INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

**ISSN: 2454-132X**
**Impact factor: 4.295**
***(Volume3, Issue4)***
Available online at www.ijariit.com

# Comparison and Analysis of Multistoried R.C.C.Building in Different Seismic Zones

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***Abstract*: The principle objective of this project is to analyses and design a multistoried building [G + 21 (3-dimensional frame)] using STAAD Pro. And comparing the results on basis of**

1. ***Economic***
2. ***Difference in material requirement***
3. ***Degree of stability under different seismic zones***
4. ***Level of supervision of construction***
5. ***Requirement of special tool and equipment***

***Therefore the four requirements named as***

1. ***Utility***
2. ***Safety***
3. ***economical***
4. ***elegance***

***Must be fulfilled for a structural design to be satisfactory. This project presents a comparative study on the design a multistoried RCC building in different seismic zones in India by limit state method. The design involves load calculations manually and analysing the whole structure by STAAD Pro.Based on Limit State Design conforming to Indian Standard Code of Practice IS: 456, IS: 1893, IS: 13920, IS: 875.The structure was subjected to self-weight, dead load, live load, wind load and seismic loads. Under the load case details of STAAD.Pro. The wind load values were generated by software considering the given wind intensities at different heights and strictly abiding by the specifications of IS 875. Seismic load calculations were done following IS 1893-2005. The materials were specified and cross-sections of the beam and column members were assigned. The supports at the base of the structure were also specified as fixed. The codes of practice to be followed were also specified for design purpose with other important details. After completion of the design, we can work on the structure and study the bending moment and shear force values with the generated diagrams. We may also check the deflection of various members under the given loading combinations. The design of the building is dependent upon the minimum requirements as prescribed in the Indian Standard Codes. The minimum requirements pertaining to the structural safety of buildings are being covered by way of laying down minimum design loads which have to be assumed for dead loads, imposed loads, and other external loads, the structure would be required to bear. Strict conformity to loading standards recommended in this code, it is hoped, will ensure the structural safety of the buildings which are being designed. Structure and structural elements were normally designed by Limit State Method.***

***Keyword: Staad Pro, Seismic Zone, Limit state method, IS 1893-2005***

## CHAPTER 1
## INTRODUCTION

Building construction is the engineering deals with the construction of building such as residential houses. In a simple building can be defined as an enclosed space by walls with a roof, food, cloth and the basic needs of human beings. In the early ancient times, humans lived in caves, over trees or under trees, to protect themselves from wild animals, rain, the sun, etc. as the times passed as humans being started living in huts made of timber branches. The shelters of those old have been developed nowadays into beautiful houses. Rich people live in sophisticated condition houses.

Buildings are the important indicator of the social progress of the country. Every human has the desire to own comfortable homes on an average generally one spends his two-third life times in the houses. The security civic sense of the responsibility. These are the few reasons which are responsible that the person does utmost effort and spend hard earned saving in owning houses.

A building frame consists of a number of bays and story. A multi-storey, multi-paneled frame is a complicated statically intermediate structure. A design of R.C building of G+21 story frame work is taken up. The building in plan consists of columns built monolithically forming a network. The size of the building is 22x15.25m. The number of columns is 22. It is an office complex.

The design is made using the software on structural analysis design (stand-pro). The building subjected to both the vertical loads as well as horizontal loads. The vertical load consists of a dead load of structural components such as beams, columns, slabs etc. and live loads. The horizontal load consists of the wind forces thus building is designed for dead load, live load and wind load as per IS 875. The building is designed as two-dimensional vertical frames and analyzed for the maximum and minimum bending moments and shear forces by trial and error methods as per IS456-2000.

The increase in the number of the story of a building and/or the increase in the seismic one factor of the site increases the total cost of RCC building. However, the relationship between these factors may not be linear. The difference in the cost of a regular 21-story building designed for a site defined as seismic zone III and an identical building designed for a site defined as seismic zone V is not necessary to match the difference in the cost of similar buildings but having a different number of stories. Such a comparison, though difficult to carry out due to various factors involved, can be possible through some assumptions. The shape and plinth area of the building is assumed to be constantly fixed throughout the analysis. The costs of all RCC columns for a particular building were determined by computing the amount of PCC (M20) and steel (HYSD) required for the construction and using their prevalent cost rates. The number of construction materials for columns was determined for 4, 6, 8 and 10 story buildings of identical nature for seismic zones III and V by using STAAD Pro analysis and design.

### 1.2 COMPONENT OF BUILDING

The elements of industrial buildings are listed below.

1) Columns
2) Beams
3) Slabs
4) Foundation
5) Stairs
6) Shear wall

**1.2.1 Column: -**A column may be defined as an element used primarily to support axial compressive loads and with a height of a least three times its lateral dimension. The strength of column depends upon the strength of materials, shape, and size of the cross section, length and degree of proportional and dedication restrain at its ends.

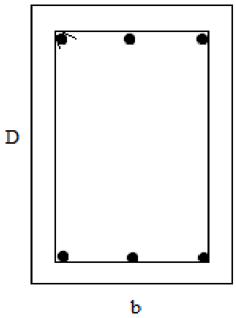



**Figure No.1**

**1.2.2 Beams: -**There are three types of reinforced concrete beams

- Single reinforced beams
- Double reinforced beams
- Flanged beams.

**1.2.2.1 Single Reinforced Beams: -**In singly reinforced simply supported beams steel bars are placed near the bottom of the beam where they are effective in resisting in the tensile bending stress.

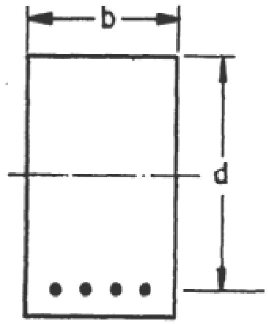



**Figure No.2**

**1.2.2.2 Double Reinforced Beams: -**It is reinforced under compression tension regions. The necessities of steel of compression region arise due to two reasons. When the depth of beam is restricted. The strength availability singly reinforced beam is in adequate.

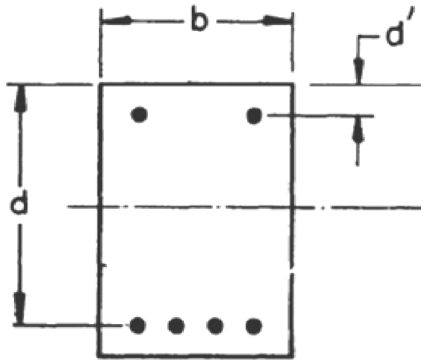



**Figure No.3**

**1.2.2.3 Flanged Beams: -**There are two types of flanged beam

1. T - beam
2. L - beam

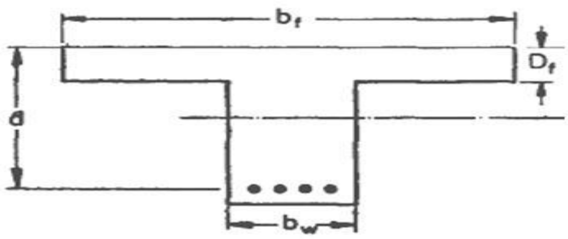



**Figure No.4**

**1.2.3 Slab: -**Slabs are most widely used structural elements forming floor and roof of the building. Slab support the mainly transverse load and transfer them to supports by bending actions more or one direction. On the basis of scanning direction: It is two type one way slabs and two-way slab.

**1.2.3.1 one way slab:** When the slab is supported on two opposite side parallel edges, it spans only in the directions perpendicular to the supporting edges. It bends in one direction and main steel is provided in the directions of the span. Such a slab is known as one- way slab.

**1.2.3.2 One way continuous slab:**

In the case of large halls, auditoriums, marriage halls, etc. the length is divided into equal bays by providing beams perpendicular to the length. The slab provided over such area is called one-way continuous slab.

**Design steps:** - For calculation of S.F. and B.M., IS: 456-2000, P.36. As the coefficient for D.L. and L.L. are different, for D.L. and L.L. are calculated separately. In one way continuous slab, the negative bending moment will be produced at the top of intermediate supports. Thus, negative reinforcement is provided over intermediate supports.
For B.M. calculations, coefficiently gives in IS: 456, table-12 is multiplied by wl2.
For S.F. calculations, coefficiently gives in IS: 456, table-13 is multiplied by wl.
Maximum shear occurs at the support next to the end support. Therefore, slab must be checked for shear at this support.
The slab must be checked for deflection at the locations of maximum positive B.M.
The slab must be checked for development length at the end support.

**1.2.4 Footing:-**Foundations are structural elements that transfer loads from the building or individual column to the earth .If these loads are to be properly transmitted, foundations must be designed to prevent excessive settlement or rotation, to minimize differential settlement and to provide adequate safety against sliding and overturning.

## CHAPTER 2
## OBJECTIVES OF THE PROJECT

The main aim of the study to provide the analysis of practical R.C.C building by limit state method with seismic effect in deferent zone and make a comparative study for the economic point of view, and also which method is most economical method and, high bending strength, more load carrying capacity and high flexural strength by analysis in different seismic zones of India by limit state method.

The primary objective of earthquake resistant design is to prevent building collapse during earthquakes thus minimizing the risk of death or injury to people in or around those buildings. Because damaging earthquakes are rare, economics dictate that damage to buildings is expected and acceptably provided collapse is avoided. Earthquake forces are generated by the inertia of buildings as they dynamically respond to ground motion. The dynamic nature of the response makes earthquake loadings markedly different from other building loads.

The designer temptation is to consider earthquakes as ‘a very strong wind’ is a trap that must be avoided since the dynamic characteristics of the building are fundamental to the structural response and thus the earthquake induced actions are able to be mitigated by design. The concept of dynamic considerations of buildings is one which sometimes generates unease and uncertainty within the designer. Although this is understandable, and a common characteristic of any new challenge, it is usually misplaced. Effective earthquake design methodologies can be, and usually are, easily simplified without detracting from the effectiveness of the design. Indeed the high level of uncertainty relating to the ground motion generated by earthquakes seldom justifies the often used complex analysis techniques nor the high level of design sophistication often employed. A good earthquake engineering design is one where the designer takes control of the building by dictating how the building is to respond. This can be achieved by selection of the preferred response mode, selecting zones where inelastic deformations are acceptable and suppressing the development of undesirable response modes which could lead to building collapse.

## CHAPTER 3
## METHODOLOGY

**3.1 GENERAL: -**If the structure not properly designed and constructed with the required quality they may cause the large destruction of structures due to earthquakes. Time history analysis is a useful technique for seismic analysis of structure when the structure shows a nonlinear response. This method is step by step analysis of the seismic responses of a structure to a specified loading that may change with time.

1) An extensive literature survey by referring books, technical papers carried out to understand the basic concept of the topic.
2) Selection of the type of structures.
3) Modeling of the selected structures
4) Structural Analysis of Building by Staad Pro
5) Structural Design of component of Building by Staad RCDC Program
5) Interpretation of result and conclusion.

In the present work, it is proposed to carry out seismic analysis of multistoried RCC buildings using IS: 1893-2002 for the different zone in India and compare the results with the help of Staad. Pro and Staad. RCDC software.

STAAD. Pro features a state-of-the-art user interface, visualization tools, powerful analysis and design engines with the advanced finite element and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification, STAAD.Pro is the professional’s choice for steel, concrete, timber, aluminum and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more.

- STAAD.Pro consists of the following:

1. The STAAD. Pro Graphical User Interface: It is used to generate the model, which can then be analyzed using the STAAD engine. After analysis and design are completed, the GUI can also be used to view the results graphically.
2. The STAAD analysis and design engine: It is a general-purpose calculation engine for structural analysis and integrated Steel, Concrete, Timber and Aluminum design.

- To start with we have to solve some sample problems using STAAD Pro and check the accuracy of the results with manual calculations. The results must be satisfactory and accurate. In the initial phase of our project we have to do calculations regarding loadings on buildings and also considered seismic and wind loads.
- The structural analysis comprises the set of physical laws and mathematics required to study and predicts the behavior of structures. Structural analysis can be viewed more abstractly as a method to drive the engineering design process or prove the soundness of a design without a dependence on directly testing it.
- To perform an accurate analysis a structural engineer must determine such information as structural loads, geometry, support conditions, and materials properties. The results of such an analysis typically include support reactions, stresses, and displacements. This information is then compared to criteria that indicate the conditions of failure. The advanced structural analysis may examine dynamic response, stability, and nonlinear behavior.
- Structure and structural elements shall normally be designed by Limit State Method. Account should be taken of accepted theories, experiment and experience and the need to design for durability. Design, including design for durability, construction, and use in service should be considered as a whole. The realization of design objectives requires compliance with clearly defined standards of materials, production, workmanship and also maintenance and use of structure in service. The design of the building is dependent upon the minimum requirements as prescribed in the Indian Standard Codes. The

minimum requirements pertaining to the structural safety of buildings are being covered by way of laying down minimum design loads which have to be assumed for dead loads, imposed loads, and other external loads, the structure would be required to bear. Strict conformity to loading standards recommended in this code, it is hoped, will not only ensure the structural safety of the buildings which are being designed.

- Here we have designed the component i.e. Column (whole building) and beams (typical floor) by Staad RCDC program which designs the members as per IS 456 and also facilitate for BOQ as per design. This Program enables us to compare the quantity and cost of the components.

**3.11 Basic Geography and Tectonic Features:-**

- India lies at the northwestern end of the Indo Australian Plate, which encompasses India, Australia, a major portion of the Indian Ocean and other smaller countries. This plate is colliding against the huge Eurasian Plate

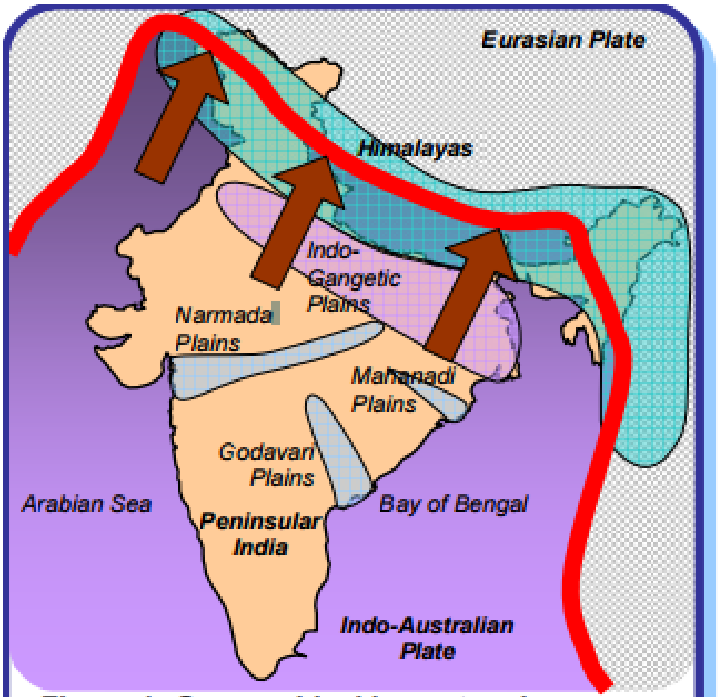



Figure 1: Geographical Layout and Tectonic Plate Boundaries at India

**Figure No-4**

And going under the Eurasian Plate; this process of one tectonic plate getting under another is called subduction. A sea, Tethys, separated these plates before they collided. Part of the lithosphere, the Earth's Crust, is covered by oceans and the rest of the continents. The former can undergo subduction at great depths when it converges against another plate, but the latter is buoyant and so tends to remain close to the surface. When continents converge, large amounts of shortening and thickening takes place, like at the Himalayas and the Tibet. Three chief tectonic sub-regions of India are the mighty Himalayas along the north, the plains of the Ganges and other rivers, and the peninsula. The Himalayas consist primarily of sediments accumulated over long geological time in the Tethys. The Indo Gangetic basin with deep alluvium is a great depression caused by the load of the Himalayas on the continent. The peninsular part of the country consists of ancient rocks deformed in the past Himalayan-like collisions. Erosion has exposed the roots of the old mountains and removed most of the topography. The rocks are very hard but are softened by weathering near the surface. Before the Himalayan collision, several tens of millions of years ago, lava flowed across the central part of peninsular India leaving layers of basalt rock. Coastal areas like Kachchh show marine deposits testifying to submergence under the sea millions of years ago.

- **3.12 Prominent Past Earthquakes in India**

  A number of significant earthquakes occurred in and around India over the past century (Figure 2). Some of these occurred in populated and urbanized areas and hence caused great damage. Many went unnoticed, as they occurred deep under the Earth's surface or in relatively un-inhabited places. Some of the damaging and recent earthquakes are listed in Table 1. Most earthquakes occur along the Himalayan plate boundary (these are inter-plate earthquakes), but a number of earthquakes have also occurred in the peninsular region (these are intra-plate earthquakes).

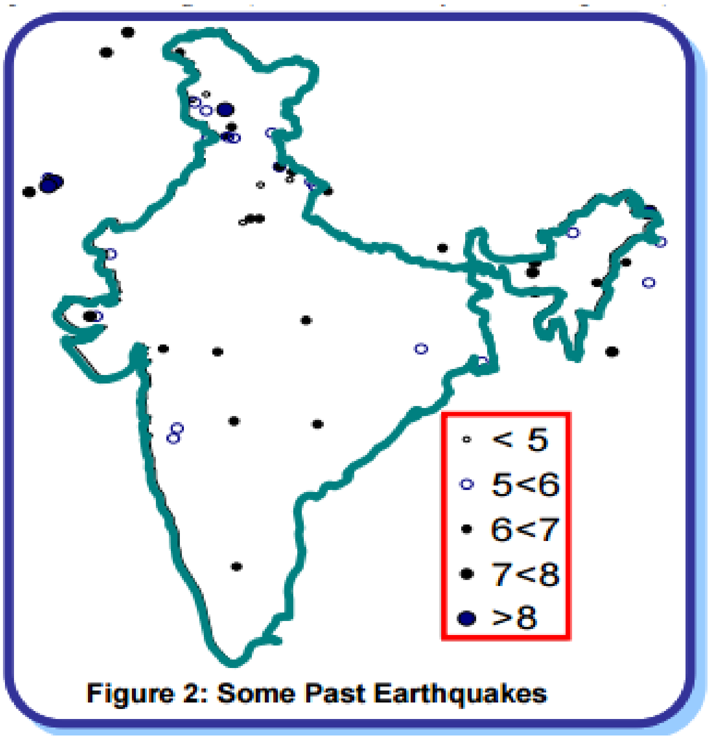



Figure 2: Some Past Earthquakes

**Figure No-5**

- Four Great earthquakes (M>8) occurred in a span of 53 years from 1897 to 1950; the January 2001 Bhuj earthquake (M7.7) is almost as large. Each of these caused disasters, but also allowed us to learn about earthquakes and to advance earthquake engineering. For instance, 1819 Cutch Earthquake produced an unprecedented ~3m high uplift of the ground over 100km (called Allah Bund). The 1897 Assam Earthquake caused severe damage up to 500km radial distances; the type of damage sustained led to improvements in the intensity scale from I-X to I-XII. Extensive liquefaction of the ground took place over a length of 300km (called the Slump Belt) during 1934 Bihar-Nepal earthquake in which many structures went afloat. Figure 1: Geographical Layout and Tectonic Plate Boundaries at India Deccan Shield Indo Gangetic Plains Himalayas Peninsular India Arabian Sea Bay of Bengal Indo-Australian Plate Eurasian Plate Narmada Plains Godavari Plains Mahanadi Plains < 5 58 Figure 2: Some Past Earthquakes.

- **3.13 Seismic Zones of India**
  The varying geology at different locations in the country implies that the likelihood of damaging earthquakes taking place at different locations is different. Thus, a seismic zone map is required to identify these regions. Based on the levels of intensities sustained during damaging past earthquakes, the 1970 version of the zone map subdivided India into five zones – I, II, III, IV and V.

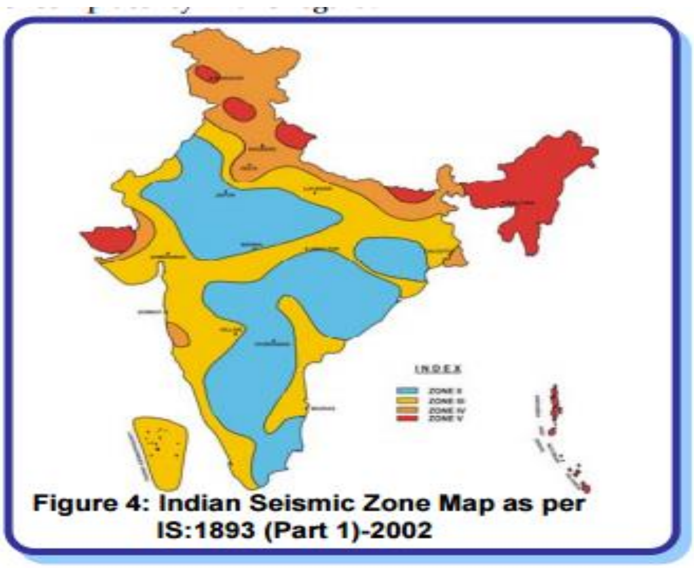



Figure 4: Indian Seismic Zone Map as per IS:1893 (Part 1)-2002

**Figure No-6**

- The maximum Modified Mercalli (MM) intensity of seismic shaking expected in these zones was V or less, VI, VII, VIII, and IX and higher, respectively. Parts of the Himalayan boundary in the north and northeast, and the Kachchh area in the west were classified as zone V. The seismic zone maps are revised from time to time as more understanding is gained on the geology, the seism tectonics and the seismic activity in the country. The Indian Standards provided the first seismic zone map in 1962, which was later revised in 1967 and again in 1970. The map has been revised again in 2002 (Figure 4), and it now has only four seismic zones – II, III, IV, and V. The areas falling in the seismic zone I in the 1970 version of the map are merged with those of seismic zone II. Also, the seismic zone map in the peninsular region has been modified. Madras now comes in seismic zone III as against in zone II in the 1970 version of the map. This 2002 seismic zone map is not the final word on the seismic hazard of the country, and hence there can be no sense of complacency in this regard.

- The National Seismic Zone Map presents a large scale view of the seismic zones in the country. Local variations in soil type and geology cannot be represented at that scale. Therefore, for important projects, such as a major dam or a nuclear power plant, the seismic hazard is evaluated specifically for that site. Also, for the purposes of urban planning, metropolitan areas are microzones. Seismic micro zonation accounts for local variations in geology, local soil profile, etc, Reading Material BMTPC, (1997), Vulnerability Atlas of India, Building Materials and Technology Promotion Council, Ministry of Urban Development, Government of India, New Delhi Dasgupta,S., et al, (2000), Seismo tectonic Atlas of Indian and its Environs, Geological Survey of India IS:1893, (1984), Indian Standard Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standards, New Delhi Figure 4: Indian Seismic Zone Map as per IS:1893 (Part 1)-2002 Figure 3:

## CHAPTER 4
## LOADS CONSIDERED

**4.1 DEAD LOADS:** - All permanent constructions of the structure from the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights. the unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kN/m” and 25 kN/m” respectively.

**4.2 IMPOSED LOADS / LIVE LOAD (LL): -**Imposed load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, the load due to impact and vibration and dust loads. Imposed loads do not include loads due to the wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo.

**4.3 WIND LOAD (WL): -** The Wind is air in motion relative to the surface of the earth. The primary cause of wind is traced to earth’s rotation and differences in terrestrial radiation. The radiation effects are primarily responsible for convection either upwards or downwards. The wind generally blows horizontally to the ground at high wind speeds. Since vertical components of atmospheric motion are relatively small, the term ‘wind’ denotes almost exclusively the horizontal wind, vertical winds are always identified as such. The wind speeds are assessed with the aid of anemometers or anemographs which are installed at meteorological observatories at heights generally varying from 10 to 30 meters above ground.

Design Wind Speed (V,) The basic wind speed (Vb,) for any site shall be obtained from and shall be modified to include the following effects to get design wind velocity at any height (V,) for the chosen structure:

- a) Risk level;
- b) Terrain roughness, height, and size of structure;
- c) Local topography. It can be mathematically expressed as follows: Where: V = Vb * kl * k* ksVb = design wind speed at any height z in m/s; kl = probability factor (risk coefficient) k = terrain, height and structure size factor and ks = topography factor
- **Risk Coefficient (kI Factor)** gives basic wind speeds for terrain Category 2 as applicable at 10 m above ground level based on 50 years mean return period. In the design of all buildings and structures, a regional basic wind speed having a mean return period of 50 years shall be used.
- **Terrain, Height and Structure Size Factor (k, Factor) Terrain** - Selection of terrain categories shall be made with due regard to the effect of obstructions which constitute the ground surface roughness. The terrain category used in the design of a structure may vary depending on the direction of the wind under consideration. Wherever sufficient meteorological information is available about the nature of wind direction, the orientation of any building or structure may be suitably planned.
- **Topography (ks Factor)** - The basic wind speed Vb takes account of the general level of the site above sea level. This does not allow for local topographic features such as hills, valleys, cliffs, escarpments, or ridges which can significantly affect wind speed in their vicinity. The effect of topography is to accelerate the wind near the summits of hills or crests of cliffs, escarpments or ridges and decelerate the wind in valleys or near the foot of cliff, steep escarpments, or ridges.

Wind Pressures and Forces on Buildings/Structures: -The wind load on a building shall be calculated for The building as a whole,

**4.311 Pressure Coefficients:**

The pressure coefficients are always given for a particular surface or part of the surface of a building. The wind load acting normal to a surface is obtained by multiplying the area of that surface or its appropriate portion by the pressure coefficient (C,) and the design wind pressure at the height of the surface from the ground. The average values of these pressure coefficients for some building shapes Average values of pressure coefficients are given for critical wind directions in one or more quadrants. In order to determine the maximum wind load on the building, the total load should

be calculated for each of the critical directions shown from all quadrants. Where considerable variation of pressure occurs over a surface, it has been subdivided and means pressure coefficients given for each of its several parts. Then the wind load, F, acting in a direction normal to the individual structural element or Cladding unit is:
F= (Cpe – Cpi) A Pd
Where,
Cpe = external pressure coefficient,
Cpi = internal pressure- coefficient,
A = surface area of structural or cladding unit, and
Pd = design wind pressure element
Here we do not have to consider any opening in the building for Cpe and Cpi calculations

**Table No-1**

**4.314 Wind Load Calculations for Zone IV: -**Here we have shown only for zone IV similarly we have done foe other zones

| Height | k1 | k2 | k3 | Vb | Vz=Vbxk1xk2xk3 | Pz=0.6Vz^2/1000 |
|---|---|---|---|---|---|---|
| 66.615 | 1.07 | 1.046584 | 1 | 47 | 52.63270936 | 1.662121257 |
| 63.39 | 1.07 | 1.041424 | 1 | 47 | 52.37321296 | 1.645772061 |
| 60.265 | 1.07 | 1.036424 | 1 | 47 | 52.12176296 | 1.630006904 |
| 57.14 | 1.07 | 1.031424 | 1 | 47 | 51.87031296 | 1.61431762 |
| 54.015 | 1.07 | 1.026424 | 1 | 47 | 51.61886296 | 1.598704208 |
| 50.89 | 1.07 | 1.021424 | 1 | 47 | 51.36741296 | 1.583166669 |
| 47.765 | 1.07 | 1.013295 | 1 | 47 | 50.95860555 | 1.558067688 |
| 44.64 | 1.07 | 1.00392 | 1 | 47 | 50.4871368 | 1.529370589 |
| 41.515 | 1.07 | 0.994545 | 1 | 47 | 50.01566805 | 1.50094023 |
| 38.39 | 1.07 | 0.98517 | 1 | 47 | 49.5441993 | 1.472776611 |
| 35.265 | 1.07 | 0.975795 | 1 | 47 | 49.07273055 | 1.44487973 |
| 32.14 | 1.07 | 0.96642 | 1 | 47 | 48.6012618 | 1.417249589 |
| 29.015 | 1.07 | 0.955075 | 1 | 47 | 48.03072175 | 1.384170139 |
| 25.89 | 1.07 | 0.93945 | 1 | 47 | 47.2449405 | 1.339250642 |
| 22.765 | 1.07 | 0.923825 | 1 | 47 | 46.45915925 | 1.295072087 |
| 19.64 | 1.07 | 0.90712 | 1 | 47 | 45.6190648 | 1.248659444 |
| 16.515 | 1.07 | 0.88212 | 1 | 47 | 44.3618148 | 1.180782367 |
| 13.39 | 1.07 | 0.8539 | 1 | 47 | 42.942631 | 1.106441734 |
| 10.265 | 1.07 | 0.82265 | 1 | 47 | 41.3710685 | 1.026939185 |

**4.4 SEISMIC LOAD (EQX, EQZ):-**The design lateral force shall first be computed for the building as a whole. This design lateral force shall then be distributed to the various floor levels. The overall design seismic force thus obtained at each floor level shall then be distributed to individual lateral load resisting elements depending on the floor diaphragm action.

**4.41 Design Seismic Base Shear: -**The total design lateral force or design seismic base shear (Vb) along any principal direction shall be determined by the following expression:

Vb = Ah W

Where, Ah = horizontal acceleration spectrum W = seismic weight of all the floors

**4.42 Fundamental Natural Period:-**The approximate fundamental natural period of vibration (T,), in seconds, of a moment resisting frame building without brick in the panels, may be estimated by the empirical expression: Ta=0.075 h0.75 for RC frame building Ta=0.085 h0.75 for steel frame building Where, h = Height of building, in m. This excludes the basement story, where basement walls are connected to the ground floor deck or fitted between the building columns. But it includes the basement story when they are not so connected. The approximate fundamental natural period of vibration (T,), in seconds, of all other buildings, including moment-resisting frame buildings with brick lintel panels, may be estimated by the empirical Expression:

T=.09H/√D

Where, h= Height of building d= Base dimension of the building at the plinth level, in m, along with the considered direction of the lateral force.

**4.43 Design Horizontal Seismic Coefficient$A_h$: -**The design horizontal seismic coefficient for a structure has been calculated by the following formula.

$$A_h = \frac{Z}{2}\frac{I}{R}\frac{S_a}{g}$$

Here Z=Zone Factor I =Importance Factor

R=Response reduction factor $S_a/g$=Average response acceleration coefficient

**4.44 Design Seismic Base Shear ($V_B$):-**The total design lateral force or design base shear ($V_B$) along any principal direction has been calculated as following formula by staad pro software itself.

$$V_B = A_h.W$$

Here W=Seismic Weight of Building

**4.45 Distribution of Design Force: -** Vertical Distribution of Base Shear to Different Floor Level The design base shear (VB) shall be distributed along the height of the building as per the following expression:

$$Qi = V_B \frac{W_i}{\sum_{j=1}^{n} W_j} \frac{h_i^2}{h_j^2}$$

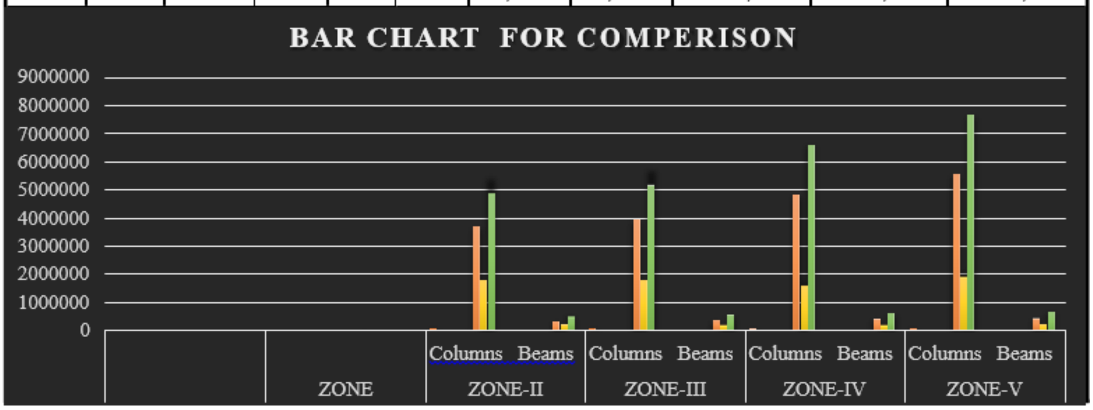
Qi=Design lateral force at floor i, the Wi=Seismic weight of floor i, hi=Height of floor i measured from the base, and n=Number of stories in the building is the number of levels in which the masses are located. Distribution of horizontal design lateral force to the different lateral force resisting elements in case of buildings whose floors are capable of providing rigid horizontal diaphragm action, the total shear in any horizontal plane shall be distributed to the various vertical elements of the lateral force resisting system, assuming the floors to be infinitely rigid in the horizontal plane. In the case of a building whose floor diaphragms cannot be treated as infinitely rigid in their own plane, the lateral shear at each floor shall be distributed to the vertical elements resisting the lateral forces, considering the in-plane flexibility of the diagram.

## CHAPTER 5
## RESULTS

**Table No-2**
**COMPERITIVE STATEMENT OF COST UNDER DIFFERENT SEISMIC ZONES**

COMPERITIVE STATEMENT FOR DIFFERENT EARTH QUAKE ZONES

| ZONE | | Steel Qty. in Kg. | C.C. Qty M35 (Cum) | M40 (Cum) | Rate of steel | Rate of M-35 CC | Rate of M-40 CC | Amount of steel | Amount of Conc. | Total Amount |
|---|---|---|---|---|---|---|---|---|---|---|
| ZONE-II | Columns | 61572.80 | 255.29 | 0.00 | ₹ 60.00 | ₹ 7,000.00 | ₹ 7,500.00 | ₹ 3,694,368.00 | ₹ 1,787,030.00 | ₹ 5,481,398.00 |
| | Beams | 5497.74 | 31.06 | 0.00 | ₹ 60.00 | ₹ 7,000.00 | ₹ 7,500.00 | ₹ 329,864.40 | ₹ 217,420.00 | ₹ 547,284.40 |
| ZONE-III | Columns | 66137.72 | 255.51 | 0.00 | ₹ 60.00 | ₹ 7,000.00 | ₹ 7,500.00 | ₹ 3,968,263.20 | ₹ 1,788,570.00 | ₹ 5,756,833.20 |
| | Beams | 5834.10 | 31.18 | 0.00 | ₹ 60.00 | ₹ 7,000.00 | ₹ 7,500.00 | ₹ 350,046.00 | ₹ 218,260.00 | ₹ 568,306.00 |
| ZONE-IV | Columns | 80343.56 | 257.26 | 0.00 | ₹ 60.00 | ₹ 7,000.00 | ₹ 7,500.00 | ₹ 4,820,613.60 | ₹ 1,800,820.00 | ₹ 6,621,433.60 |
| | Beams | 6749.20 | 31.33 | 0.00 | ₹ 60.00 | ₹ 7,000.00 | ₹ 7,500.00 | ₹ 404,952.00 | ₹ 219,310.00 | ₹ 624,262.00 |
| ZONE-V | Columns | 92784.06 | 292.28 | 11.55 | ₹ 60.00 | ₹ 7,000.00 | ₹ 7,500.00 | ₹ 5,567,043.60 | ₹ 2,132,585.00 | ₹ 7,699,628.60 |
| | Beams | 7655.22 | 31.68 | 0.00 | ₹ 60.00 | ₹ 7,000.00 | ₹ 7,500.00 | ₹ 459,313.20 | ₹ 221,760.00 | ₹ 681,073.20 |




## CHAPTER 6
## CONCLUSIONS

From the above results we can observe that the same building designed in seismic zone II, III,IV and V becomes more expensive as seismic zone increase due to increase the horizontal seismic forces causes the increase in column moment. Here we also observed that the increment in the cost is due to 60% column cost and 40% due to beam cast.

1. Designing using Software's like Staad reduces a lot of time in design work.
2. Details of each and every member can be obtained using a standard pro. & Staad RCDC
3. All the List of failed beams can be also obtained and also Better Section is given by the software.
4. Accuracy is improved by using the software.
5. From the comparative table of BOQ, we can easily say that it is much different in the quantity of steel and concrete for same column design in different seismic zones. While a little bit different in both the material for designing the beam at same level under different seismic zones.

**ACKNOWLEDGMENT**

I express my deep gratitude to **Mr. Mirza Aamir Baig,** Assistant Professor Department of Civil Engineering, Al-Falah University guide for the initiative, motivation, and guidance provided during the course of this work.

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