International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 04 | Apr-2018 www.irjet.net p-ISSN: 2395-0072

COST MODELING OF RC BUILDINGS DESIGNED IN DIFFERENT SEISMIC EFFECTS

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ABSTRACT: *An earthquake is a shaking of the ground caused by the sudden breaking and movement of large sections (tectonic plates) of the earth's rocky outermost crust. If an earthquake occurs in a populated area, it may cause many deaths and injuries and extensive property damage. Although there are no guarantees of safety during an earthquake, identifying potential hazards ahead of time and advance planning to save lives and significantly reduce injuries and property damage. Hence it is mandatory to do the seismic analysis and design to structural against collapse. It is highly impossible to prevent an earthquake from occurring, but the damage to the buildings can be controlled through proper design and detailing. Designing a structure in such a way that reducing damage during an earthquake makes the structure quite uneconomical, as the earth quake might or might not occur in its life time and is a rare phenomenon. This study addresses the performance and variation of percentage steel and concrete quantity of R.C framed structure in different seismic zones and influence on overall cost of construction. The present IS code 1893:2002 doesn't provide information about the variation of concrete and percentage of steel from zone to zone. This study mainly focuses on the building when is designed for earthquake forces in different seismic zones as per IS 1893:2002.*

The paper presents the quantity and cost modeling of reinforced concrete multi storey buildings in the range of two to 10 storey designed for seismic forces in the various seismic zones of Indian subcontinent and quantifies the cost premium for providing seismic resistance. The result of the study are useful for the design professionals and cost engineers during early stages of design development and cost planning.

Keywords: Earthquake, Seismic Analysis, Seismic Zones, Indian subcontinent, ductility, Overall Cost, seismic resistance, design development and cost planning.

1.INTRODUCTION

In the last decade, the Indian subcontinent has experienced many devastating earthquakes. The occurrence of earthquakes is not evenly distributed in India. Major earthquakes of India are associated with the collision plate boundary between the Indian and Eurasian plate. The occurrence of earthquake is irregular in the southern India, whereas the north-eastern, the northern and the north-western part of India are subjected to regular earthquakes. The Himalayan Frontier is seismically one of the most active regions of the world.

The most commonly adopted structural system for medium rise buildings in developing countries has been the cast-in-situ reinforced concrete moment resisting frames coupled by solid floor slabs. These bare frames are in filled with non-structural brick or concrete block masonry panel walls for creating the external enclosure and internal partition walls. The buildings with regular architectural and structural configurations having moment resisting frames with adequate beam-column sizes for joint rigidity and reinforcement detailing satisfying ductility requirements are proved to be quite capable of resisting high seismic forces as demonstrated in the recent major earthquakes in the Indian subcontinent.

1.2. SCOPE OF COST MODELING

A building parameters are broadly affected by the seismic effects. Hence a wide range of analysis has be to required during the design of a multi storey building. Now a days with the increasing populations in developing country it is become essential to design a building which is structurally safe as well as economical. All building materials especially concrete and steel are most commonly affected by the seismic waves. Provide affordable housing become the necessity of the all development authorities for the society. And to meet this need of cost modeling cost analysis is done by so many researches and all journals provide different information about material consumptions and cost model of the building.

2. LITERATURE REVIEW

Renavikar Aniket V, The project involves Analysis of a residential building with steel-concrete composite and R.C.C. construction. The proposed structure is a four multistoried buildings of G+9, G+12, G+15, G+18, with 3.0m as the height of each floor. The overall plan dimension of the building is 15m x 9m. The analysis and involves the load calculation, analyzing it by 2D modeling using software STAAD-Pro 2007. Analysis has been done for various load combinations as per the Indian Standard Code of Practice. The project also involves analysis of an equivalent R.C.C. structure so that a cost comparison can be made between a steel concrete composite structure and an equivalent R.C.C. structure.

Geeta Mehta, Bidhan Sharma and Anuj Kumar, Optimization of structural cost can be achieved by optimizing the size of structural components as the cost of the material required in structural system for a multi-storey building makes 40-50 % of the overall cost of a typical RCC structure. Material required for construction varies with change in size of members. In the present study optimizing the size of structural components using ETABS has been achieved. The analysis and design has been done for G+9, G+11, G+13 and G+15 RCC structure for seismic zone V. The loading and all other relevant considerations are made for office building. For the analysis and design of a RCC structure, there are much software available in the market such as STAAD-Pro, ETABS, SAP, ANSYS etc. Among all the available software, ETABS has many advantages over its counterparts such as accurate analysis result, optimized

Sangeetha k, Vinod Shavare, G H Basavaraj evaluated deflection control of 30 story commercial building using E-tabs software. Different structural framing systems are applied to know the building performances in Zone III. Response spectrum method is used due to its innate simplicity of computation. Models are prepared with bare frame having central core, braced frame, shear wall frame system in order to get effective lateral load resisting system.

Shubham R. Kasat analyzed a model of 18 storey building with and without shear walls by static analysis method for earthquake zone III. E-TAB v9.2.0 software For achieving economy in reinforced concrete building structures, design of critical section is carefully done to get reasonable concrete sizes and optimum steel consumption in members.

3. EARTHQUAKE ZONES IN INDIA

In the Indian subcontinent history there were so many devastating earthquakes. The major reason for the high frequency and intensity of the earthquakes is that the Indian plate is driving into Asia at a rate of approximately 47 mm/year. Geographical statistics of India show that almost 54% of the land is vulnerable to earthquakes. 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. 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.

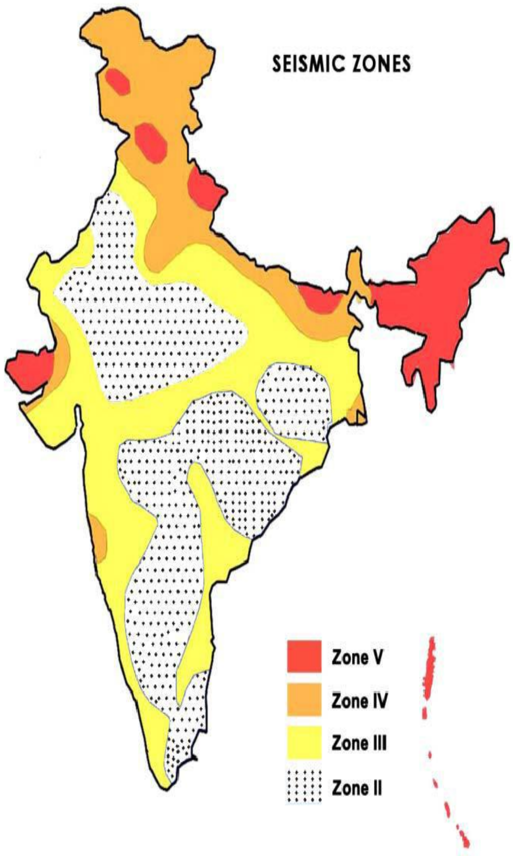

Fig 1- Seismic zone in India

5. METHODOLOGY

- In the present study a 2 to 10 storey RC framed building with a typical plan described below has been considered. The Length of the building is 23 m and Width of the building is 22 m.
- Floor to floor height considered is 3.0 m.
- The depth of the foundation below the ground level is 1.2 m to 2m.
- All external & internal walls are 115 mm thick.
- All floor diaphragms are considered to be rigid.
- Centre to centre dimension is followed for analysis and design, and the effect of finite size joint width is not considered.
- Seismic loads are considered to act in the horizontal direction (along either of the two principle directions) and not in the vertical direction.
- Stiffness of infill walls is not considered in the seismic analysis of the building.
- Deductions for opening is done while calculating the seismic weight of building.
- Wind load is not considered.
- Building is considered to be fixed at the base level in all the cases.
- Projection of 1m is taken at all four sides of the building for all floors.
- Grade of Concrete- M20
- Grade of steel- Fe415

LOADS:

Dead loads are basically due to self weight of structure, as well the weight of floor slab, beams, columns, walls, floor finish and live loads.

Weight of floor finish 1 kN/m^2
Weight of roof treatment 1.5 kN/m^2
Live load on floors 2.5 kN/m^2
Live load on roof 1.5 kN/m^2
Unit weight of RCC 25 kN/m^3
Unit weight of masonry infill 20 kN/m^3

Table 1- Seismic Zone intensities

Seismic Zone	Zone Factor (Z)
II Low seismic zone	0.10
III Moderate seismic	zone 0.16
IV Severe seismic	zone 0.24
V Very severe seismic	zone 0.36

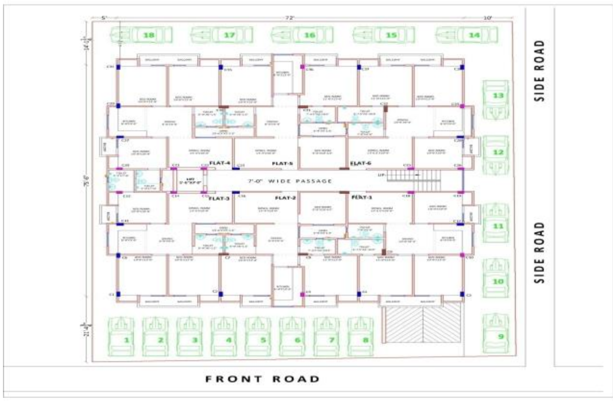

Fig 2- Plan of Building

6. ANALYSIS OF BUILDING

6.1 Comparison of materials used in different seismic zones for 2 Storey building

The variation of material consumption at different seismic zones for using two grade of steel in 2 storey building is represented in the in below table-2. It is observed that in Reinforcement variations (fig. 8) are 0.63, 1.48, 1.21 and 2.27 for seismic zones II, III, IV and V respectively. Concrete variations (fig. 9) are 0.013, 0013, 0.0127 and 0.012 for seismic zones II, III, IV and V respectively**.** And formwork variations (fig. 10) are 0.001, 0.002, 0.004 and 0.009 for seismic zones II, III, IV and V respectively. From the above observation it is clear that variation in concrete and shuttering is too small to be discussed.

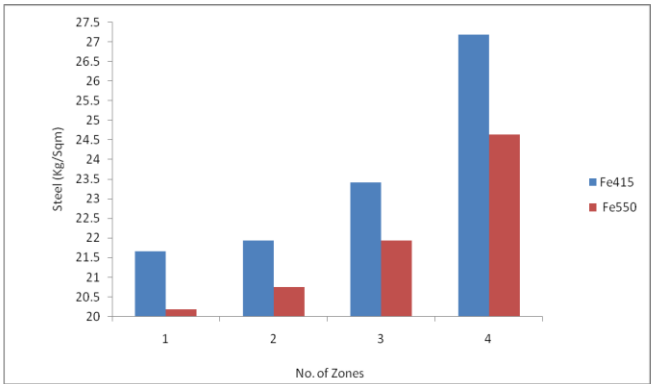

Fig.3. Comparison of steel(in kg) in different zones for two different grade of steel for 2 storey building

6.2 Comparison of materials used in different seismic zones for 4 Storey building

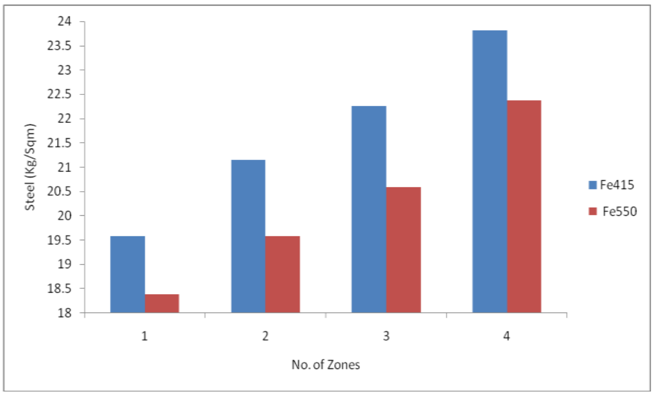

Fig.4. Comparison of steel(in kg) in different zones for two different grade of steel for 4 storey building

6.3 Comparison of materials used in different seismic zones for 6 Storey building

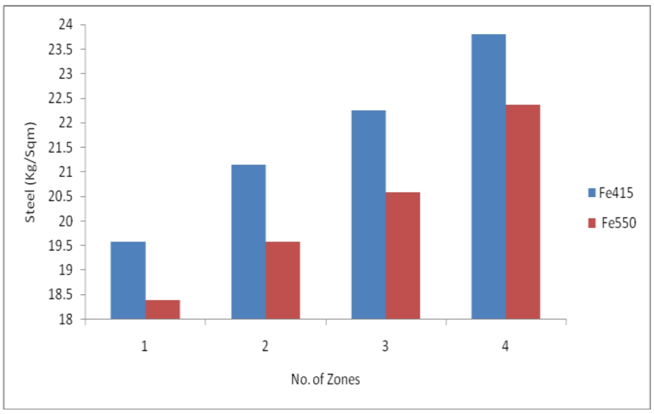

Fig.5. Comparison of steel(in kg) in different zones for two different grade of steel for 6 storey building

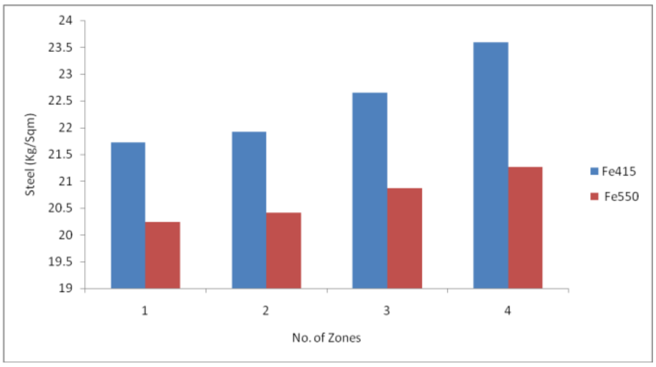

Fig.6. Comparison of steel(in kg) in different zones for two different grade of steel for 6 storey building

6.5 Comparison of materials used in different seismic zones for 8 Storey building

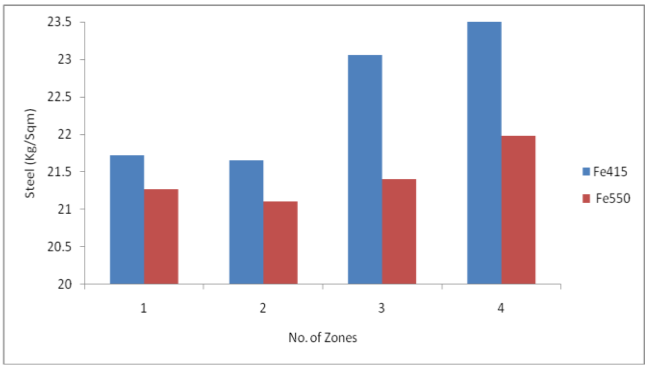

Fig.7. Comparison of steel(in kg) in different zones for two different grade of steel for 7 storey building

7. RESULT AND DISCUSSION

The structural quantities used in the R.C.C buildings with moment resisting frames are compiled in the proposed cost model format from the structural drawings and co-related with the final bill of quantities executed. The results of this compilation are shown in table 2, which broadly validates the reasonability of the proposed cost model.

7.1. Comparison of steel consumption in different seismic zones for different no. of Storey

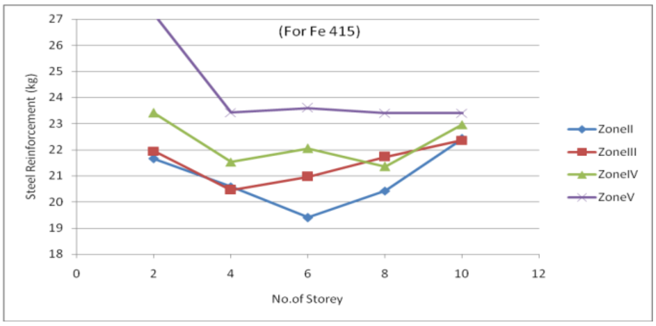

Fig.8.Reqirement of steel reinforcement (kg/sq.m of floor area)

7.2. Comparison of Concrete consumption in different seismic zones for different no. of Storey

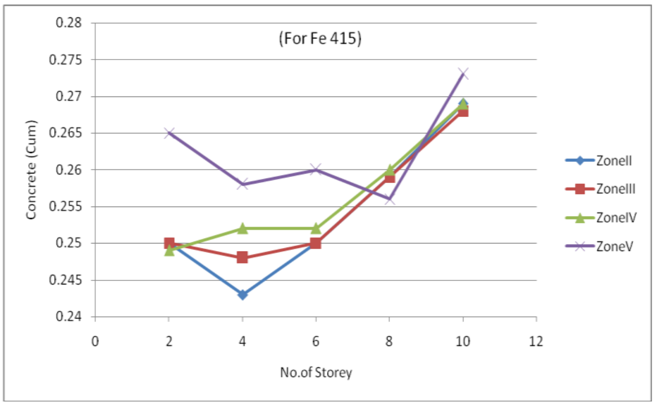

Fig.9.Reqirement of Concrete (cum/sq.m of floor area)

7.3. Comparison of shuttering consumption in different seismic zones for different no. of Storey

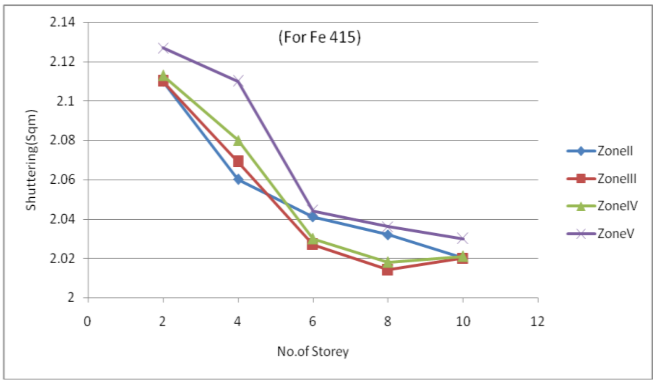

Fig.10.Reqirement of Shuttering (Sqm/sq.m of floor area)

7.4. Comparison of cost of reinforcement in different seismic zones for different no. of Storey

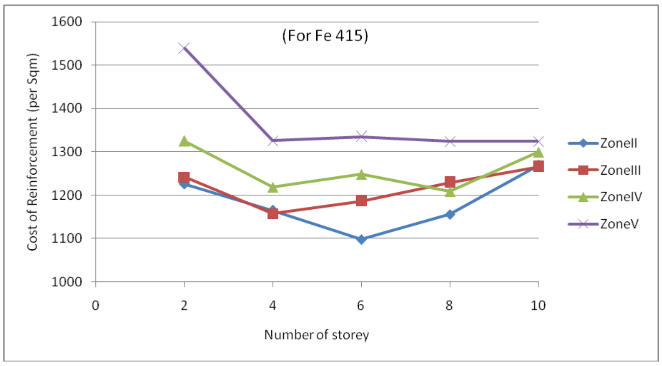

Fig.11. Cost of reinforcement (Rs./sq.m of floor area)

7.5. Comparison of cost of concrete in different seismic zones for different no. of Storey

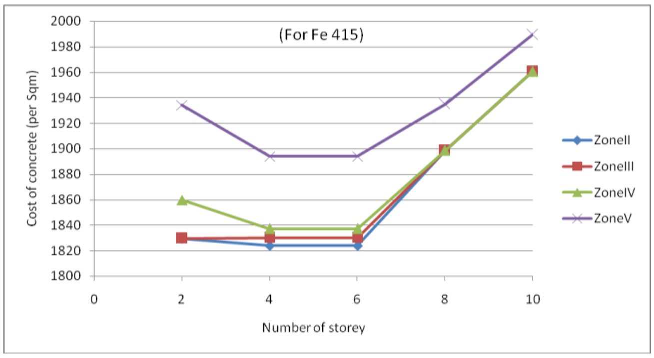

Fig.12. Cost of concrete (Rs./sq.m of floor area)

7.6. Comparison of cost of shuttering in different seismic zones for different no. of Storey

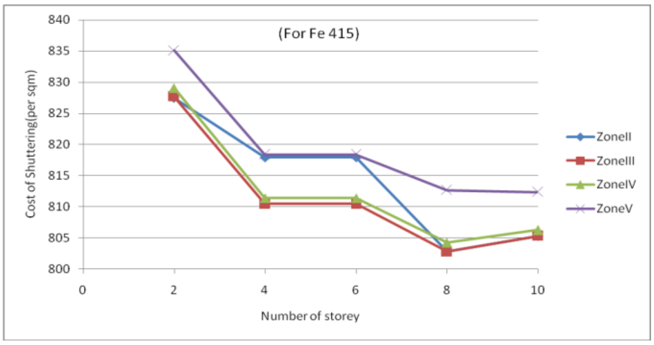

Fig.13. Cost of Shuttering (Rs./sq.m of floor area)

7.7. Comparison of Total Cost of building (including Steel ,R.C.C. & shuttering work only) in different seismic zones for different no. of Storey

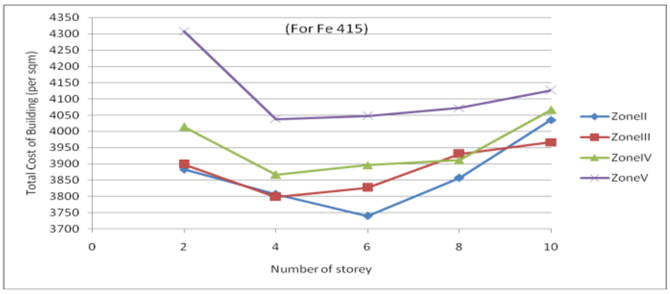

Fig.14. Total Cost of Building (Rs./sq.m of floor area)

3. CONCLUSIONS

From the seismic resistant design and cost estimation of the representative office buildings in the range of two to ten storey under various levels of seismic forces in different seismic zones of Indian subcontinent, the following inferences are made:

i. The requirement of structural concrete per sq.m of floor area varies from 0.243 cu.m to 0.273 cu.m for 2 to 10 storey.
ii. The requirement of structural shuttering per sq.m of floor area varies from 2.014 sq.m. to 2.127 sq.m. for 2 to 10 storey.

These requirements need not be very sensitive to the seismic zones because structural member sizes are usually kept same except column sizes which could be reduced in the upper storey of the buildings.

iii. The effects of increasing levels of seismic forces are taken care in the design by increasing the steel requirements in column and beams.
iv. The steel requirements per square meter of floor area vary from 20.42 kg to 27.18 kg depending upon the number of storey and seismic zones.
v. Max. steel per sq.m area is for 2 storey building in Zone-II .
vi. Min. steel per sq.m. area is for 6 storey building in Zone- II.
vii. Steel consumption is almost equal in Zone II and Zone III for 4, 8 and 10 storey buildings.
viii. Steel consumption is almost equal in Zone II and Zone III for 2, 4 and 10 storey buildings.
ix. For 8 storey Steel consumption in Zone III is more than Zone IV.
x. Min. total cost of the building per sq.m. will be achieved for 6 storey building in Zone II .
xi. Max. total cost of the building per sq.m. come when for 2 storey building will be constructed in Zone II .
xii. In Zone V buildings of 4,6 & 8 storey will be economical .

ACKNOWLEDGEMENT

I m very thankful to all the authors and researchers who worked with the issue and provide a vast knowledge regarding this topic. I am also thankful to all publishers and authors of the journals.

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BIOGRAPHIES

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