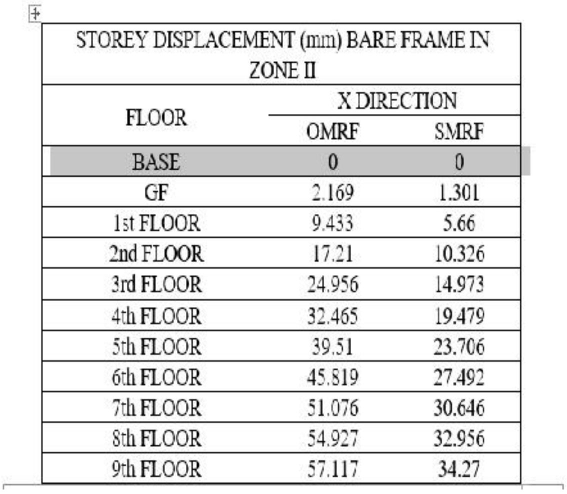
dx= dimension of building along X direction in meter

dz= dimension of building along Z direction in meter

RESULTS AND DISCUSSION

Table 22 indicate the Storey deformation (mm) bare frame in zone II in the X direction.

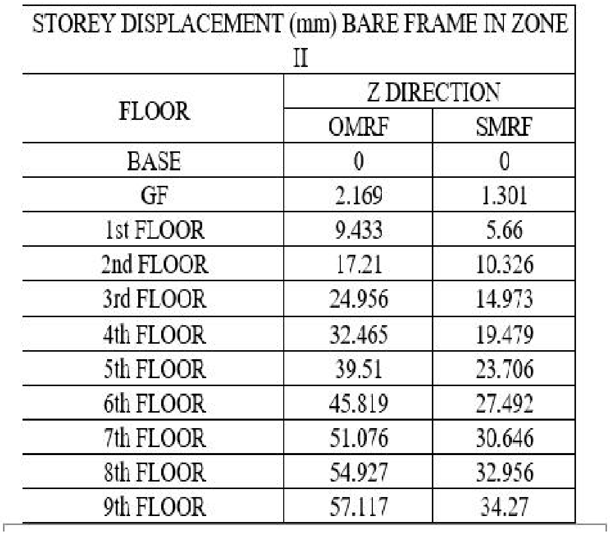
TABLE 22: STOREY DISPLACEMENT (MM) BARE FRAME IN ZONE II AT X DIRECTION



STOREY DISPLACEMENT (mm) BARE FRAME IN ZONE II		
FLOOR	X DIRECTION	
	OMRF	SMRF
BASE	0	0
GF	2.169	1.301
1st FLOOR	9.433	5.66
2nd FLOOR	17.21	10.326
3rd FLOOR	24.956	14.973
4th FLOOR	32.465	19.479
5th FLOOR	39.51	23.706
6th FLOOR	45.819	27.492
7th FLOOR	51.076	30.646
8th FLOOR	54.927	32.956
9th FLOOR	57.117	34.27

The OMRF has the highest storeydeformation and the SMRF has the lowest.Table 23 indicate the Storey deformation (mm) bare frame in zone II in the Z direction.

TABLE 23: STOREY DISPLACEMENT (MM) BARE FRAME IN ZONE II AT Z DIRECTION



STOREY DISPLACEMENT (mm) BARE FRAME IN ZONE II		
FLOOR	Z DIRECTION	
	OMRF	SMRF
BASE	0	0
GF	2.169	1.301
1st FLOOR	9.433	5.66
2nd FLOOR	17.21	10.326
3rd FLOOR	24.956	14.973
4th FLOOR	32.465	19.479
5th FLOOR	39.51	23.706
6th FLOOR	45.819	27.492
7th FLOOR	51.076	30.646
8th FLOOR	54.927	32.956
9th FLOOR	57.117	34.27

The OMRF has the highest storeydeformation and the SMRF has the lowest

CONCLUSION

The OMRF and SMRF are evaluated for all seismic zones, considering various types of traditional and irregular buildings. The following concludes the work.

BENDING MOMENT

- The irregular plaza building has the highest bending moment, while the standard bare frame building has the lowest.
- The moments of regular bare-frame and irregular stepped building were close,irrespective of the type of frames.Though plaza building showed greater moments in every case.
- The special moment resisting frame is more efficient than ordinary moment resisting frame and SMRF reduces moments means reduces area of steel so it is more economical to OMRF.
- As the seismic zone intensity rises, so does the rate of bending moment.
- While the form of the graph is consistent throughout seismic zones, it is evident that bare frame is best, stepped is second best, and plaza buildings are critical.

SHEAR FORCE

- The irregular plaza building has the most shear force, whereas the standard bare frame building has the lowest.
- Regardless of the type of frames, the shear forces of standard bare-frame and irregular stepped buildings were similar. In every case, however, the plaza building demonstrated stronger shear forces.
- The special moment resisting frame (SMRF) is more efficient than the ordinary moment resisting frame (OMRF), as it decreases shear forces and hence shear reinforcement, making it more cost effective.
- As the seismic zone intensity rises, the rate of shear forces rises as well.
- While the form of the graph is consistent throughout seismic zones, it is evident that bare frame is best, stepped is second best, and plaza buildings are critical.

MAXIMUM DEFORMATION

- In an irregular plaza building, the maximum deformation is noticed, while in a regular bare frame building, the smallest deformation is observed.
- As the seismic zone strength increases, the rate of deformation increases.
- In both directions, the maximum deformation is nearly the same (X and Z direction).
- Regardless of the type of frames, the deformation s of regular bare-frame and irregular stepped buildings were near. In the plaza building showed larger deformation s.
- The special moment resisting frame is more efficient than the ordinary moment resisting frame, and because SMRF minimises deformation and hence section size, it is more cost effective than OMRF.
- While the form of the graph is consistent throughout seismic zones, it is evident that bare frame is best, stepped is second best, and plaza buildings are critical.

REFERENCES

[1] SivaPrasad G.V.S., Adiseshu 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] Dr. Valsson Varghese, YogeshRamakantBorkar “Comperative Study Of S.M.R.F. Building Over O.M.R.F. Building With Seismic And Wind Effect”, International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 3, Issue 3, May-Jun 2013, pp.1501-1503.

[3] AbhyudayTitiksh, Dr. M.K. Gupta. “A Study of the Various Structural Framing Systems Subjected to Seismic Loads”, SSRG International Journal of Civil Engineering (SSRG-IJCE) – volume 2 Issue 4 April 2015ISSN: 2348 – 8352.

[4] Jaya ParasadKadai, M.K.M.V. Ratnam. “Static Analysis of Multistoreyed RC Buildings By Using Pushover Methodology.”
IJIRST –International Journal for Innovative Research in Science & Technology| Volume 1 | Issue 8 | January 2015 ISSN (online): 2349-6010.

[5] P.Ram Prasad, R. Rama Rao “Determination Of Moment Resisting RC Frames Of Response Reduction Factors” , IJARSE International Journal of Advance Research in Science and Engineering Vol. No. 4 , Issue No. 12 , December 2015.

[6] Payal P. Khobragade1, Prof. Sushant M. Gajbhiye2, “Seismic Comparison of OMRF & SMRF Structural System on Zone II” IRJET Volume: 07 Issue: 02 | Feb 2020

[7] Mamathashree K.S, Sanjay S.J,”Seismic Evaluation of RC Framed Irregular Buildings with Soil Structure Interaction”, International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391.

[8] ApurbaMondal , Siddhartha Ghosh , G.R. Reddy , “Performance-based evaluation of the response reduction factor for ductile RC frames”.

[9] G. Magliulo and R. Ramasco ,”SEISMIC PERFOMANCE OF R/C FRAMES WITH REGULAR AND IRREGULAR STRENGTH VERTICAL DISTRIBUTIONS”,The 14th
World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China.

[10] SuchitaHirde, Rahul Aher,”Seismic Evaluation of Irregular Structures”International Journal of Engineering Research ISSN:2319-6890)(online),2347-5013(print)
Volume No.5 Issue: Special 3, pp: 750-755 27-28 Feb. 2016.

[11] Shaikh Abdul Aijaj Abdul Rahman and Ansari UbaidurrahmanSalik,”Seismic analysis of vertically irregularbuildings”,CURRENT SCIENCE, VOL. 111, NO. 10, 1658 25 NOVEMBER 2016.

[12] SarfarajMunshi and M.S. Bhandiwad,”Seismic Analysis of Regular and Vertical Irregular RC Buildings”,Bonfring International Journal of Man Machine Interface, Vol. 4, Special Issue, July 2016.