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Study of RC Framed Building in Different Siesmic Zones for Economic Consideration

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Abstract

In present scenario, the society is expecting to have optimum design with economic considerations. Cost of building, plays a very important role in construction. As the structural cost forms the major component of the building cost, there is need to evolve appropriate cost modeling techniques to project the structural cost at the early stages of the planning and design. Earthquake resistant design is very important factor that decides the variation in cost of construction. For different seismic zones, the construction techniques changes and also design of building changes. This paper deals with the variation of zones with respect to cost of a building according to different seismic zones applicability and importance of the structure. In the study, different models of same plan of a building are analyzed for different earthquake zones to study the variation in forces and cost of beams and columns. The building models were designed to estimate the cost as per the Indian standards. Comparison has been made to check the variation of cost in different earthquake zones. Our purpose of this study is to know the variation in material require for building in different earthquake zones. By the study, we know that the high percentage of reinforcement is required in higher seismic zones and cost of construction increases as we go from seismic zone III–zone V.

Key words: Seismic zones, earthquake, economy, RC buildings, cost

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INTRODUCTION

Earthquakes are severe which causes collapse of buildings and structures. The earthquake resistant building and construction is very necessary. At present time earthquake resistant regulation should be implemented to strengthen the building and to resist the building from collapse.[1]
In past time the earthquake effects on building were neglected resulting severe damages to the building and great loss of human lives as well as economy. The design criteria help us to reduce the losses as well as it strengthen the building and increase the life span of the structure. Most of the approaches are approximate and are to be rationalized based on the parametric study of the cost influencing factors such as; structural and architectural configuration, wind and seismic effects, soil parameters, exposure conditions deciding durability requirements, construction technology, importance of building utility etc.[2]

In economic terms, the building is estimated to be cost effective if it results in benefits equal to those of alternatives design and has lower the whole cost, or total cost of ownership. Components of the whole life cost include the initial design cost and construction cost, and off course useful life of the system or buildings.[3]

Seismic effect is one of the relatively less understood parameter on the cost implications of the structural components. Although studies have been reported on the premium for earthquake resistance comprehensive cost models are needed for the cost management studies. In developing countries many buildings in seismic zones are constructed without considering seismic effects due to lack of awareness and wrongly presuming to be expensive. Hence there is a need to focus comprehensively on the issue of cost implications to incorporate seismic resistance in buildings.

MODELLING

The building model is designed in SAP2000.[4] The model is basically six storey model. The structural system with moment resisting frames considered for this study is based on the actual buildings constructed for central government offices in various cities in India. The length of each bay is 8.1 m in x-direction, and number of bay in x-direction are 12. Length of each bay in y direction is 8.1m and number of bays are 6.

Height of each floor is taken as 4m. The design has been done on basis of IS-456:2000.[5] The plan and elevation are shown in Figure 1 and 2 respectively. The building configuration is symmetrical and simple. The column sizes provided were varying from size 400 mm × 400 mm to maximum size 600 mm × 600 mm. The beams on top storeys were provided with cross-section size of 300 mm × 400 mm and the beam size on bottom storeys are of 400 mm × 600 mm. The variation in column and beam sizes had done to restrict the maximum percent of reinforcement according to IS Code.

STRUCTURE ANALYSIS AND DESIGN[6]

Concrete Density = 25 KN/m^2
Grade of concrete = M-30
Steel reinforcement= Fe-415
Slab load = 3.5 KN/m^2
Floor finish = 1 KN/m^2
Live load = 4 KN/m^2
Live load on roof = 2 KN/m^2
Intensities of earthquake forces considered

Table 1. *Different Seismic Zones and Intensity.*

Seismic zones	Zone factor	Design peak ground acceleration	Siesmic intensity
ZONE-III	0.16	08 g	VII
ZONE-IV	0.24	12 g	VIII
ZONE-V	0.36	18 g	IX

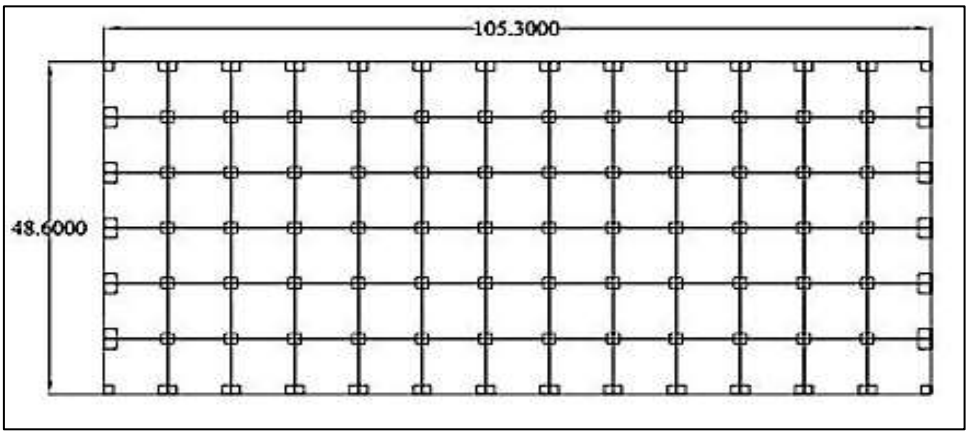


Fig.1. *Plan of the Six Storey Building.*

Seismic Analysis

The earthquake analysis of the building was carried out for three seismic zones. The analysis of the building was done on SAP2000 and response spectrum method is applied to do the analysis.[4] Three spectral acceleration were chosen and the value of the seismic coefficients is mentioned in above Table 1. The analysis of building was carried out as per Indian Standard Codes, the design of building was carried out as per IS-1893:2002(Part-1).[7,8] The earthquake loading were provided in positive x-direction as well as negative x-direction.

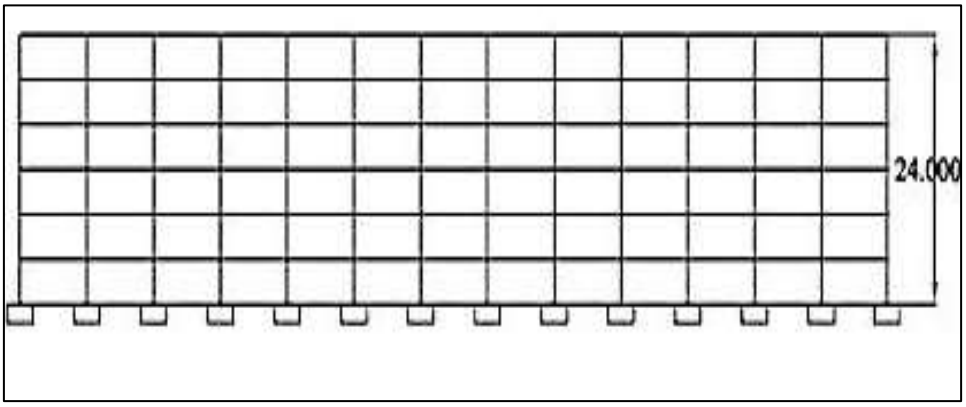


Fig.2. *Elevation of the Six Storey Building.*

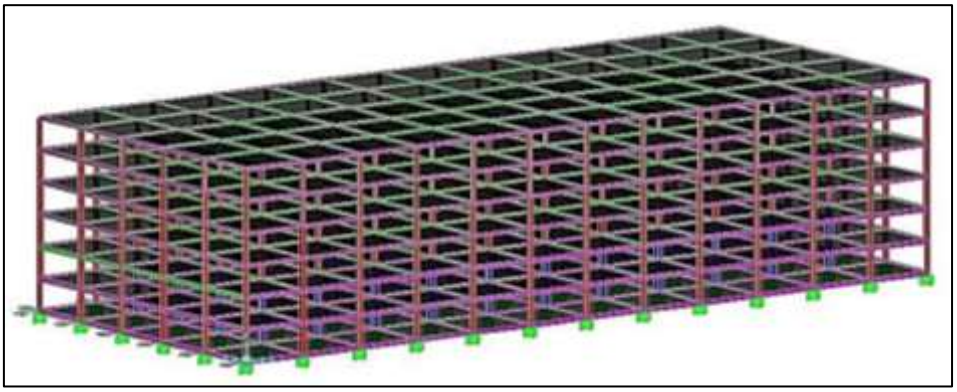


Fig.3. *Three Dimensional View of the Six Storey Building.*

LOAD COMBINATIONS

Some of the critical load combinations are provide by the Indian Code IS-1893:2002(Part-1). These load combinations were used to analyze the given building are as follows

1. 1.5(DL + LL)
2. 1.2(DL + LL + EQX)
3. 1.2(DL + LL - EQX)
4. 1.2(DL + LL+ EQZ)
5. 1.2(DL + LL - EQZ)
6. 1.5(DL + EQX)
7. 1.5(DL - EQX)
8. 1.5(DL + EQZ)
9. 1.5(DL - EQZ)
10. 0.9DL + 1.5EQX
11. 0.9DL - 1.5EQX
12. 0.9DL + 1.5EQZ
13. 0.9DL - 1.5EQZ

RESULTS AND DISCUSSIONS

The total quantity of the concrete required for different seismic zones for different models of the building has been shown in Table 2.

Table 2. *Variation in Concrete Quantity According to Various Earthquake Zones.*

Earthquake zones	Amount of concrete (cubic meter)
Zone-V	371400
Zone-IV	344750
Zone-III	337573

The total quantity of the reinforcement required in columns for the different model of building in different seismic zones has been shown in Table 3.

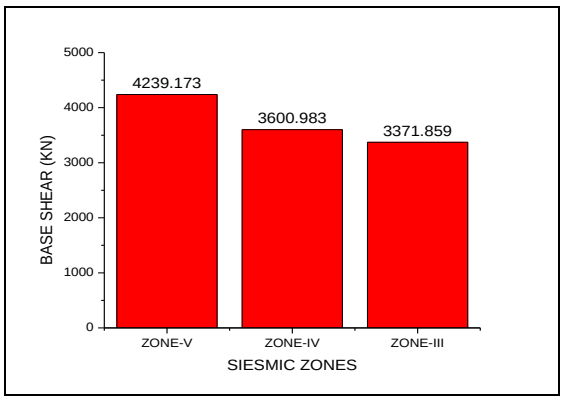
Table 3. *Variation in Reinforcement of Columns.*

Earthquake zones	Amount of reinforcement (Kg)
Zone-V	17175.97
Zone-IV	3350.097
Zone-III	3189.141

The different quantity of the reinforcement required in beams for different models of the building in different seismic zones has been shown in Table 4.

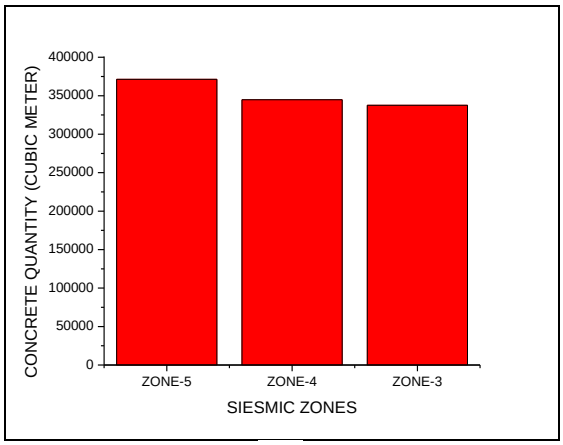
Table 4. *Variation in Reinforcement of Beams.*

Earthquake zones	Amount of reinforcement(Kg)
Zone-V	11139.42
Zone-IV	11096.74
Zone-III	10718.63



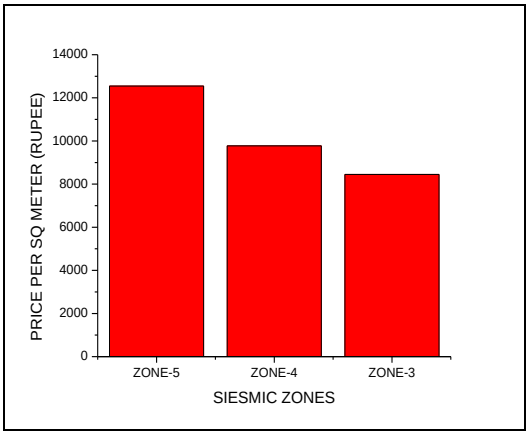
(a)

Fig.4. (a) *Plot Between Seismic Zones and Base Shear of the Building in Different Seismic Zones.*



(b)

Fig.4. (b) *Plot Between Different Seismic Zones and the Concrete Quantity.*



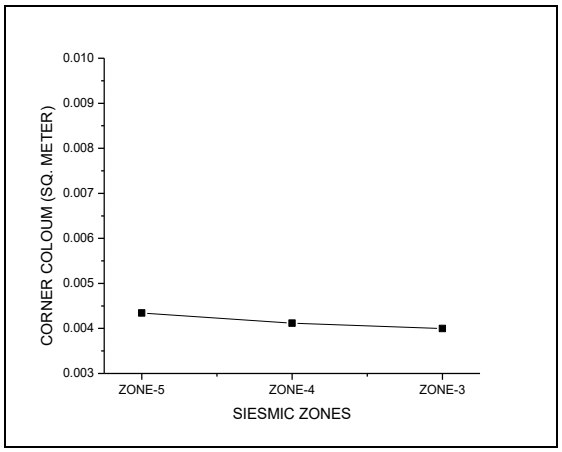
(c)

Fig.4. (c) *Plot Between Seismic Zones and Price Per Square Meter.*

As seen above Figure 4 (a) is graph plotted between base shear and seismic zones. The variation of base shear for zone V and zone IV is much more than the variation of base shear in zone IV and zone III.

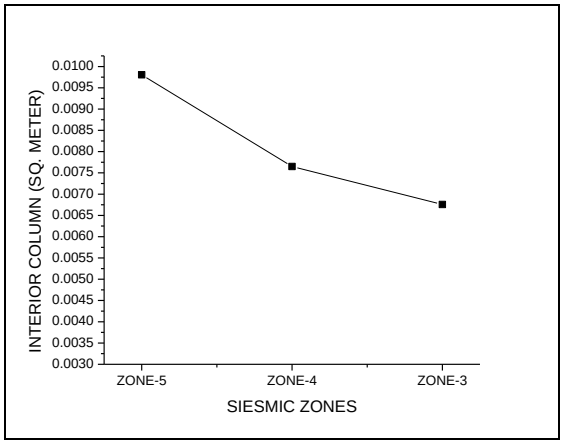
It can be observed from the above figures, that the more quantity of concrete is required for higher zones. In higher zone the intensity of earthquake is very high to resist that vibration the structure, the cross section of member is more, which results in increase in the amount of the construction material in the building. As

the quantity of the material is increasing the cost will also increase.



(a)

Fig.5. (a) *Plot Between the Different Seismic Zones and the Reinforcement in Corner Column.*



(b)

Fig.5. (b) *Plot Between Different Seismic Zones and Reinforcement on Interior Column.*

CONCLUSIONS

The different models have been prepared for the building for different seismic zones. The design of the building has been done on basis of IS-456:2000. For the design of earthquake loading IS-1893:2002 (Part-1) is preferred. After the designing for the different earthquake loadings we have got the following results. The results are as follows:

1. The variation of support reactions in exterior columns increasing from 7.38–41.71% and in edge columns increasing from 17.72–63.7% in seismic Zones III–V. However the variations of support reactions are very small in interior columns.
2. The volume of concrete is increasing in seismic zones III, IV and V due to increase of support reactions with the effect of lateral forces. However the variation is very small.
3. The percentage variation of steel in exterior and interior columns varies from 0.8–3.9% and 1.1–3.7% between seismic zones III to seismic zone V respectively.
4. The variation of percentage of steel at support sections in external beams is 0.54–1.23% and in internal beams is 0.78–1.4%.
5. In the external and internal beams, the percentage of bottom middle reinforcement is almost same for both earthquake and non-earthquake designs.
6. Percentage variation of total concrete quantity for the whole structure, between seismic zones III, IV and V varies as, 2.69 and 3.8 respectively.
7. Percentage variation of total steel quantity for the whole structure, between seismic zones III, IV and V varies as, 41.39 and 89.05 respectively.
8. Variation in cost of the building for different zones is as follows: (cost per sq. meter)
   Zone III-8449.78/-
   Zone IV-9775.77/-
   Zone V-12546.56/-
9. It is observed that the percentage variation of cost for the whole structure, between seismic zones III, IV and V varies as 2.71 and 7.17 respectively.

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