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Analysis of Design of Multistorey Framed Structures in different Seismic Zones of India and Their Comparative Study

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Abstract - Earthquake is a natural phenomenon which can happen suddenly and can cause vast destruction. Designing a structure in such a way that reducing damage during an earthquake makes the structure quite uneconomical, as the earthquake might or might not occur in its life time and is a rare phenomenon. In this paper a G+5 and G+10 RCC framed structure has been analysed and designed using STAAD.Pro V8i. The buildings are designed as per IS 456:2000 for gravity loads and also designed as per IS 1893(Part 1):2016 for earthquake forces in different seismic zones .Their comparative study result have been shown in this paper. The study also includes the determination of Axial force, displacement, moment and shear and the results are shown using various comparative diagram. The present IS code 1893:2016 doesn't provide information about the variation of concrete and percentage of steel from zone to zone. This study mainly focuses on the comparison of percentage Steel, concrete quantities, variation of loads, Shear-force and Bending moment. When the building is designed using gravity loads as per IS 456:2000 and earthquake forces in different seismic zones as per IS 1893(Part 1):2016.

Key Words: Bending moment, shearforce, steel reinforcement, axial force.

1. INTRODUCTION

Vibrations of the earth's surface caused by waves coming from a source of disturbances inside the earth are described as earthquake. In the present scenario earthquake engineering attracts major attention of scientist because this is the event which cannot be accurately predicted it is the sadden event which happens due to various reasons such as;

1. Movement of tectonic plates.

2. Sudden slips at the faults.

3. Building of dams.

4. Volcanic earthquakes.

5. Due to explosive.

6. Due to mining etc.

India is divided into 4 seismic zones according to the Indian earthquake zoning map. The four seismic zones are zone II, III, IV & V in which zone II has lowest level of seismicity and zone V has highest level of seismicity.

No structures will completely resist seismic forces without damage. Most of the structures will undergo minor or major damage due to earthquake. The damage to the structure may be minor if the magnitude of the earthquake is small, whereas structure may collapse if the magnitude of the earthquake is very high. Thus in recent days every structure is designed for earthquake resistance.

Whenever a structure is designed for natural incident such as earthquake we design it to behave the following limits state.

i. **Serviceability**. In this case structure will suffer less or no structural damage. Buildings which are important in their nature such as hospital, assembly halls, and nuclear plants are designed under this category because even after earthquake it should be serviceable.

ii. **Damageability**. In this type, if an earthquake occurs some damaged will happen and it can repaired and put to re-use. Permanents building fall in these categories

iii. **Collapse**. In this case building is free to damaged but the supports will be remains safe to bear the permanents loads. In earthquake analysis the force that actually acts on the structure at the time of earthquake are much higher than the forces which are designed. The lateral forces applied during seismic analysis are highly unpredictable. Thus, the design criteria should provide minimum requirements to maintain safety against earthquake and major fails and loss of lives.

1.1 The collapse of structure can be minimized if following points are taken into consideration.

-The pattern of failure can be made ductile instead of brittle, if ductility is assured dissipation of energy produced will show small amount of deterioration.

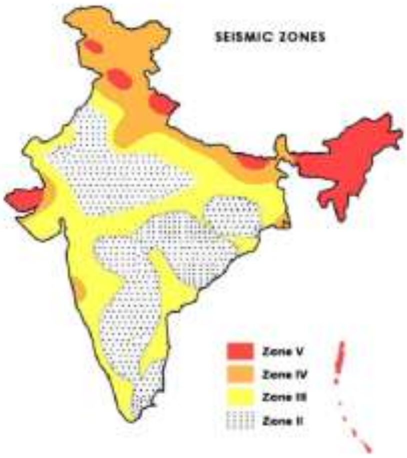
-Failure of flexure should come before shear failure.

-The columns should not fail before beams.

-The joints should be hard compare to members which will meet into them.

These are the reason why this study was necessary so that a general idea of variation of steel ,concrete ,shear ,bending.and loads should be known.

Fig:-1 Sketch of Seismic Zone Map of India: sketch based on the seismic zone of India map given in IS:1893 (Part 1)



1.2 Division of sesmic zones in India.

-The latest version of seismic zoning map of India given in the earthquake resistant design code of India [IS 1893 (Part 1) 2016] assigns four levels of seismicity for India in terms of zone factors.

-In other words, the earthquake-zoning map of India divides India into 4 seismic zones (Zone 2, 3, 4 and 5) unlike its previous version, which consisted of five or six zones for the country.

-**Zone 5**:- According to the present zoning map, Zone 5 expects the highest level of seismicity whereas Zone 2 is associated with the lowest level of seismicity. Zone 5 covers the areas with the highest risks zone that suffers earthquakes of intensity MSK IX or greater.

The IS code assigns zone factor of 0.36 for Zone 5. Structural designers use this factor for earthquake resistant design of structures in Zone 5. The zone factor of 0.36 is indicative of effective (zero periods) level earthquake in this zone. It is referred to as the Very High Damage Risk Zone. [The region of Kashmir, the western and central Himalayas, North and Middle Bihar, the North-East Indian region and the Rann of Kutch fall in this zone.]

- **Zone 4**:-Is called the High Damage Risk Zone and covers areas liable to MSK VIII. The IS code assigns zone factor of 0.24 for Zone 4. [The Indo-Gangetic basin and the capital of the country (Delhi), Jammu and Kashmir fall in Zone 4. In Maharashtra, the Patan area (Koyananager) is also in zone no 4. In Bihar the northern part of the state like- Raksaul, near the border of India and Nepal, is also in zone no 4.]

- Zone 3:- This zone is classified as Moderate Damage Risk Zone, which is liable to MSK VII. The IS code assigns zone factor of 0.16 for Zone 3. Zone 2 is liable to MSK VI or less and is classified as the Low Damage Risk Zone. The IS code assigns zone factor of 0.10 (maximum horizontal acceleration that can be experienced by a structure in this zone is 10% of gravitational acceleration) [the Andaman and Nicobar Islands, parts of Kashmir, Western Himalayas fall under this zone].
-Zone 2:- Since the current division of India into earthquake hazard zones Zone 1 does not use, no area of India is classed as Zone 1.Future changes in the classification system may or may not return this zone to use.

2. METHODOLOGY

Seismic analysis of the structures is carried out on the basis of lateral force assumed to act along with the gravity loads. The methods used for the analysis of building are Equivalent Static Lateral Force Method (ESLM) and Response Spectrum Method (RSM). Most codes in practice permits the analysis by equivalent linear static methods for simple, regular and low to medium height buildings as often sufficient. Regular, low to medium height buildings can also be designed using equivalent static analysis. Response spectrum analysis is required for tall buildings or those buildings with significant irregularities in plan or elevation

In this project seismic analysis and design for the building is carried out for different seismic zones by an equivalent static analysis method using STAAD.Pro software.

2.1 PRELIMINARY DATA OF THE STRUCTURE CONSIDERED FOR ANALYSIS AND DESIGN 0f G+5

PRELIMINARY DATA OF THE STRUCTURE CONSIDERED FOR ANALYSIS AND DESIGN 0f G+10

STRUCTURAL PROPERTIES of RCC FRAMED STRUCTURE	
Number of stories	10
Floor to floor height	3M
Plinth height	3M
Size of column	0.4*0.7
Size of beam	0.4*0.5
Earthquake load	As per IS:1893:2016
Wall thickness	0.300M
Live load including floor finish	3.5 KN/M2
Floor finishes	As per IS: part-I
Seismic zones	All five seismic zones of India
Type of soil taken	Red Hard
SBC of soil taken	200KN/M

STRUCTURAL PROPERTIES of RCC FRAMED STRUCTURE	
Number of stories	5
Floor to floor height	3M
Plinth height	3M
Size of column	0.3*0.4
Size of beam	0.3*0.5
Earthquake load	As per IS:1893:2016
Wall thickness	0.300M
Live load including floor finish	3.5 KN/M2
Floor finishes	As per IS: part-I

Seismic zones	All five seismic zones of India
Type of soil taken	Red Hard
SBC of soil taken	200KN/M

MATERIAL PROPERTIES FOR G+5

Grade of concrete	M 30
Young's modulus of (M25) concrete, E	25
Poisson's ratio of Concrete	0.15
Coefficient of thermal expansion of concrete	170E-3
Coefficient of thermal expansion of steel	300E-3
Density of Reinforced Concrete	25 KN/m3
Grade of reinforcing steel	Fe415
Young's modulus of steel E	2E5
Poisson's ratio of Steel	0.286

MATERIAL PROPERTIES FOR G+10

Grade of concrete	M 30
Young's modulus of (M40) concrete, E	31.662
Poisson's ratio of Concrete	0.15
Coefficient of thermal expansion of concrete	170E-3
Coefficient of thermal expansion of steel	300E-3
Density of Reinforced Concrete	25 KN/m3
Grade of reinforcing steel	Fe415
Young's modulus of steel E	2E5
Poisson's ratio of Steel	0.286

3. RESULTS & DISCUSSION

3.1 LOAD CALCULATIONS FOR BOTH THE FRAMES

Dead load –(IS 875-Part 1)

Live load –(IS 875-Part 2)

Sesmic load –(IS 1893 :2005 ,IS 1983:2016)

1. DEAD LOAD CALCULATIONS

Exterior wall=0.35*2.45*20=17.15+2=19.15

Paparet wall=0.2*1.5*20=6+2=8

Plaster for two face =0.02*2.65*1*18*2=2

CODE USED:- IS 1893:2002 ,IS 1893:2005, IS 1893:2016 (PART 1-4)

3.2 EQUIVALENT STATIC METHOD

Vb=Ah*W

Where, Vb=design sesmic base shear

Ah=average response acceleration coefficient

W=sesmic weight of building (W=Dl +50%LL)

Ah=Z/2*I/R*Sa/g

Where,

I= Importance factor(Table 8)

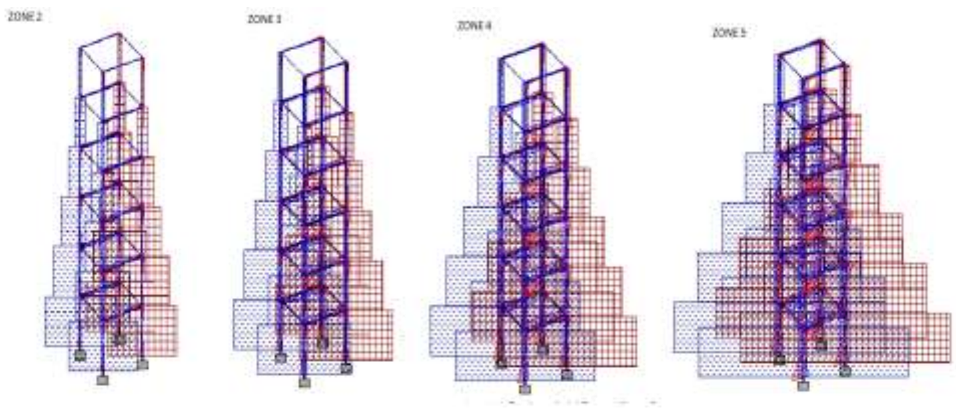
Z=Importance factor(sesmic zone factor ,Table 3)

R=Response reduction factor(Table 9)

Sa/g =Design acceleration spectru

3.3 FOR G+5 FRAMED STRUCTURE

3.3.A. ZONE WISE DISTRIBUTION AND VARIATION OF SHEAR FORCE,BENDING MOMENT,BEAM STRESS AND AXIAL FORCE.



3.3.1 VARIATION OF STEEL AND CONCRETE PERCENTAGE IN COLLUMN IN VARIOUS ZONES.

ZONE	STEEL SQ.MM	% STEEL	VARIATION OF STEEL	CONCRETE SQ.MM	%CONCRETE	VARIATION OF CONCRETE
ZONE 2	19556.65	0.793	+0.000	2427301	99.207	0.000
ZONE 3	21707.26	0.835	+0.042	2575226	99.165	0.042
ZONE 4	30135.54	1.050	+0.215	2826712	98.950	0.215
ZONE 5	52471.78	1.821	+0.771	2827527	98.179	0.771

3.3.3 TOTAL % OF STEEL IN THE STRUCTURE

ZONE	STEEL in TONS	VARIATION
Zone 2	14.367	0.000
Zone 3	16.932	2.565
Zone 4	20.139	3.207
Zone 5	27.057	6.918

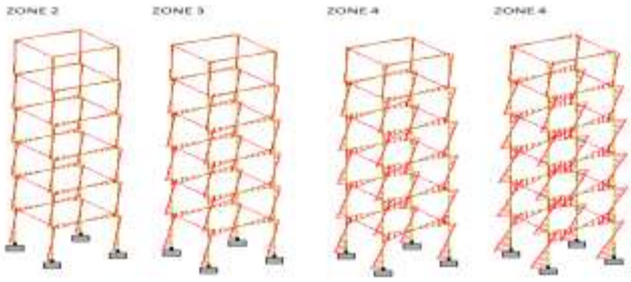
3.3.2 VARIATION OF STEEL IN BEAM IN VARIOUS ZONES

ZONE	BEAM STEEL IN SQ.MM	VARIATION
ZONE 2	22771.9	0
ZONE 3	32961.56	10189.66
ZONE 4	50681.41	17720.00
ZONE 5	78038.71	27357.71

3.3.4 TOTAL QUANTITY OF CONCRETE IN STRUCTURE

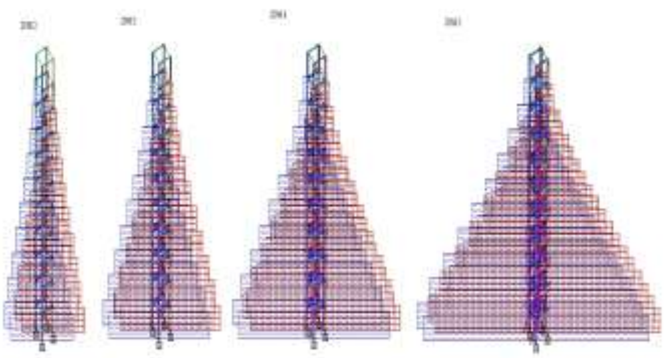
ZONE	CONCRETE IN CUMEC	VARIATION
ZONE 2	19.4	0
ZONE 3	19.4	0
ZONE 4	19.4	0
ZONE 5	19.4	0

3.3.B. BENDING MOMENT VARIATION IN VARIOUS ZONES FOR STRUCTURE.(G+5)



3.4 FOR G+10 FRAMED STRUCTURE

3.4.A. ZONE WISE DISTRIBUTION AND VARIATION OF SHEAR FORCE,BENDING MOMENT,BEAM STRESS AND AXIAL FORCE.

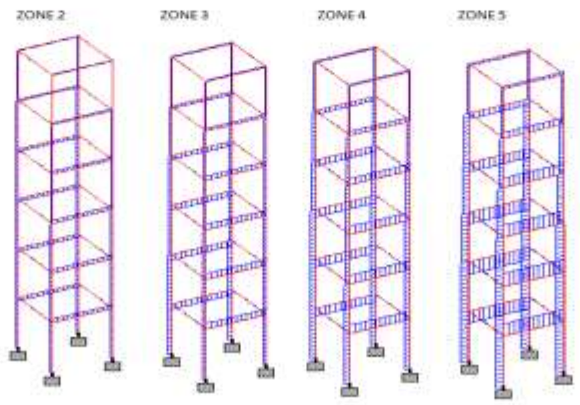


3.4.1. VARIATION OF PERCENTAGE OF STEEL AND CONCRETE IN COLUMN IN VARIOUS ZONES(G+10)

ZONE	STEEL SQ.MM	% STEEL	VARIATION OF STEEL	CONCRETE SQ.MM	%CONCRETE	VARIATION OF CONCRETE
ZONE 2	81378.85	0.677	0	10106560	99.20	0

ZONE 3	87855.65	0.790	0.113	12881797	99.32	0.12
ZONE 4	117546.11	0.93	0.253	12458925	99.06	0.26
ZONE 5	184542.72	1.53	0.600	11854737	98.47	0.59

3.3.C. SHEAR FOR VARIATION IN VARIOUS ZONES FOR STRUCTURE(G+5)



3.4.2 VARIATION OF STEEL IN BEAM IN VARIOUS ZONES

ZONE	BEAM STEEL IN SQ.MM	VARIATION
ZONE 2	58748.00	0
ZONE 3	91518.00	32770
ZONE 4	143169.00	51651
ZONE 5	219192.00	76023

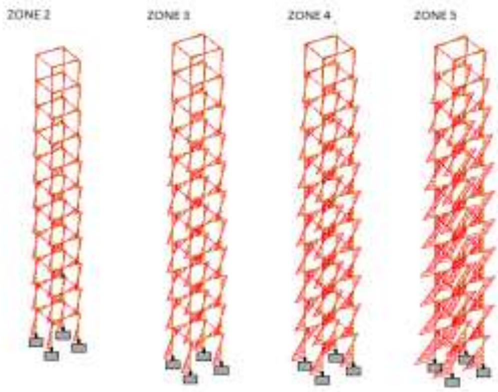
3.4.3. VARIATION OF TOTAL STEEL IN THE FRAMED STRUCTURE

ZONE	STEEL in NEWTON	VARIATION
Zone 2	44080	0.000
Zone 3	46442	2362
Zone 4	62747	16305
Zone 5	91602	28855

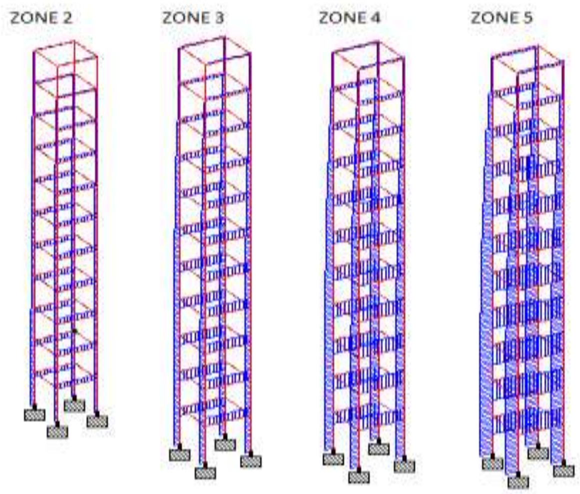
3.4.4. TOTAL QUANTITY OF CONCRETE IN STRUCTURE

ZONE	CONCRETE IN CUMEC	VARIATION
ZONE 2	63.4	0
ZONE 3	63.4	0
ZONE 4	63.4	0
ZONE 5	63.4	0

3.4.C. BENDING MOMENT VARIATION IN VARIOUS ZONES FOR STRUCTURE.



3.4.B. SHEAR FOR VARIATION IN VARIOUS ZONES FOR sTRUCTURE



4. CONCLUSIONS

1. As the zone varies from 2-5, Shear force and bending moment on the framed structure increases.

2. As the zone varies from 2-5 there is less variation of steel in a G+5 buildingg as compared to a G+10 and above building .

3. As the zone varies from 2-5, there is a Increasing variation of steel in the framed structure but very little change in its concrete statement.

4. The deflection tends to be more as the zone fluctuates from lower to higher level.

5. The table shows %increase in steel in column and beams in various framed structure.

6. There is a great fluctuation in steel requirement as the height of framed structure increases, as here G+5 building's steel fluctuation among various zones is less as compared to a G+10 building.

4. A. FOR G+5 FRAMED STRUCTURE

ZONE	%INCREASE IN STEEL IN COLUMN As of previous zones.	%INCREASE IN STEEL IN BEAMS	%INCREASE IN STEEL IN TOTAL
Zone2	0	0	0
Zone3	5.29	44.7	17.85
Zone4	25.74	53.75	18.94
Zone5	73.42	53.97	34.35

4. B. FOR G+10 FRAMED STRUCTURE

ZONE	%INCREASE IN STEEL IN COLUMN As of previous zones.	%INCREASE IN STEEL IN BEAMS	%INCREASE IN STEEL IN TOTAL
Zone 2	0	0	0
Zone 3	16.69	55.7	5.35
Zone 4	17.72	56.43	35.10
Zone 5	64.51	53.10	45.98

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6. BIOGRAPHIES

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