



Cost Analysis of RC Buildings in Different Seismic Zones

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Abstract: Reinforced cement concrete buildings are widely used in India because they offer a practical balance of strength, durability, and economy. However, seismic zone classification has a major influence on structural design, reinforcement demand, and overall construction cost. This paper presents a comparative study of a G+6 RCC framed building designed for Seismic Zones II, III, IV, and V as per IS 1893:2016 and IS 13920:2016. The building was analyzed using standard seismic design concepts to evaluate changes in base shear, storey displacement, drift, reinforcement requirement, concrete consumption, and total structural cost. The findings show a clear increase in seismic demand as the zone severity increases. Base shear, member sizes, and reinforcement quantities all rise progressively from Zone II to Zone V, which leads to a noticeable increase in construction cost. The study confirms that seismic design is not only a safety requirement but also a cost-driving factor in multi-storey RCC construction. The results are useful for engineers who need to achieve a practical balance between structural performance and economy in earthquake-prone regions.

Keywords: RCC buildings, seismic zones, cost analysis, base shear, storey drift, reinforcement demand, seismic design, ETABS, IS 1893, construction cost.

I. INTRODUCTION

Reinforced cement concrete, or RCC, remains one of the most common structural systems used for residential, commercial, and institutional buildings in India. Its popularity comes from its durability, adaptability, and relatively economical construction process. With the growth of urban areas and the increasing need for multi-storey development, the structural safety of RCC buildings has become more important than ever.

Earthquake loading is one of the main design concerns in seismic regions. A building that performs well under gravity loads may still experience high lateral forces, excessive displacement, and damage to members during an earthquake. For this reason, Indian design practice requires seismic consideration through IS 1893:2016 and ductile detailing through IS 13920:2016. As the seismic zone becomes more severe, the structural demand on the building increases, which in turn raises the quantity of steel, concrete, and detailing required.

II. PROBLEM STATEMENT

Although RCC buildings are widely designed using established code provisions, many projects still do not fully compare the cost effect of seismic zoning. As seismic intensity increases, the design becomes more conservative, structural members become larger, and reinforcement demand rises. This leads to a higher project cost, especially in multi-storey buildings. The problem addressed in this paper is the lack of a clear and systematic comparison of structural response and construction cost for the same G+6 RCC building under different seismic zones.

III. LITERATURE REVIEW

Earlier research consistently shows that seismic intensity affects both structural performance and economy. Several studies report that base shear, displacement, and drift increase as the seismic zone becomes more severe, while steel and

concrete demand also rise. Comparative studies on RCC frames have also shown that higher seismic zones require stronger ductile detailing and more material consumption, especially in beams, columns, and foundations.

Research by Soni et al. and later studies by Kumbhar and Saoji, Sharma and Pandey, and others showed that seismic response grows progressively from Zone II to Zone V, which directly affects material quantities and cost. More recent studies have confirmed that improved seismic resistance often comes with a moderate to significant increase in construction expenditure. These findings support the need for a study that combines structural comparison and cost evaluation for a typical G+6 RCC building.

IV. METHODOLOGY

4.1 Building Model

The study considers a G+6 RCC framed building with a regular plan and uniform storey height. The same building geometry is maintained for all seismic zones so that the results can be compared on an equal basis. The structural system is designed as a moment-resisting RC frame, which is commonly used in urban construction.

4.2 Design Parameters

The building is analyzed using standard Indian code provisions. Gravity loads are taken from IS 875, seismic loads from IS 1893:2016, and ductile detailing requirements from IS 13920:2016. Material properties are kept constant for all zones so that the influence of seismic loading can be isolated more clearly.

Table 3.1: Design Material Specifications Used in the G+6 RCC Building Model

Parameter	Value
Concrete Grade	M25
Steel Grade	Fe415
Unit Weight of Concrete	25 kN/m ³
Unit Weight of Brick	20 kN/m ³
Wall Thickness	230 mm

4.3 Seismic Analysis

The response spectrum method is used to study the seismic behavior of the building in different zones. This method is suitable for multi-storey RCC buildings because it gives a more realistic estimate of dynamic response than simplified static loading. The main output parameters considered are base shear, storey displacement, drift, reinforcement requirement, and member sizing.

4.4 Cost Evaluation

The construction cost is evaluated by comparing the quantity of reinforcement steel, concrete volume, and additional requirements caused by seismic detailing. Since steel is one of the major cost contributors in seismic design, any increase in reinforcement demand has a direct effect on the final cost. The cost comparison is used to estimate how much more expensive the building becomes as the seismic zone increases.

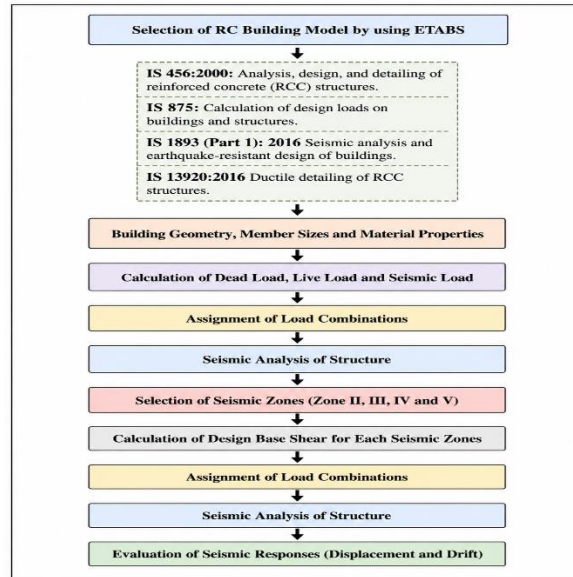


Fig 4.1 Flowchart Process

V. RESULTS AND DISCUSSION

The analytical results indicate that the seismic zone has a direct influence on the structural response and cost of the G+6 RCC building. As the zone severity increases from Zone II to Zone V, the design forces, storey displacement, drift, reinforcement demand, and construction cost all rise progressively. This confirms that a building cannot be designed identically for all seismic zones, because higher seismic demand requires stronger structural provisions.

4.1 Seismic Response

The horizontal seismic coefficient increases steadily from Zone II to Zone V, which leads to a corresponding increase in design earthquake forces. As a result, the base shear also increases with seismic zone severity, with Zone V showing the highest value. This trend is expected because stronger earthquake zones impose larger lateral forces on the building frame.

Storey displacement and storey drift also increase as the seismic zone becomes more severe. Although the drift values remain within the permissible code limits, the higher zones show a more critical deformation response, which can affect serviceability and non-structural components. Therefore, the results show that seismic design must address both strength and deformation control.

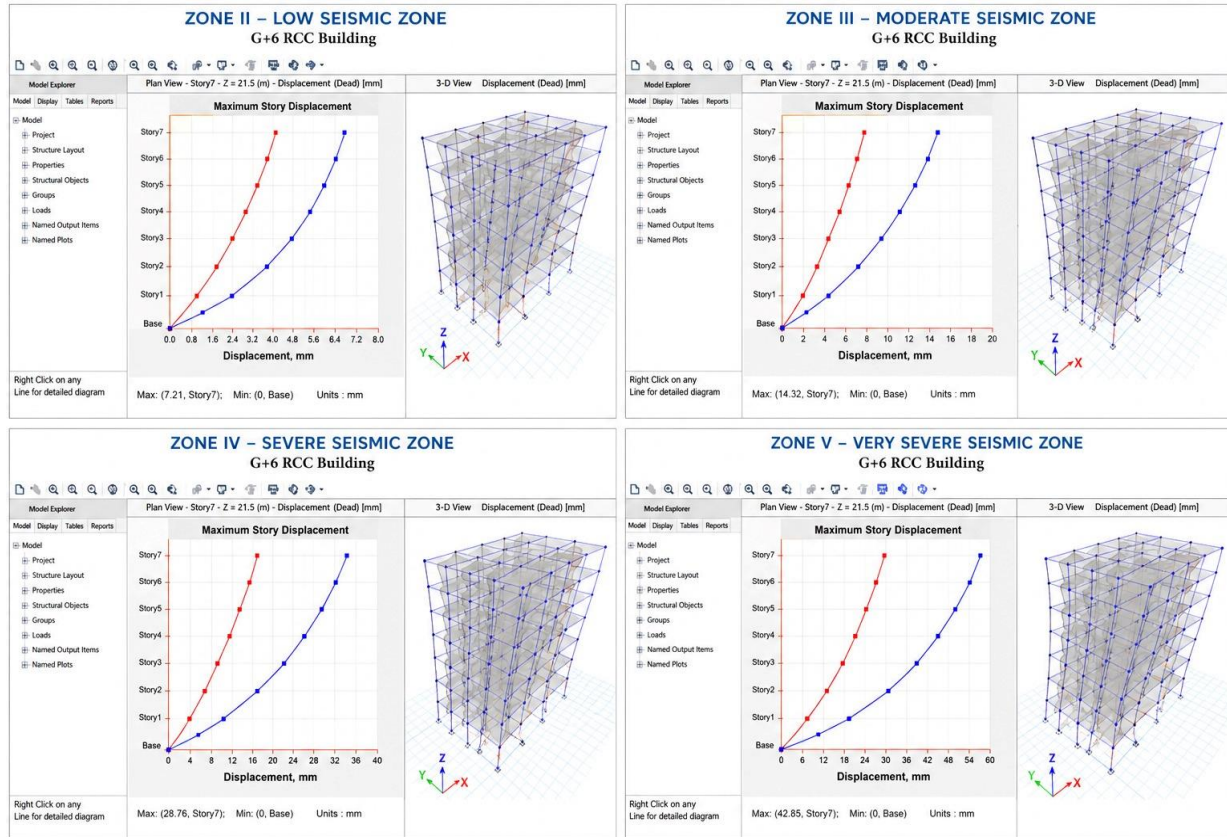
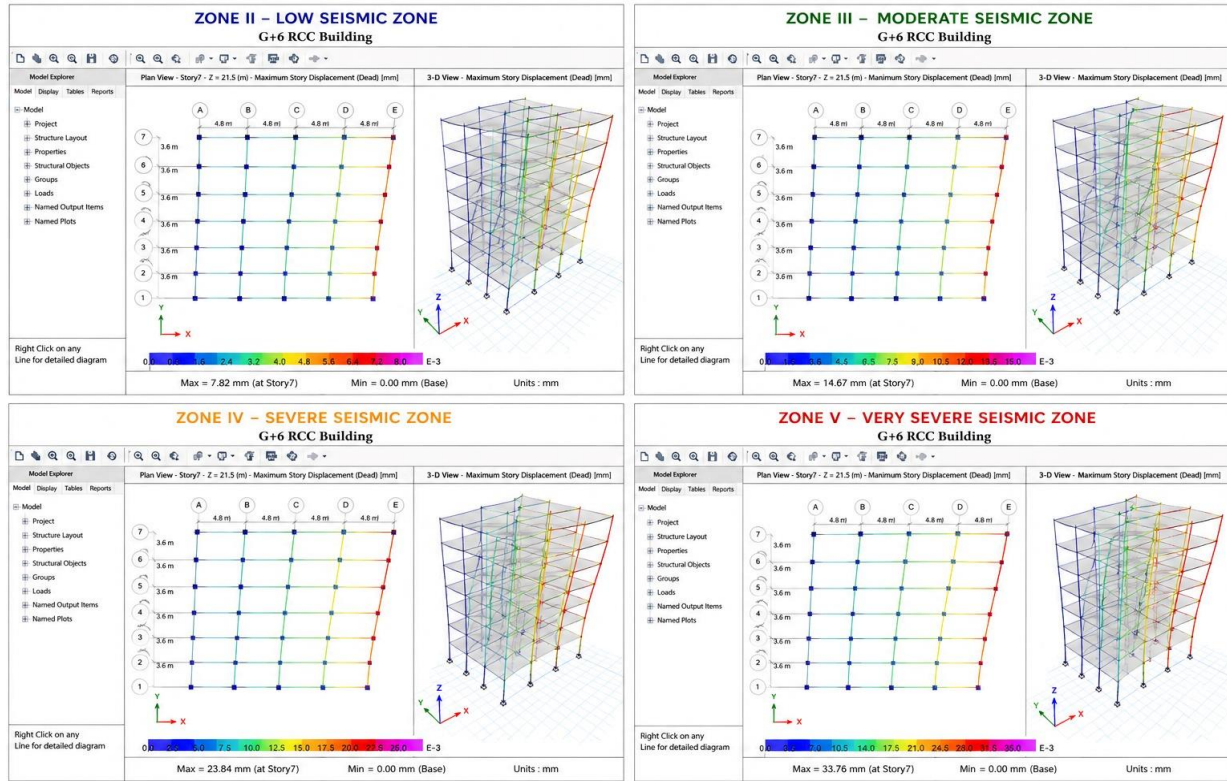


Figure 4.1: Displacement Distribution Diagram of G+6 RCC Building in Different Seismic Zones (Zone II, Zone III, Zone IV and Zone V)



Note: Values are predicted based on seismic zone factors as per IS 1893 (Part 1): 2016 for academic purpose.

Units : mm

Figure 4.2: Storey Displacement Distribution Diagram of G+6 RCC Building in Different Seismic Zones (Zone II, Zone III, Zone IV and Zone V)

4.2 Member Behavior

Beam response changes significantly with increased seismic intensity. Higher seismic zones produce larger bending moments and shear forces in beams, which increases the requirement for flexural reinforcement and closer stirrup spacing. This is especially important in Zone V, where ductile detailing becomes essential for safe performance.

Column behavior also becomes more demanding in the higher zones. The increase in axial load, bending moment, and shear force requires larger column sizes and higher longitudinal reinforcement percentages. Beam-column joints are similarly affected because they must transfer higher cyclic forces during seismic loading, making joint confinement and anchorage a key design requirement.

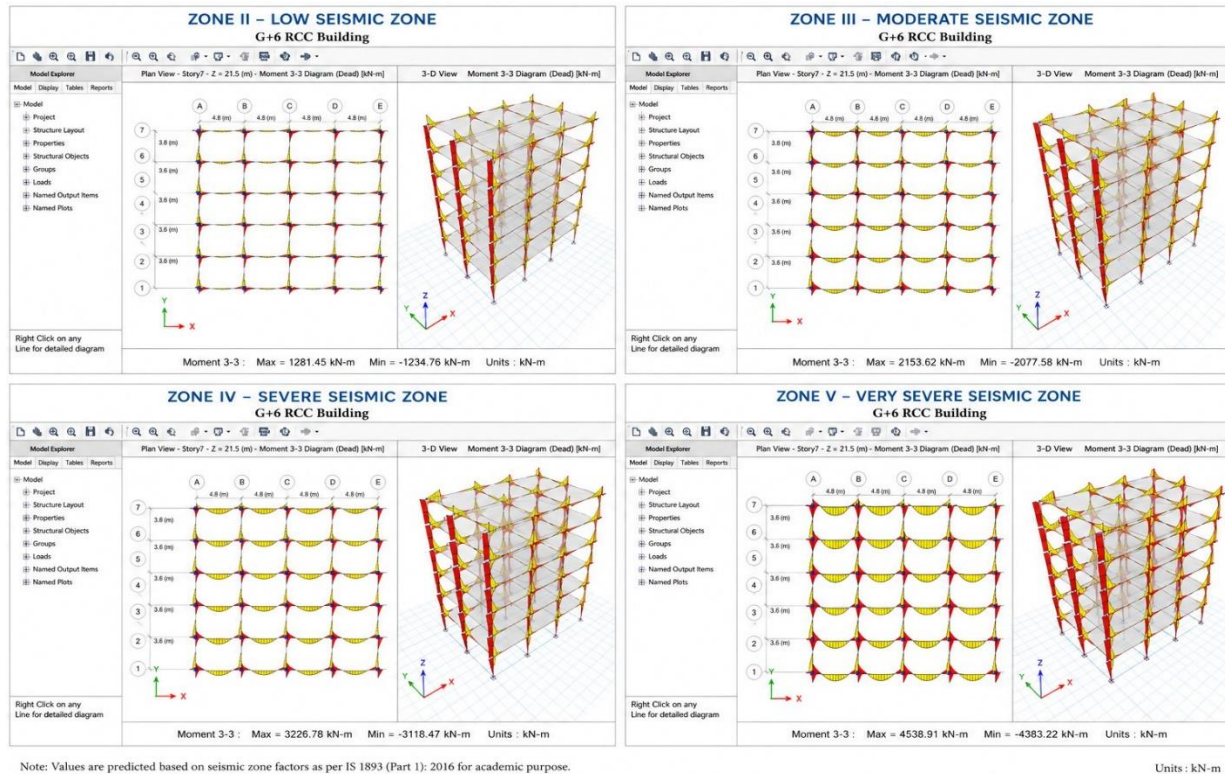


Figure 3.3: Bending Moment Distribution Diagram of G+6 RCC Building in Different Seismic Zones (Zone II, Zone III, Zone IV and Zone V)

4.3 Foundation Response

Foundation demand increases with seismic zone severity because higher earthquake forces generate larger overturning moments and lateral loads. This leads to greater reinforcement demand in the footing or raft system, along with larger concrete quantity. The foundation therefore plays an important role in maintaining overall structural stability during seismic action.

4.4 Cost Variation

The cost analysis shows a progressive increase in structural cost from Zone II to Zone V. The main reasons are the increase in reinforcement steel, larger member sizes, and enhanced ductile detailing requirements. Concrete quantity also rises with seismic zone, which further adds to the total construction cost.

This increase in cost is justified because it improves safety, durability, and earthquake resistance. In practical terms, the extra cost is not a drawback but a necessary investment to reduce damage and improve long-term performance.

4.5 Discussion

The study clearly shows that seismic zone has a strong effect on both structural behavior and economic demand. Lower zones allow a more economical design, whereas higher zones require stronger and more detailed structural provisions, which naturally increases the cost. This trend highlights the need for balanced design decisions that consider both safety and economy.



The results also confirm that strength alone is not sufficient in seismic design. Drift, displacement, and joint behavior must also be controlled to ensure satisfactory performance during earthquakes. Overall, the findings support the use of code-based seismic design, proper detailing, and optimized member proportions for RCC buildings in different seismic zones.

VI. CONCLUSION

This study achieved a clear comparison of the structural response and construction cost of a G+6 RCC building in different seismic zones. It showed that as the seismic zone increases from Zone II to Zone V, the building experiences higher base shear, greater displacement, larger drift, and increased reinforcement demand. The analysis also confirmed that beams, columns, beam-column joints, and foundations all require stronger design in higher seismic zones.

The study further demonstrated that construction cost increases progressively with seismic severity, mainly because of the extra steel, larger member sizes, and additional ductile detailing requirements. At the same time, this increased cost is justified because it improves earthquake safety, structural reliability, and long-term performance. Overall, the work successfully established the relationship between seismic intensity, structural demand, and cost, and it proved that proper seismic design is essential for achieving both safety and economy in RCC buildings.

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