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COMPARATIVE ANALYSIS OF SEISMIC RESISTANT DESIGN FOR VARIED SEISMIC ZONES

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ABSTRACT
India's location in a seismically active region and its vulnerability to earthquakes necessitates the design of seismic-resistant structures to minimize the potential large-scale loss of human lives and damage to property due to such events. India is divided into four seismic zones (Zone II to Zone V) based on the seismic risk. Each zone requires appropriate structural design to prevent the potential damage from earthquakes. This study aims to investigate and compare seismic-resistant design tailored to different seismic zones. It will focus on understanding the unique challenges posed by seismic activity in various regions and exploring zone-specific design considerations. The work will include comparative seismic analysis of a residential structure designed using strength-based and performance-based approaches. Comparative seismic analysis will be conducted for the residential structures across different seismic zones.

INTRODUCTION

Earthquake, any sudden shaking of the ground, are geological events caused by the passage of seismic waves through Earth's rocks. Seismic waves are produced when some form of energy stored in Earth's crust is suddenly released, usually when masses of rock straining against one another suddenly fracture and slip. Earthquakes occur most often along geologic faults, narrow zones where rock masses move in relation to one another. The major fault lines of the world are located at the fringes of the huge tectonic plates that make up Earth's crust.

India is seismically active due to its location at the convergence of two tectonic plates – the Indian plate and the Eurasian plate. The interactions between these tectonic plates result in frequent seismic activity, which have resulted in multiple earthquakes through the years with devastating effects. One of the worst earthquakes in India occurred on Jan 26, 2001, with its epi centre in Bhuj, Gujarat. The earthquake killed close to 20,000 people, injured over 1.5 lakh, destroyed nearly 400,000 homes, and damaged millions of structures.

India's location in a seismically active region and its vulnerability to earthquakes necessitates the design of seismic-resistant structures to minimize the potential large-scale loss of human lives and damage to property due to such events.

Seismic-resistant design practices in India are primarily guided by the Bureau of Indian Standards (BIS) and the National Disaster Management Authority (NDMA). These organizations provide codes, guidelines, and recommendations to ensure that structures are designed and constructed to withstand seismic forces. The BIS is also responsible for classification of seismic zones in India. A seismic zone is used to describe an area where earthquakes are focused. India is divided into four seismic zones (Zone II to Zone V) based on the seismic risk, with Zone V being the highest risk zone. Figure 2 represents the four seismic zones in India. Zones are designated to guide

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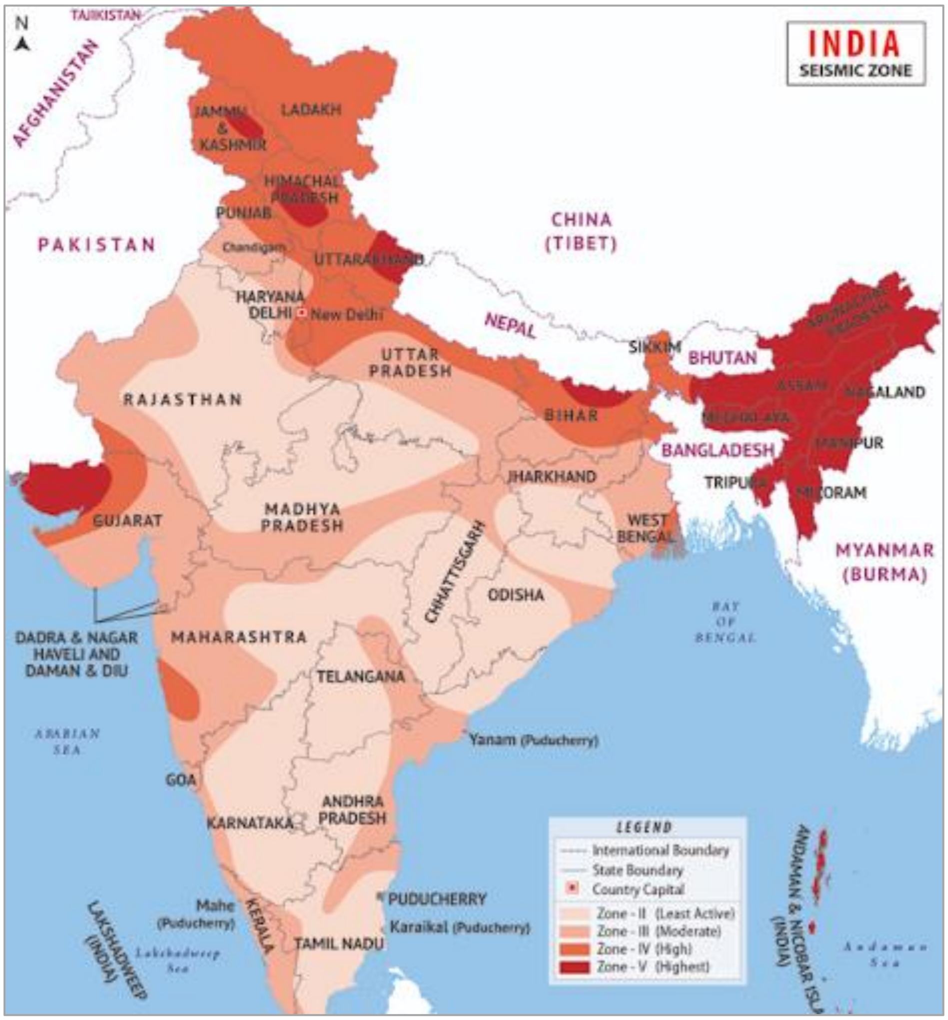
building codes and construction practices, with the objective of reducing hazards. Higher seismic zones require more stringent design and construction measures.



LITERATURE REVIEW

Suchita Hirde and Irshad Mullani [5] conducted a study to compare seismic performance of a multi-storey (G+5) RCC building designed using the performance-based approach with the same building designed using conventional code provisions (IS1893:2002). Direct displacement based seismic design approach was used to carry out Performance based design. A theoretically developed beams depth on the basis of unified approach to performance based seismic design was calculated first for specific performance level. Rest of design procedure was in line with direct displacement based seismic design. Performance evaluation was carried out through pushover analysis. For building designed with performance based design under design basis earthquake and maximum considered

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earthquake, column performance was elastic, while in IS code method it was B-IO and IO-LS respectively. It concluded that capacity design is necessary with column beam capacity ratio1.3.Hinge formation locations were observed. It showed that, in performance based design hinge formation in beams was uniform as compared to IS code design. It concluded that distribution of lateral strength is more rational in performance based design than IS code design method.

Mani Deep and P. Polu Raju [7] conducted a non-linear static analysis (pushover analysis) to understand the behaviour of G+9 multi storey residential building located in different seismic zones (II, III, IV, V) of India having similar geometrical properties using SAP2000. The behaviour of multi storey building was investigated in terms of force-displacement relationships, inelastic behaviour of structure and sequential hinge formations. It was observed that, when the zone varies from II to V, base shear, displacement and time period increase gradually, indicating the severity of seismic activity. Hinges were formed in beams and then in columns at ground floor of structure. The hinge formation propagated from ground floor to middle floor columns and then finally to the upper floor columns. The propagation of hinges from lower stories to upper stories leads to collapse of structure. It was concluded that the damage in the building was limited and columns at the lower stories could be retrofitted based on the importance of the structure.

METHODOLOGY

We have undertaken the following approach for comparing seismic-resistant design across different seismic zones.

A. We determined the specifications of the building structure to be used for the analysis by Strength –based design method. Specifications include:
   - Length of the building : 15.30m
   - Width of the building : 9m
   - Height of the building : 44m
   - Number of floors of the building : 15
   - Height of each floor of the building : 3m
   - Dead Load of the building : 0.43 Mton/m2
   - Live Load of the building : 0.2Mton/m2

B. We conducted a seismic analysis for the model to understand the change in behaviour across different seismic zones (Zone 2 ,Zone 3 , Zone 4 , Zone 5)

DESIGN PROCESS

1. We made a simple model using nodes and connecting them

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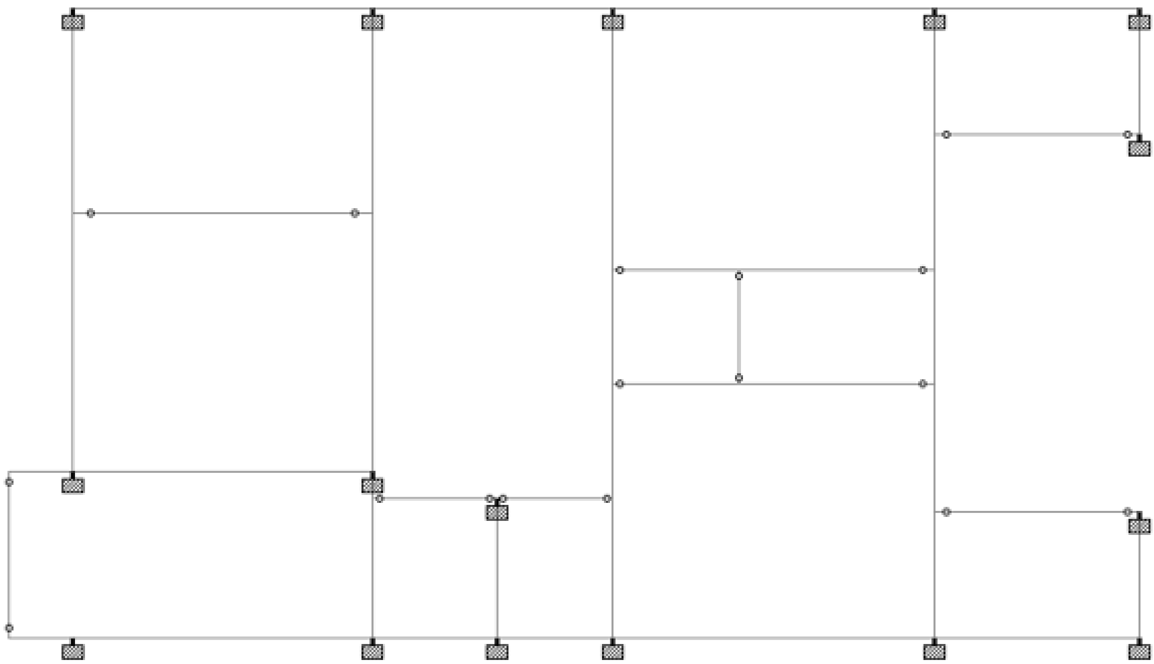

Fig 5. Staad Model

2. We assigned transational repeat property upto 14 floors with 3m distance between each floor to make the structure G+15.

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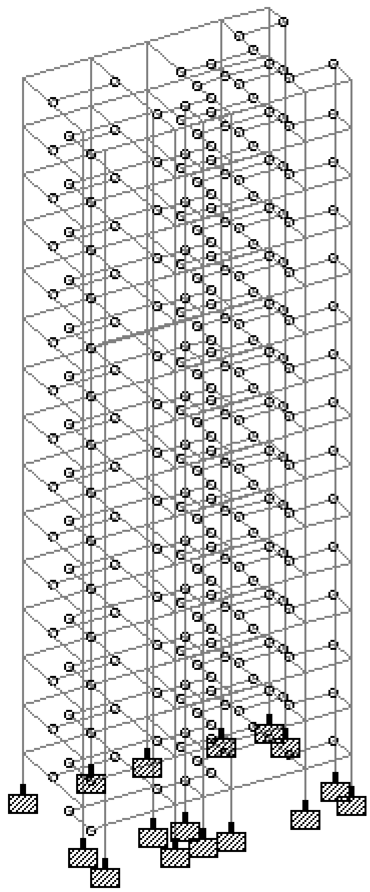

Isometric View of Staad Model

3. We assigned both fixed and pinned supports to the structure.
4. We assigned various different column sizes to the structure.

COLUMN NUMBERS	COLUMN SIZES
C1, C7	300X900 mm
C2, C8	300X750mm
C3 , C4 , C13 , C14	300X1200mm
C5 , C11	300X450mm
C6 , C10 , C15	230X450mm
C9 , C12	230X750mm
C16	230X600mm

5. We defined loads with

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- Zone Factor : 0.10 (Zone 2) , 0.16 (Zone 3) , 0.24 (Zone 4) , 0.36 (Zone 5)
- Response reduction Factor : 5
- Importance Factor : 1
- Rock and Soil Type Factor : 2
- Type of Structure : 1

6. We assigned Dead Load as
   - Selfweight : -0.95Mton/m2
   - Force : - 0.43Mton/m2
7. We assigned Live Load as
   - Force : -0.2Mton/m2
8. We assigned Floor Load as
   - For 115mm wall : -0.8Mton/m2
   - For 230mm wall : -1.3Mton/m2
9. We assigned the following Load Combinations

```
*LOAD COMB 6 (DL+0.25LL)
*3 1.0 4 0.25 5 1.0
LOAD COMB 7 (DL+0.6LL)
3 1.0 4 0.6 5 1.0
LOAD COMB 8 1.5(DL+LL)
3 1.5 4 1.5 5 1.5
LOAD COMB 9 1.2(DL+LL+SIESMIC IN X DIRECTION)
1 1.2 3 1.2 4 1.2 5 1.2
LOAD COMB 10 1.2(DL+LL+SIESMIC IN -X DIRECTION)
1 -1.2 3 1.2 4 1.2 5 1.2
LOAD COMB 11 1.2(DL+LL+SIESMIC IN Z DIRECTION)
2 1.2 3 1.2 4 1.2 5 1.2
LOAD COMB 12 1.2(DL+LL+SIESMIC IN -Z DIRECTION)
2 -1.2 3 1.2 4 1.2 5 1.2
LOAD COMB 13 1.5(DL+SIESMIC IN X DIRECTION)
1 1.5 3 1.5 5 1.5
LOAD COMB 14 1.5(DL+SIESMIC IN -X DIRECTION)
1 -1.5 3 1.5 5 1.5
LOAD COMB 15 1.5(DL+SIESMIC IN Z DIRECTION)
2 1.5 3 1.5 5 1.5
LOAD COMB 16 1.5(DL+SIESMIC IN -Z DIRECTION)
2 -1.5 3 1.5 5 1.5
```

10. We assigned the following Beam sizes

BEAM NUMBERS	BEAM SIZES
B1	230X425mm
B2	300x450mm
B3	300x600mm

11. We designed both Columns and Beams as per IS 456
12. We analyzed the whole structure

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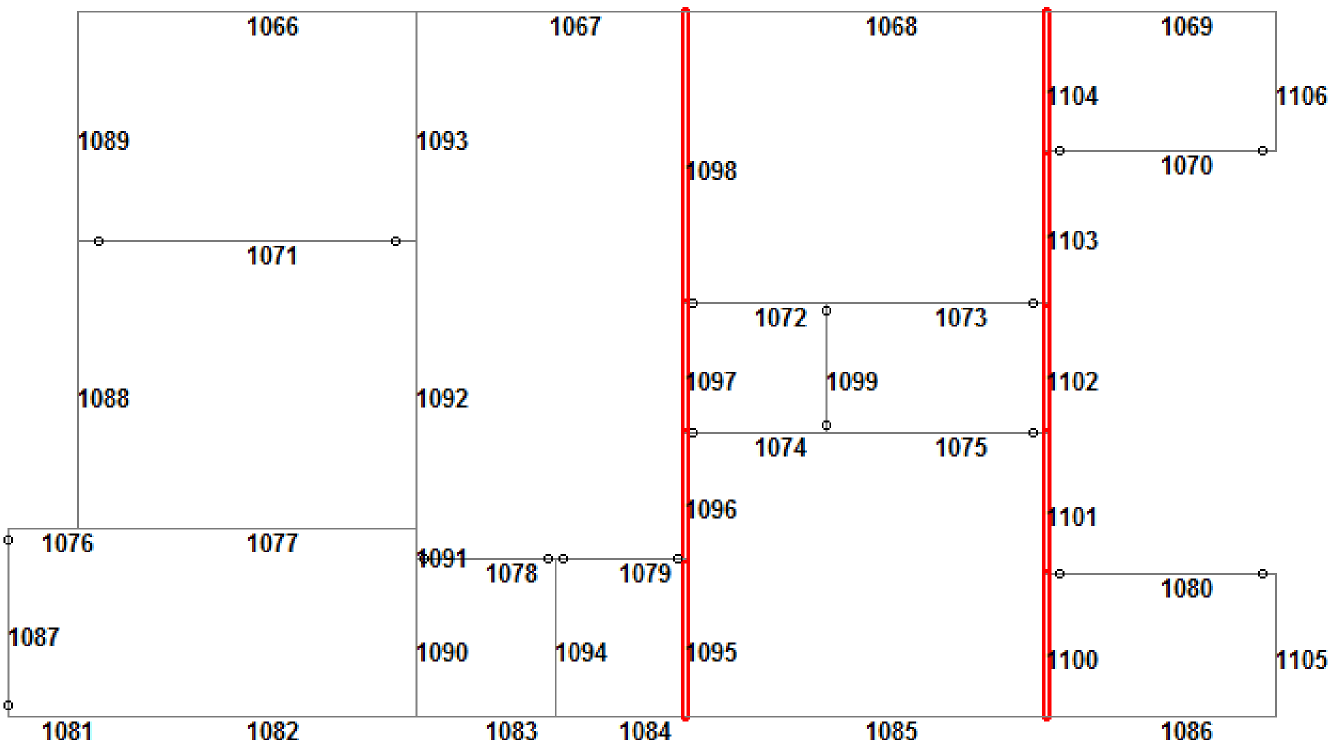
CONCLUSION

After analyzing the whole structure using STAAD PRO software in all four seismic zones the values of maximum axial force and maximum bending moment in largest beam of the structure vary considerably in all four seismic zones.



Staad Model with Beam Numbers

1. MAXIMUM AXIAL FORCE (SEISMIC IN -X DIRECTION)

Values of Maximum Axial Force in different Beams and Zones

BEAM NUMBER	ZONE 2	ZONE 3	ZONE 4	ZONE 5
1095	-0.179KN	-0.287KN	-0.430KN	-0.645KN
1096	-0.177KN	-0.283KN	-0.424KN	-0.636KN
1097	-0.187KN	-0.300KN	-0.450KN	-0.675KN
1098	-0.210KN	-0.336KN	-0.504KN	-0.756KN
1100	-2.070KN	-3.311KN	-4.967KN	-7.451KN
1101	-2.084KN	-3.335KN	-5.003KN	-7.504KN
1102	-2.069KN	-3.3310KN	-4.965KN	-7.448KN
1103	-2.051KN	-3.282KN	-4.923KN	-7.384KN
1104	-2.039KN	-3.262KN	-4.893KN	-7.340KN

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The values of Maximum Axial Force for Seismic loading in –X direction for the largest beams of the structure when compared in all four seismic zones is least in Zone 2 and large in Zone 5

2. MAXIMUM BENDING MOMENT (SEISMIC IN -X DIRECTION AND Mz)

Values of Maximum Bending Moment in different Beams and Zones

BEAM NUMBER	ZONE 2	ZONE 3	ZONE 4	ZONE 5
1095	-2.722KNm	-4.355KNm	-6.533KNm	-9.799KNm
1096	-1.520KNm	-2.433KNm	-3.649KNm	-5.473KNm
1097	-0.436KNm	-0.698KNm	-1.047KNm	-1.571KNm
1098	0KNm	0KNm	0KNm	0KNm
1100	-0.215KNm	-0.345KNm	-0.517KNm	-0.776KNm
1101	-0.176KNm	-0.282KNm	-0.422KNm	-0.633KNm
1102	-0.160KNm	-0.257KNm	-0.385KNm	-0.578KNm
1103	-0.029KNm	-0.046KNm	-0.069KNm	-0.104KNm
1104	0KNm	0KNm	0KNm	0KNm

The values of Maximum Bending Moment for Seismic loading in –X direction and along Z direction for the largest beams of the structure when compared in all four seismic zones is least in Zone 2 and large in Zone 5

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