# TO EVALUATE THE SAFE AND ECONOMICAL RCC MULTISTORY BUILDING W.R.T SHAPE AND ANALYSIS METHOD IN ALL SEISMIC ZONES OF PAKISTAN

by

Registered No. 1**9-CIVIL-015** Name: **ABDUL HAFIZ**

Registered **No. 19-CIVIL-009** Name: **USMAN ABDULLAH**

Project Supervisor

(Lecturer, Engr. Yasir Rasheed)

Project Co-Supervisor

(Lecturer, Engr. Inayat Ullah Khan)

CIVIL ENGINEERING DEPARTMENT
HITEC UNIVERSITY, TAXILA

April, 2022

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**FINAL YEAR PROJECT REPORT**

**SESSION 2019**

**THESIS IS SUBMITTED TO THE FACULTY OF THE DEPARTMENT OF CIVIL ENGINEERING, HITEC UNIVERSITY, TAXILA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR'S OF SCIENCE IN CIVIL ENGINEERING**

**DEPARTMENT OF CIVIL ENGINEERING**

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Project Co-Supervisor

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(Designation and Name)

Project Supervisor

______________________

(Designation and Name)

Head of Department

______________________

(Designation and Name)

# DEDICATION

"With gratitude for the unwavering support and guidance of my supervisor, I confidently present this thesis, a testament to our collaborative efforts, aimed at pushing the boundaries of scholarly excellence."

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# ACKNOWLEDGEMENTS

I would like to express my deepest appreciation to the following individuals and organizations for their invaluable contributions and unwavering support during the completion of this thesis:

My supervisor, [Engr. Yasir Rasheed], for their guidance, expertise, and continuous encouragement throughout the research process. Their insightful feedback and constructive criticism have significantly shaped the direction and quality of this work.

The faculty members of the [Department/civil engineering], for their dedication to fostering an intellectually stimulating environment that nurtured my academic growth. Their expertise and willingness to engage in scholarly discussions enriched my understanding of the subject matter.

I am grateful to the members of my thesis committee, [Abdul Hafiz & Usman Abdullah], for their thoughtful insights, critical evaluation, and valuable suggestions that have greatly improved the overall quality of this thesis.

I extend my sincere gratitude to the [Institution/HITEC University] for providing the necessary resources, facilities, and funding that facilitated the successful completion of this research.

# ABSTRACT

The impact of earthquake forces on structure is very serious issue in its stability. These forces have larger impact in high seismic zone. To counter these impacts large concrete sections are provided in the structure which make the structure costly. In this research impact of earthquake forces in the geometry of structure has been studied in different seismic zones of Pakistan. The main objective of this research is to evaluate safe and economical design of structure w.r.t. geometry of building and seismic analysis method applied in all seismic zones of Pakistan.

12 storeys building having (01xBasement +ground floor + 10 Stories) is consider for analysis and design. The geometry of buildings are considered as rectangular, circular and triangular. In all geometric shapes of building total covered area is approximately equal with each other and also by span of all geometric structure are approximately same. For seismic analysis of structure two types of analysis method is used **(Static equivalent Method** is used for static analysis of earthquake forces) and (dynamic analysis has been done through **Response Spectrum Analysis** as per UBC97 Code).To find safe and economical design of structure in all seismic zone has been done through different parameters (storey displacement,story drift, moment, shear and base shear) and for economical design cost estimation has been done. The final recommendation for the structure design of 12 storey building is analysis based on shape and analysis methods in all seismic zones.

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**CHAPTER 1**

# 2 INTRODUCTION

In recent years, the world has been noticing a major increase in population, accompanied by a parallel decrease in available horizontal land space. This increase in population has presented numerous challenges, mostly in urban areas, where the demand for housing and infrastructure continues to rise and the horizontal available space become shorter. To address this issue, architects, urban planners, and engineers have turned to construct high-rise buildings as a sustainable solution. These high structures not only get the best out of land utilization but also offer a range of benefits that provide to the growing needs of our society. But the process of constructing of high rise structure is complicated and costly, and its demands careful consideration of a number of element, e.g natural disasters like earthquakes, flooding, wind e.t.c. It is uneconomical to design and construct a structure in such a manner that it minimizes damage during an earthquake. This is because an earthquake may or may not occur during the structure's life time and is a unusual phenomenon, making the construction of the structure uneconomical.To reduce cost and to filled the different visual needs of people, the building of different shapes and sizes is in practice. Such building structure is more vulnerable to seismic force. Numerous methods have been followed to reduce the severe effects. The geometry of a building is one such method which changes the performance of the structural. In this research three different shapes of buildings such as (rectangular, triangular, and circular) are considered in the study and a comparison is made between different shapes of buildings against the effect of lateral loads due to the earthquake. Computer-Aided Design (CAD) is carried out to perform the relative comparison between different zone of Pakistan building codes providing and focus on the effect due to building shape variation.

## 2.1 IMPACT OF EARTHQUAKE ON HIGH RISE BUILDING

Earthquake is the most hazardous natural phenomenon that generates large damage in structures. That is why the understanding of the seismic impact on a structure is very important, and designers and contractors should study the impact of seismic forces on buildings in order to be able to established prevention measures against failures and collapses. There are some major effect of structure.

### 2.1.1 Inertia Forces in Structures

The generation of inertia forces in a structure is one of the seismic impacts that adversely affect the structure. When an earthquake produce ground shaking, the base of the building would move but the roof of the building would be at rest.

The trend of the roof structure to remain at its original position is called inertia. The inertia forces can source shearing of the structure which can focus stresses on the weak walls or joints in the structure resulting in failure or maybe total collapse. Finally, high weight means higher inertia forces produce that is why lighter buildings bear the earthquake shaking better.

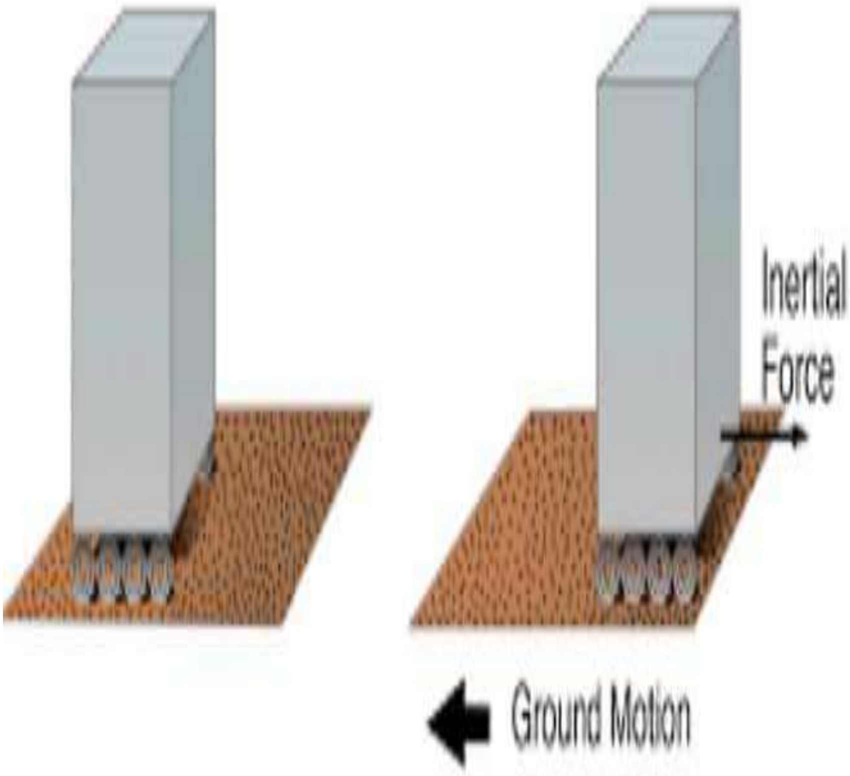



*Figure 1*

## 2.1.2 Effect of Deformations in Structures

When a building experiences earthquake and ground shaking happens, the base of the building moves with the ground shaking. But, the movement of roof would be different from that of the base of the building. This difference in the movement produce internal forces in columns which tend to return the column to its original position.

These internal forces are called stiffness forces. The stiffness forces would be higher as the size of columns come to be higher.

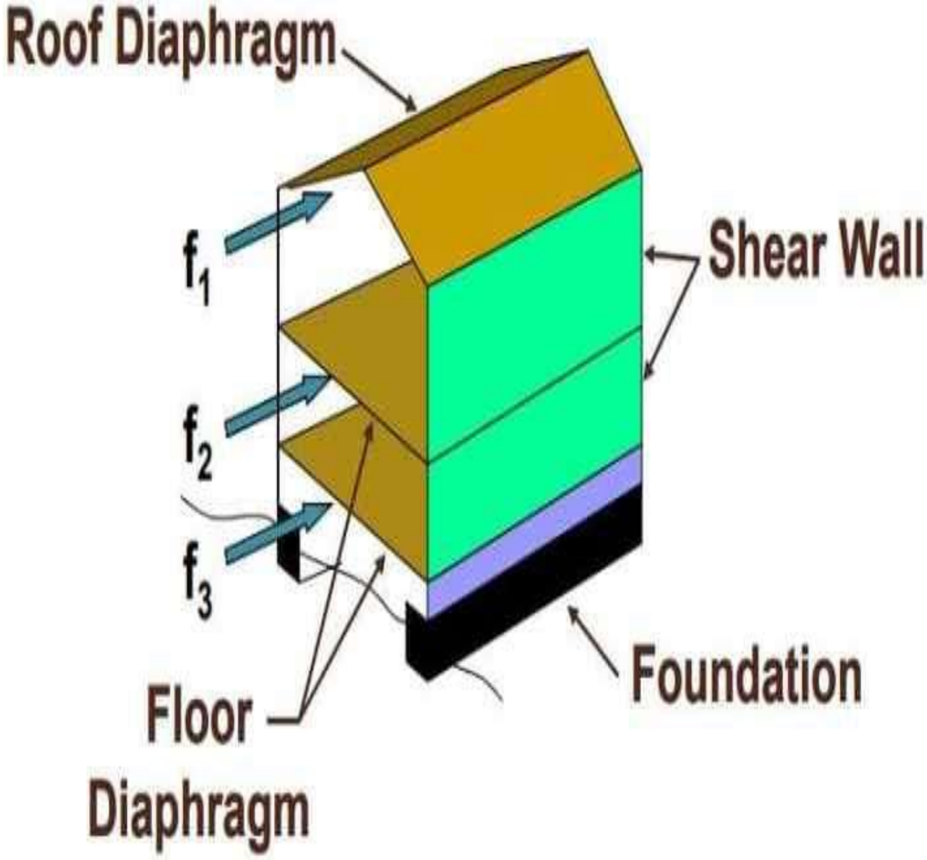



*Figure 2*

### 2.1.3 Horizontal and Vertical Shaking

Earthquake origins shaking of the ground in all the three directions X, Y and Z, and the ground shakes back and forth motion along each of these axis directions. Normally, high rise building aredesigned to resist vertical loads, so the vertical shaking due to earthquakes is tackled through safety factors used in the design of high rise building to support vertical loads.

Horizontal shaking along X and Y directions is critical for the act of the structure since it produces inertia forces and lateral displacement, then in future suitable load transfer path shall be provided to avoid damaging impacts on the structure.

Accurate inertia force transfer path can be made through suitable design of floor slab, walls or columns, and connections between these structural elements. It is means stating that the walls and columns are critical structural element that transferring the inertial forces. It is confirmed that, masonry walls and thin reinforce concrete columns would produce weak points in the inertia force transfer path.

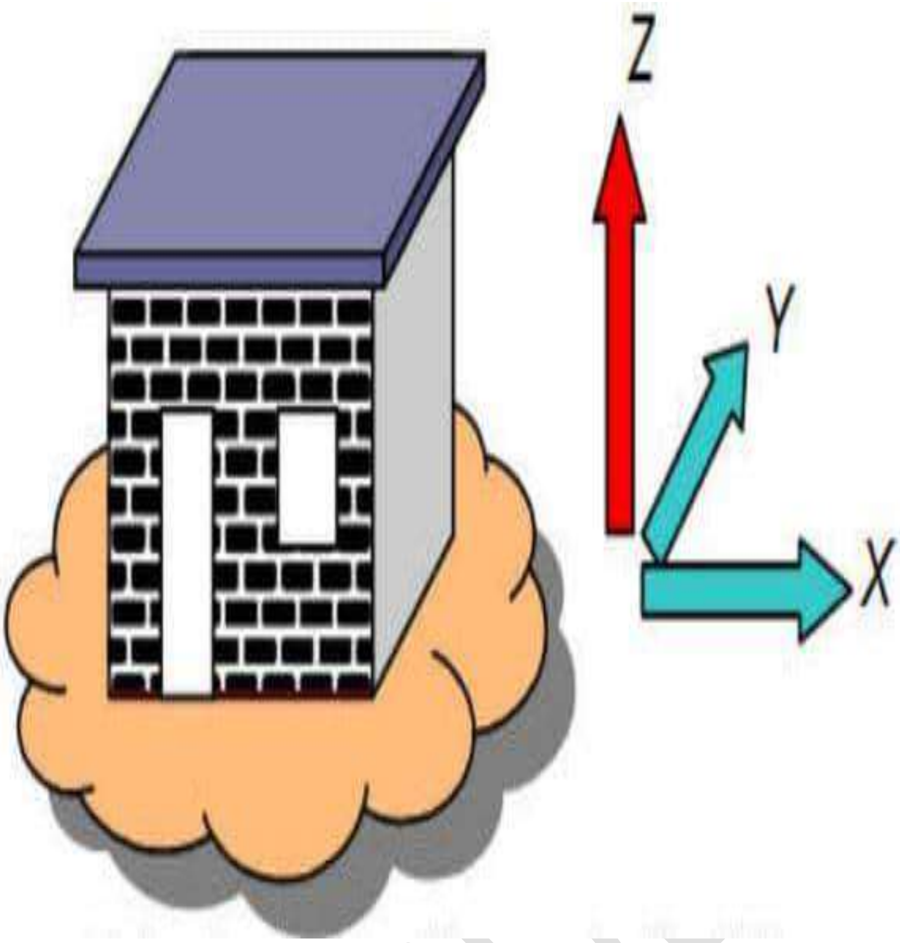



*Figure 3*

### 2.1.4 Other Effects

Away from the direct impact of earthquakes on a structure which are discussed above, there are other effects such as liquefaction, tsunami, and landslides. These are the indirect effects of strong earthquakes that can create large destruction.

## 2.2 SEISMIC ZONE OF PAKISTAN

As Pakistan is divided in to five zones (zone 1, 2A, 2B, 3 and 4) considering zone 1 is the lowest and zone 4 is the largest and also each zone have different seismic parameter.

### 2.2.1 Zone 1 (Low Damage Risk)

This zone comprises the northernmost part of Pakistan, containing parts of Punjab. It experiences the lowest level of seismic activity and has a relatively lower risk of damage from earthquakes.

### 2.2.2 Zone 2A (Moderate Damage Risk)

This zone covers parts of Khyber Pakhtunkhwa, Azad Kashmir, and northern Punjab. It experiences moderate seismic movement, and buildings and infrastructure in this zone need to be constructed with appropriate seismic design considerations.

### 2.2.3 Zone 2B (Moderate to High Damage Risk)

This zone includes parts of Punjab, Balochistan, Sindh, and Khyber Pakhtunkhwa. It has a higher level of seismic activity compared to Zone 2 and poses a moderate to high risk of damage from earthquakes.

### 2.2.4 Zone 3 (High Damage Risk)

This zone covers areas such as Islamabad, Rawalpindi, Peshawar, Lahore, and Quetta. It experiences a significant level of seismic activity and has a high risk of damage to buildings and infrastructure in the event of an earthquake.

### 2.2.5 Zone 5 (Very High Damage Risk)

This zone includes some parts of Balochistan and Sindh, including Karachi. It experiences the highest level of seismic activity in Pakistan and is associated with a very high risk of damage from earthquakes. Special attention needs to be given to construction practices and building codes in this zone to ensure structural safety.

## 2.3 PROBLEM STATEMENT

1. To assess the structural response and vulnerability of these buildings under seismic loads,considering the dynamic characteristics and earthquake hazard levels specific to each zone.
2. The analysis will involve evaluating the structural integrity, stability, and deformation patterns of the buildings to determine their seismic resistance and potential failure modes.
3. The study aims to provide insights into the structural design requirements and guidelines for high-rise buildings in different geometries across various seismic zones in Pakistan, with the ultimate objective of increasing their seismic safety and resilience.

## 2.4 AIMS & OBJECTIVES

### 2.4.1 Aims

Find the economical structure with respect to shape and cost impact in all seismic zones of Pakistan.

### 2.4.2 Objectives

1. Compare the top joint displacement of all the shapes in all seismic zones.
2. Compare storey drift of all the shapes in all zones.
3. Compare moment of all the shapes in all zones.
4. Compare shear of shapes in all seismic zones.
5. Compare base shear of shapes in all seismic zones
6. Cost analysis of shapes in all seismic zones.

## 2.5 SCOPE OF RESEARCH

1. To measuring the impact of seismic hazard.
2. To determining design parameters for high rise building
3. To conducting structural analysis in different seismic zone of Pakistan
4. To ensuring compliance with relevant building codes and regulations.
5. The goal is to design high-rise buildings that can withstand seismic forces and minimize the risk to occupants and the structure itself during an earthquake.

## 2.6 ORGANIZATION OF CHAPTER

This thesis contains eight chapter. The description of chapters is given below:

1. **Chapter 1**is the introduction of topic. It consists of problem statement, Aim & objectives, scope of research.
2. **Chapter 2** is the literature review in which the method applied to find maximum parameters.
3. **Chapter 3** consists methodology of the project.
4. **Chapter 4** basis on the analysis and result of the project.
5. **Chapter 5** includes the analysis of the project.
6. **Chapter 6** includes cost and budgeting of the project.
7. **Chapter 7** contain conclusion of the research.
8. **Chapter 8** contain the recommendation for future aspect.

**CHAPTER-2**

# 3 LITERATURE REVIEW

## 3.1 ANKUR MISHRA [1]

Sustainable development is the practice of using guidelines for environmentally responsible and energy savings to create new world. The aim of this study is to analyze the benefits of circular shape buildings over rectangular buildings. The focal parameters considered in this study to generate comparison of circular and rectangle building against lateral loads, energy efficiency and aural design. Results rectangular buildings are good in strength, durability but circular buildings are more efficient in aspect of lateral load, energy efficiency and acoustics.(2017).

## 3.2 Nitesh Bhure,Rashmi Sakalle [2]

The focus of this work is over the behavior and performance of vertical irregular and regular G+10 RC building under seismic loadings. The total 8 irregular and regular high rise building models are ready and then seismic analysis is done through RSA (response spectrum analysis) technique.Results different types of seismic response like storey displacement and storey stiffness are obtained (2021).

## 3.3 Sristi Das Gupta, Md.Kamrul Hasan Kanak [3]

The paper summaries the total effect of different wind speed on high rise structure to calculate the lateral movements such as displacement and inter-storey drift as well as serviceability of a RCC high rise building. The maximum increase of displacement was found 46.2% for 260 km/h wind speed compared to 150 km/h wind speed.The maximum top storey drift was observed 0.019085 at height110ft for 260 km/hr wind speed while minimum top storey drift was found 0.0153at height 110ft for 150 km/hr wind speed.(2020).

## 3.4 K. Rama Raju,1, M.I. Shereef

The design criteria are strength, serviceability and human security. The aim of the structural engineer is to arrive at suitable structural schemes, to satisfy these criteria. In the present study, the limit state method of analysis and design of a 3B+G+40-storey reinforced concrete high rise building under wind and seismic loads as per IS codes of practice is described. Safety of the structure is checked against allowable limits prescribed for base shear, roof displacements, inter-storey drifts, acceleration.Although designing, some of the beams and column sections, the limit on maximum percentage of reinforcement in the member is greater than the maximum percentage of reinforcement in the member. To satisfy these limits, it is recommended to increase the grade size of the concrete from M35 to M60 and the cross sectional area of the columns and beams are also need to be increased (2013).

## 3.5 **RAJKUMAR KANUKUNTLA [5]**

To determine the maximum peak response of high rise building with respect to natural time period and seismic analysis is necessary. Hence, it is reasonable to go with response spectrum analysis as it would be tough to determine time history record designed for all places. In this paper G+6 RCC building was analyzed through response spectrum analysis using STAAD PRO software. There are two different shaped high rise building were modelled, they consist of of a Regular shaped (Rectangular) building and Irregular (L shaped) building. The analysis results evaluated the dynamic response in terms of Storey drift, Base shear, Storey displacement, Time periods and Mode shapes. It is from the results that the overall performance of regular structure is found better than irregular structures(2022).

## 3.6 **(Himanshu Bansal, Gagandeep )**

Response spectrum analysis (RSA) and Time history Analysis (THA) of vertically irregular RCC building structures and to transfer out the ductility based design using IS 13920 parallel to Equivalent static analysis and Time history analysis. Three types of irregularities such as mass irregularity, stiffness irregularity and vertical geometry irregularity were considered.If a high rise structure (low natural frequency) is subjected to high frequency ground motion then it results in small displacements. Similarly, if a low rise structure (high natural frequency) is subjected to high frequency ground motion it results in larger displacements whereas small displacements occur when the high rise structure is subjected to low frequency ground motion(2014).

## **3.7 ( Rajendra Kumar,Ranga Rao)**

Determines the comparison of equivalent static and response spectrum technique for earthquake loading of a high-rise building using Staad pro software. It was observed that there was an increase in base shear of 37%, 58% and 72% in the respective seismic zones III, IV and V compared to zone II in the conventional frame and base shear of 17%, 58% and 72% in the respective seismic zones III, IV and V with a comparison with zone II, respectively in an irregular framework (2014).

## 3.8 **(Chang-Hai Zhai, Zhi Zheng a, Shuang L)**

The objective of this paper to study the dynamic responses of an RCC high rise building below focal shock wave and aftershock seismic structures. The results recommend that aftershocks have amajor effect on RCC building reactions in terms of maximum peak accelerations, maximum topsshifts and accumulated damage. In addition, the RCC indices from major damage in repeated earthquakes, local damage and global damage indices are proposed as limitations within the directive. only major shocks.(2015).

### 3.9 (Anirudh Gottala, Kintali Sai Nanda Kishore)

This study defines the effect of earthquake loading which is one of the most important dynamic loading along with its consideration in structural analysis. In this study, the multi-story frame structure of the pattern (G+9) is selected. Linear seismic analysis is done for the building by static method (seismic coefficient method) and dynamic method (response spectrum method) using STAAD-Pro as per IS-1893-2002-Part 1. Results, values for moments are 35 to 45% higher for dynamic analysis than the values obtained for the static analysis, the column displacement values are 40 to 45% higher for the dynamic analysis than the values obtained for the static analysis, the nodal displacement values in the Z direction are 50% higher for the dynamic analysis than the values obtained for the static analysis, pressure and tensile stresses in the studied beams were approximately the same. (2015).

### 3.10 (Gauri G. Kakpure, Dr. A.R. Mundhada)

In this work, two tall buildings (structure G+10 and G+25) assumed to be located in seismic zone III are analyzed using two different methods. see equivalent static analysis method and response spectrum method using ETAB 15 software. From the analysis results, parameters such as storey displacement, storey displacement, axial load, bending moments are determined for the comparative study. The results confirmed the superiority of the response spectrum method over the equivalent static analysis method.(2017)

### 3.11 (Thomas-Erik N. Makris1 , Theodoros A. Chrysanidis)

In the current research study, the effect of seismic acceleration on the construction cost of co ncrete (R/C) load-bearing seismic structures has been studied. And result reinforced concrete building, with strong structural walls, designed and dimension according to modern seismic codes, the impact of seismic hazard on the construction cost of the building is not significant, due to small percentage increase in total material costs in comparison to the drastic percentage increases of the respective seismic accelerations.

**After studying** different research the mutual maximum parameters such as storey drift, storey displacement, moment, base shear and shear are considered for the design of a safe and economical building on the bases of geometry.

## 3.12 **Storey Drift**

During an earthquake, the ground motion causes the building to vibrate horizontally. This horizontal motion induces forces on the building's structural elements, resulting in lateral displacements between different levels. Storey drift is a measure of these displacements and is usually expressed as the relative horizontal displacement between two adjacent storeys.

Storey drift is typically defined as the difference in lateral displacement between the top and bottom of a storey. It is usually expressed as a ratio or a percentage of the storey height. For example, a storey drift of 0.005 means that the horizontal displacement between the top and bottom of a storey is 0.5% of the storey height.

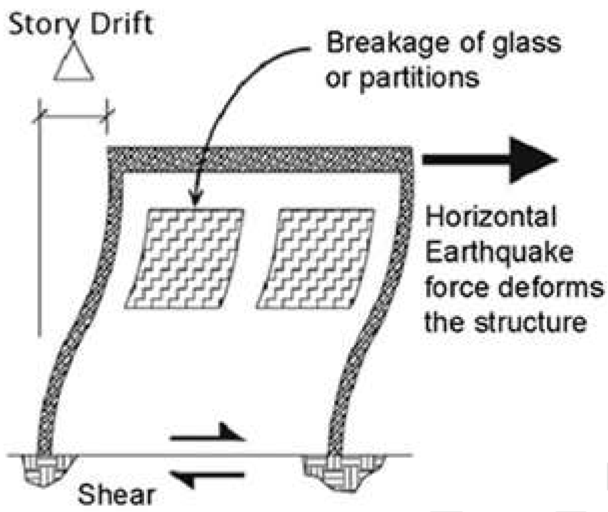



*Figure 4*

## 3.13 **Storey Displacement**

During an earthquake, for example, the ground shaking causes the building to experience dynamic forces that induce vertical movement or deformation between adjacent storeys. The storey displacement quantifies this relative movement, typically measured as the difference in vertical position between the top and bottom of a storey.

Storey displacement can be expressed in absolute terms, such as in millimeters or inches, indicating the actual vertical displacement between storeys. It can also be expressed as a ratio or percentage of the storey height, providing a relative measure of the deflection. For example, a storey displacement of 0.02 means that the vertical movement between the top and bottom of a storey is 2% of the storey height.

## 3.14 **Base shear**

During an earthquake, the ground moves back and forth in a horizontal direction, causing the structure to vibrate and experience lateral forces. These forces can cause the structure to move or deform, maybe highest to structural failure if the design is poor.

The base shear is calculated by considering several factors, including the seismicity of the region, the characteristics of the ground motion, and the dynamic properties of the structure itself. It is normally expressed in terms of a force, such as kilo-newton (kN) or pounds-force (lbf).

The base shear is influenced by the mass and stiffness of the structure. Generally, larger and stiffer structures will experience higher base shear forces compared to smaller and more flexible structures.

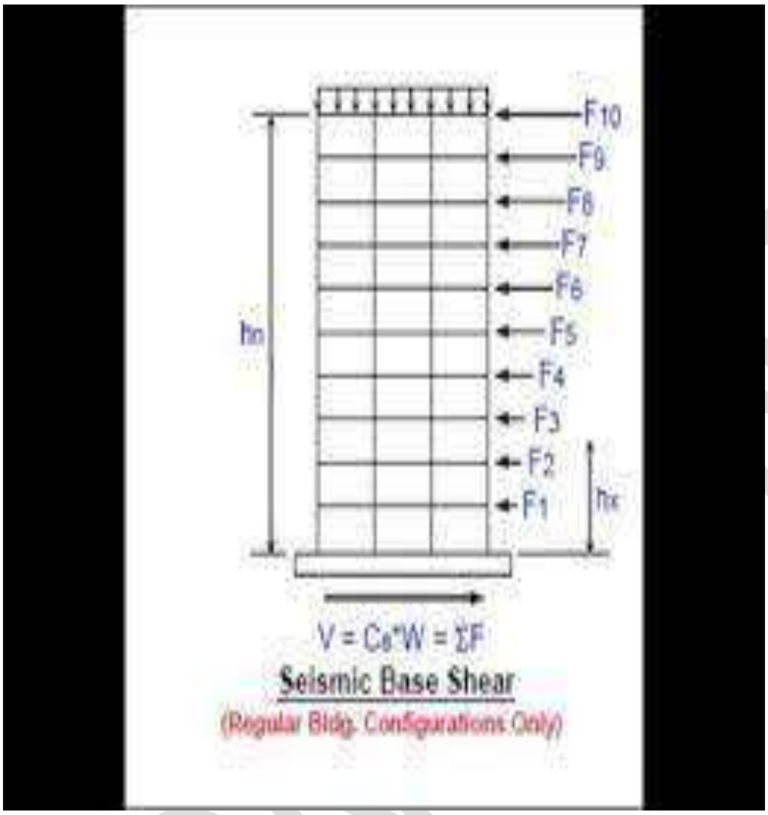



Figure 5



## 3.15 **Shear**

Shear force arises when two forces are applied in opposite directions parallel to a surface, causing the material to experience internal stress and deformation. The magnitude of the shear force is determined by the intensity of the applied forces and the area over which the forces act.

In structural engineering, shear is an important consideration in the design of beams, columns, and other load-bearing elements. When a load is applied perpendicular to the longitudinal axis of a structural member, it induces both bending and shear. The shear force represents the internal forces that resist the applied load and prevent the member from shearing or sliding apart.

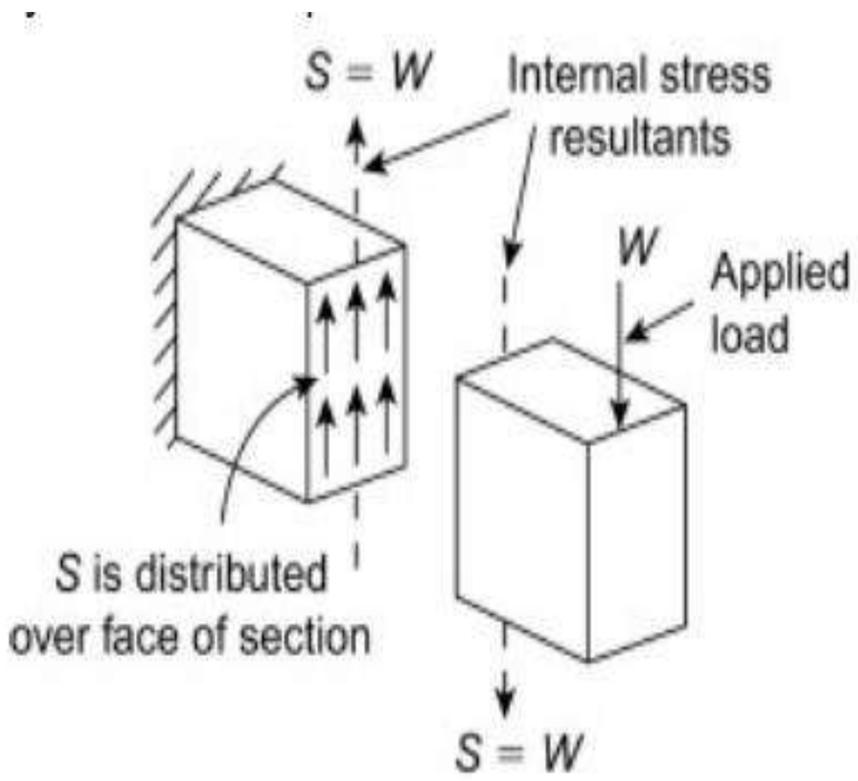



*Figure 6*



### 3.16 **Bending moment**

When a load is applied to a structural member, such as a beam, it induces internal forces that act perpendicular to the longitudinal axis of the member. These forces create bending moments, which cause the beam to bend or deflect.

The bending moment at any point along the length of a beam is determined by the magnitude and distribution of the applied loads, as well as the geometry and properties of the beam itself. It is expressed in units of force multiplied by distance, such as newton-meters (Nm) or pound-feet (lb-ft).

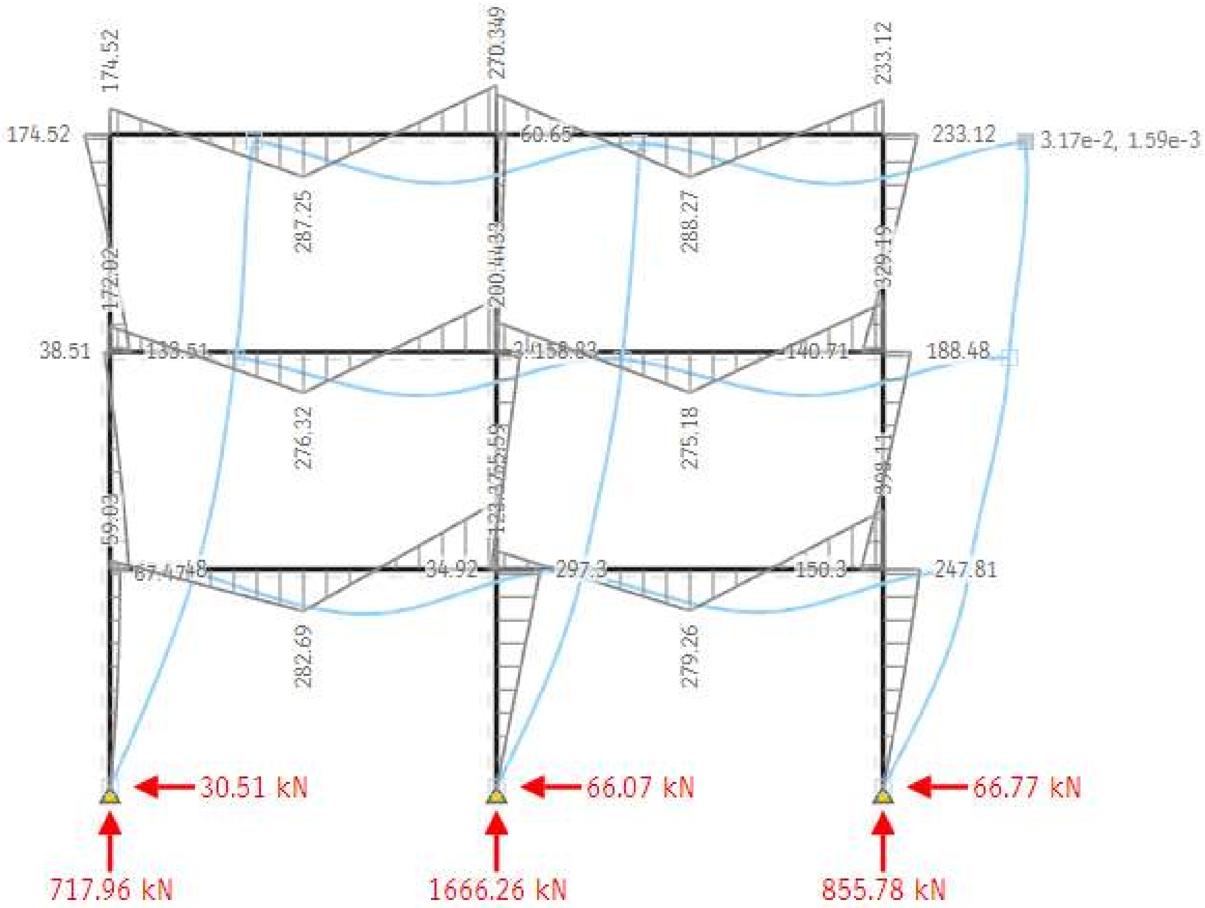



*Figure 7*

**CHAPTER-3**

# 4 METHODOLOGY

## 4.1 Modelling of building

For this study, building of three different geometrical shapes such as rectangular, triangular and circular have been considered with RCC (reinforce cement concrete) structure. G+12 storied building are modelled using conventional structure of RCC beams, columns and slabs of three different shapes (rectangular, circular, triangular) in all seismic zone of Pakistan. Total thirty building have been design.

| | Zone 1 | | Zone 2A | | Zone 2B | | Zone 3 | | Zone 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Shape of building | RSA | ESA | RSA | ESA | RSA | ESA | RSA | ESA | RSA | ESA | Number of building |
| Rectangular | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 10 |
| Triangular | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 10 |
| Circular | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 10 |
| Number of building in each zone | 6 | | 6 | | 6 | | 6 | | 6 | | 30 |

*Table 3.1*

## 4.2 Model specification

in the present study, analysis of G+12 multi-story commercial building in all seismic zone of Pakistan is considered in ETAB.

Basic parameter is considered for analysis are

1. Number of stories: G+12
    a) Basement (shops)
    b) Ground floor (shops)
    c) Storey 1 (shops)
    d) Storey (2-10) residential
2. Shape of building: Rectangular, Circular and Triangular
3. Types of construction: RCC frame structure
4. Beam: 12”X18”
5. Colum: 24”X24”
6. Slab: 8”
7. FC5000psi
8. Steel Grade 60
9. Raft 27”

10. Concrete slab 4000psi
11. Raft 3000psi

## 4.3 Model on ETAB

Rectangular building

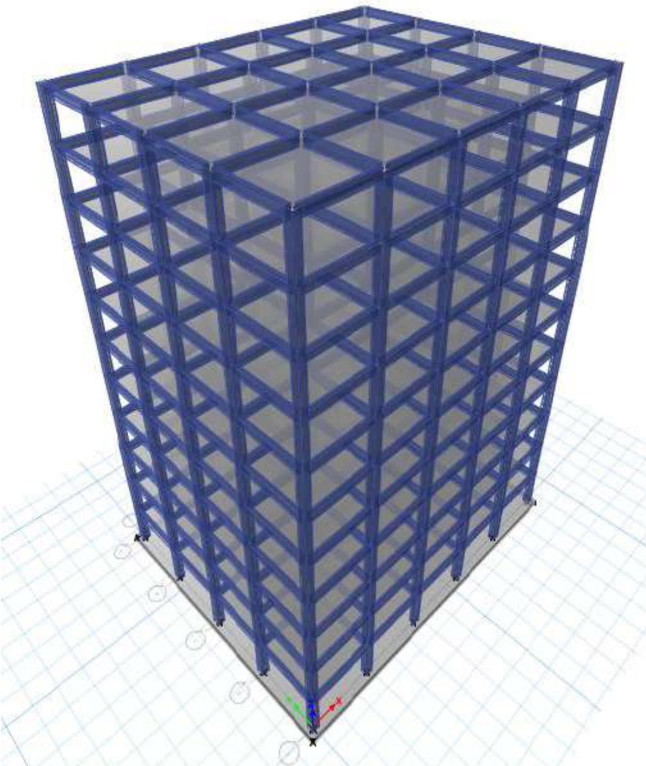


*Figure 8*

Triangular building

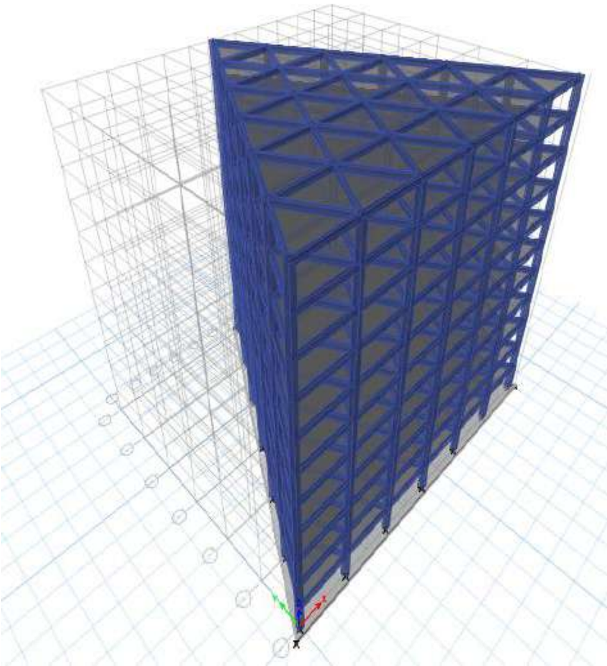


Figure 9

Circular building

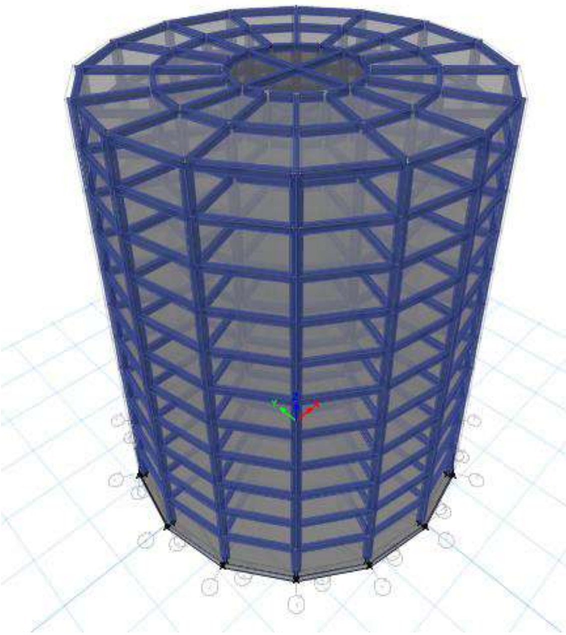


Figure 10

## 4.4 Load Pattern

Floor finishing load, partition wall load, roof live load and dead loads (permanent loads like the weight of the structure, finishes, and equipment) and live loads (temporary loads like occupants, furniture, and movable items), are uniformly distributed across the floor area based on the design parameters and building use.

Detail of project (1basement+1Ground floor+10stories)

- Basement (shops)
- Ground floor(shops)
- Storey 1( shops)
- Storey (2-10) (residential)

  Loads

  - Storey 10 top roof

| | |
|---|---|
| **Load Pattern: floorfinishing** | |
| Uniform | 50 lb/ft² |
| **Load Pattern: imposedload** | |
| Uniform | 20 lb/ft² |
| **Load Pattern: partitionwal** | |
| Uniform | 10 lb/ft² |
| **Load Pattern: rooflive** | |
| Uniform | 20 lb/ft² |

Story( 2- 9)

| | |
|---|---|
| **Load Pattern: floorfinishing** | |
| Uniform | 36 lb/ft² |
| **Load Pattern: imposedload** | |
| Uniform | 20 lb/ft² |
| **Load Pattern: liveless100** | |
| Uniform | 40 lb/ft² |
| **Load Pattern: partitionwal** | |
| Uniform | 45 lb/ft² |
| **Load Pattern: rooflive** | |
| Uniform | 20 lb/ft² |

Basement+ground floor+storey 1

| | |
|---|---|
| **Load Pattern: floorfinishing** | |
| Uniform | 36 lb/ft² |
| **Load Pattern: imposedload** | |
| Uniform | 20 lb/ft² |
| **Load Pattern: liveless100** | |
| Uniform | 50 lb/ft² |
| **Load Pattern: partitionwal** | |
| Uniform | 45 lb/ft² |
| **Load Pattern: rooflive** | |
| Uniform | 20 lb/ft² |

## 4.5 Seismic load

Seismic load, such as EQX, (EQX+ECC), (EQX-ECC), EQY, (EQY+ECC), (EQY-ECC) are applied to the building's vertical elements, including columns and walls. The forces are typically distributed based on the relative stiffness and location of these elements within the building's plan.

In all shapes, the applied loads are calculated based on building codes and standards, taking into account factors such as building occupancy, location, and seismic zone. Structural analysis and engineering calculations are performed to determine the distribution and magnitude of loads on different elements.

## 4.6 Analysis of building

In this study, the two types of analysis such as Response spectrum analysis and equivalent static analysis have done of all shape of building to generate comparison on the basis of different seismic parameter such as story drift, story displacement, base shear, shear, and moment.

### 4.6.1 Response spectrum analysis

Response spectrum analysis is a method used in structural engineering to evaluate the dynamic response of a structure endangered to earthquake or other ground motion excitations. It is a simplified approach that allows engineers to estimate the maximum response of a structure at various natural frequencies without needing to perform a detailed time-history analysis.

### 4.6.2 Equivalent static analysis

Equivalent static analysis, also known as static equivalent analysis or static equivalent method, is a simplified approach used in structural engineering to estimate the response of a structure to dynamic loads, such as seismic or wind forces. It is an approximation method that simplifies the dynamic problem into an equivalent static problem, making the analysis more manageable and less computationally determined.

## After analysis

## Rectangular building

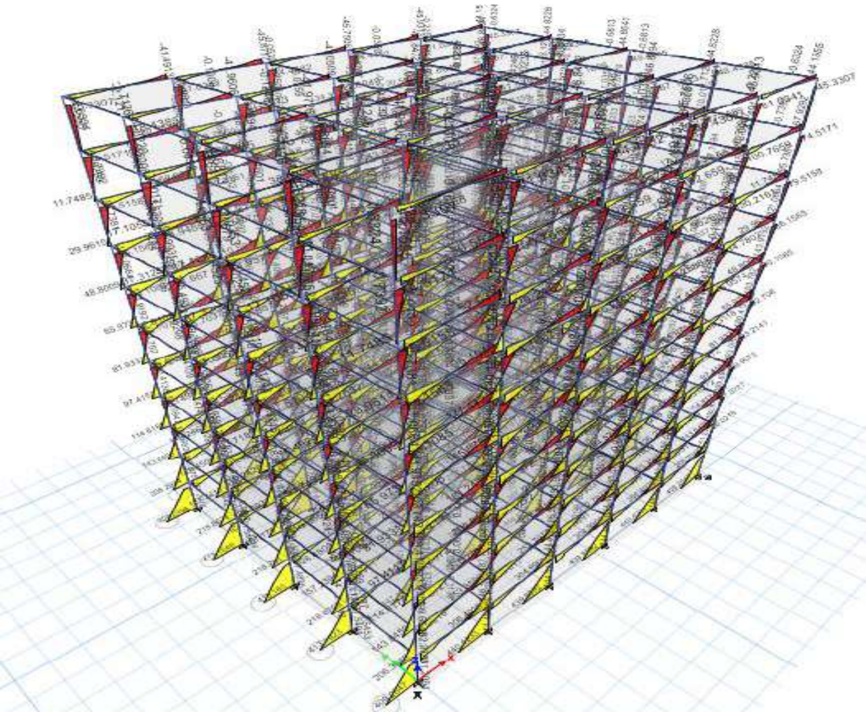


*Figure 11*

## Triangular building

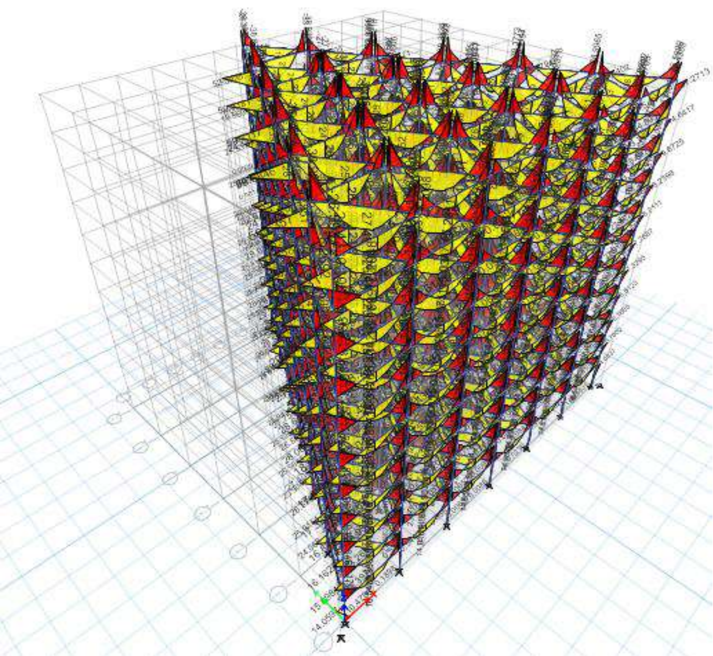


*Figure 12*

**Circular building**

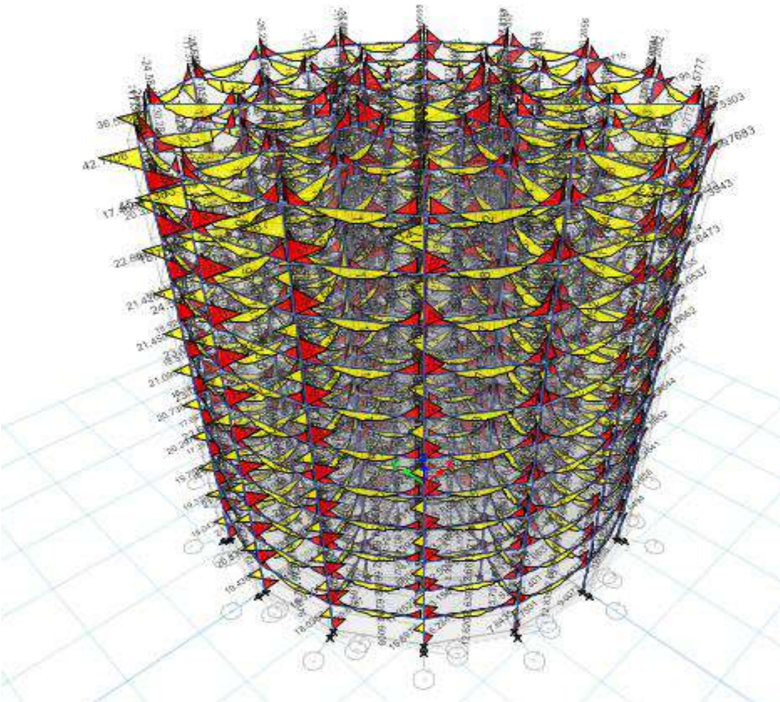


*Figure 13*

## 4.7 Cost estimation

Cost estimation is normallydone after the analysis process has been completed. During cost estimation, various factors are taken into consideration, such as resource requirements, labor costs, material costs, equipment costs, overhead expenses, and any other related expenses. This process involves estimating the quantities and costs related with each of these factors, which are then gathered to provide an overall cost estimate.

After the cost analysis, the final recommendation can be made based on the findings of the analysis. The cost analysis provides a comprehensive understanding of the financial implications associated with the construction and operation of the building.

**CHAPTER 4**

# 5 CALCULATION AND RESULT

Maximum results of parameters (Storey drift ,storey displacement, base shear, moment and shear) of building in all seismic zones of Pakistan

**<u>RECTANGUALAR,CIRCULAR,TRIANGULAR BUILDINGS</u>**

## 5.1 Base shear results (kip) (maximum values)

| BASE SHEAR(kip) RECTANGULAR BUILDING | | | | | |
|---|---|---|---|---|---|
| ANALYSIS METHODS | ZONE-1 | Zone-2A | Zone2B | Zone3 | Zone4 |
| STATIC ANALYSIS | 342.245 | 345.46 | 798.57 | 1155.54 | 1568.62 |
| RESPONSE SPECTRUM | 342.245 | 345.2 | 761.89 | 1153.05 | 1521.35 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| BASE SHEAR(kip) CIRCULAR BUILDING | | | | | |
| ANALYSIS METHODS | ZONE-1 | Zone-2A | Zone2B | Zone3 | Zone4 |
| STATIC ANALYSIS | 361.75 | 534.21 | 679.9 | 983.82 | 1335 |
| RESPONSE SPECTRUM | 361.75 | 866.63 | 1084.53 | 1950.71 | 2166.59 |
| | | | | | |
| | | | | | |
| | | | | | |
| BASE SHEAR(kip) TRIANGULAR BUILDING | | | | | |
| ANALYSIS METHODS | ZONE-1 | Zone-2A | Zone2B | Zone3 | Zone4 |
| STATIC ANALYSIS | 417.71 | 833.07 | 834.341 | 767.11 | 1041.33 |
| RESPONSE SPECTRUM | 417.71 | 506.42 | 633.53 | 1139.91 | 1266.06 |

*TABLE 4.1*

## 5.2 Storey drift (maximum values)

| STOREY DRIFT RECTANGULAR BUILDING | | | | | |
|---|---|---|---|---|---|
| ANALYSIS METHODS | ZONE-1 | Zone-2A | Zone2B | Zone3 | Zone4 |
| STATIC ANALYSIS | 0.00241 | 0.004424 | 0.0056 | 0.00724 | 0.0088 |
| RESPONSE SPECTRUM | 0.00241 | 0.004424 | 0.00563 | 0.00724 | 0.0088 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| STOREY DRIFT CIRCULAR BUILDING | | | | | |
| ANALYSIS METHODS | ZONE-1 | Zone-2A | Zone2B | Zone3 | Zone4 |
| STATIC ANALYSIS | 0.000838 | 0.00153 | 0.00195 | 0.0025 | 0.003 |
| RESPONSE SPECTRUM | 0.000838 | 0.00153 | 0.00195 | 0.0025 | 0.003 |
| | | | | | |
| | | | | | |
| | | | | | |
| STOREY DRIFT TRIANGULAR BUILDING | | | | | |
| ANALYSIS METHODS | ZONE-1 | Zone-2A | Zone2B | Zone3 | Zone4 |
| STATIC ANALYSIS | 0.00577 | 0.00577 | 0.00583 | 0.00591 | 0.00598 |
| RESPONSE SPECTRUM | 0.00577 | 0.0057 | 0.00583 | 0.00591 | 0.00598 |
| | | | | | |

*TABLE 4.2*

## 5.3 Storey displacement

| STOREY DISP.(IN) RECTANGULAR BUILDING | | | | | |
|---|---|---|---|---|---|
| ANALYSIS METHODS | ZONE-1 | Zone-2A | Zone2B | Zone3 | Zone4 |
| STATIC ANALYSIS | 2.79 | 5.118 | 6.514 | 8.37 | 10.19 |
| RESPONSE SPECTRUM | 2.79 | 5.41 | 6.514 | 8.77 | 10.19 |

| STOREY DISP.(IN) CIRCULAR BUILDING | | | | | |
|---|---|---|---|---|---|
| ANALYSIS METHODS | ZONE-1 | Zone-2A | Zone2B | Zone3 | Zone4 |
| STATIC ANALYSIS | 0.96 | 1.773 | 2.256 | 2.9 | 3.53 |
| RESPONSE SPECTRUM | 0.96 | 1.77 | 2.256 | 2.9 | 3.53 |

| STOREY DISP.(IN) TRIANGULAR BUILDING | | | | | |
|---|---|---|---|---|---|
| ANALYSIS METHODS | ZONE-1 | Zone-2A | Zone2B | Zone3 | Zone4 |
| STATIC ANALYSIS | 6.692 | 6.69 | 6.78 | 6.81 | 6.89 |
| RESPONSE SPECTRUM | 6.692 | 6.692 | 6.78 | 6.81 | 6.89 |

*TABLE 4.3*

5.4 **Shear (kip) (maximum values)**

| SHEAR(kip) RECTANGULAR BUILDING | | | | | |
|---|---|---|---|---|---|
| ANALYSIS METHODS | ZONE-1 | Zone-2A | Zone2B | Zone3 | Zone4 |
| STATIC ANALYSIS | 11.433 | 15.57 | 12.16 | 14.82 | 7.83 |
| RESPONSE SPECTRUM | 11.433 | 25.57 | 34.194 | 39.09 | 40.59 |

| SHEAR(kip) CIRCULAR BUILDING | | | | | |
|---|---|---|---|---|---|
| ANALYSIS METHODS | ZONE-1 | Zone-2A | Zone2B | Zone3 | Zone4 |
| STATIC ANALYSIS | 8.873 | 7.359 | 7.746 | 8.26 | 25.772 |
| RESPONSE SPECTRUM | 8.873 | 8.93 | 11.712 | 13.42 | 28.15 |

| SHEAR(kip) TRIANGULAR BUILDING | | | | | |
|---|---|---|---|---|---|
| ANALYSIS METHODS | ZONE-1 | Zone-2A | Zone2B | Zone3 | Zone4 |
| STATIC ANALYSIS | 12.03 | 14.946 | 15.342 | 17.28 | 19.805 |
| RESPONSE SPECTRUM | 12.03 | 14.559 | 16.476 | 19.66 | 21.65 |

*TABLE 4.4*

5.5 **Moment(kip-ft) (maximum values)**

| MOMENT(kip-ft) RECTANGULAR BUILDING | | | | | |
|---|---|---|---|---|---|
| ANALYSIS METHODS | ZONE-1 | Zone-2A | Zone2B | Zone3 | Zone4 |
| STATIC ANALYSIS | 47.24 | 71.89 | 65.16 | 78.25 | 27.709 |
| RESPONSE SPECTRUM | 47.24 | 62.81 | 196.41 | 220.26 | 222.5 |

| MOMENT(kip-ft) CIRCULAR BUILDING | | | | | |
|---|---|---|---|---|---|
| ANALYSIS METHODS | ZONE-1 | Zone-2A | Zone2B | Zone3 | Zone4 |
| STATIC ANALYSIS | 21.478 | 24.23 | 27.29 | 28.56 | 47.911 |
| RESPONSE SPECTRUM | 21.478 | 31.99 | 42.83 | 44.13 | 47.44 |

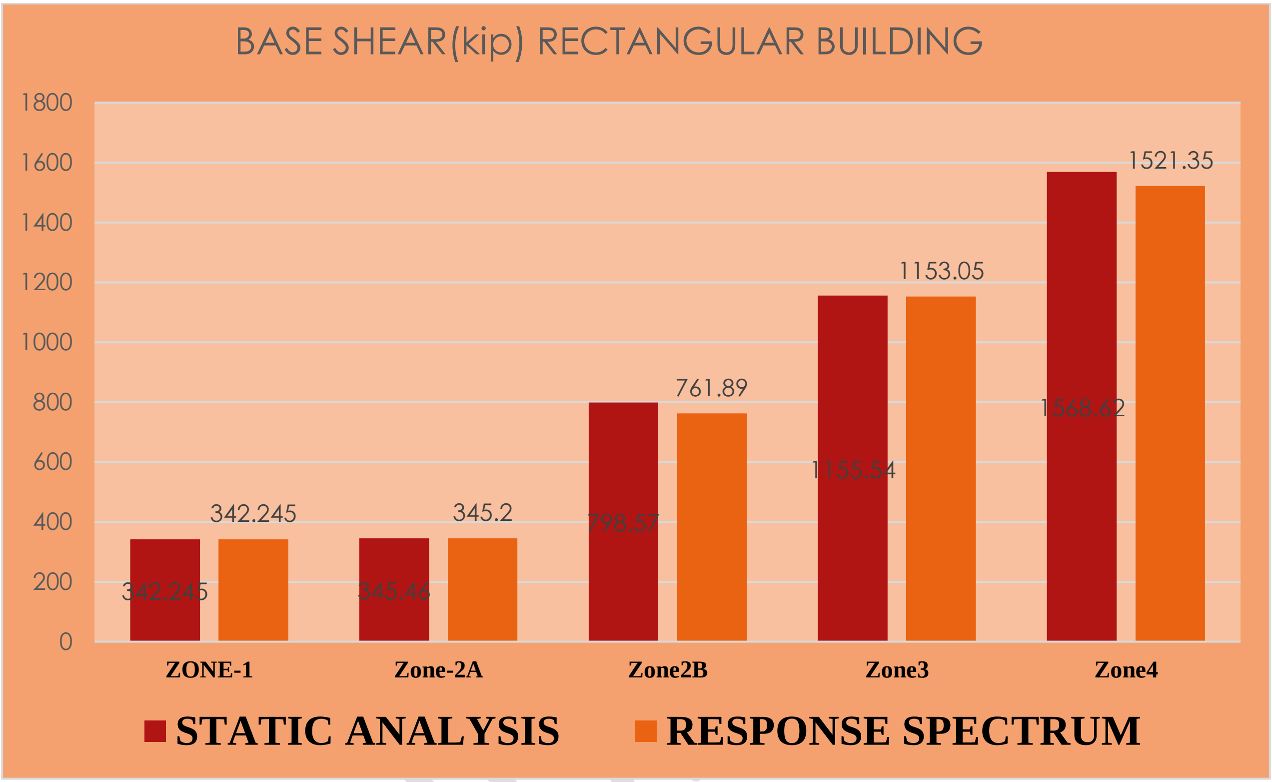
| MOMENT(kip-ft) TRIANGULAR BUILDING | | | | | |
|---|---|---|---|---|---|
| ANALYSIS METHODS | ZONE-1 | Zone-2A | Zone2B | Zone3 | Zone4 |
| STATIC ANALYSIS | 49.28 | 54.015 | 92.9 | 50.21 | 59.54 |
| RESPONSE SPECTRUM | 49.28 | 67.93 | 61.58 | 96.12 | 96.797 |

*TABLE 4.5*

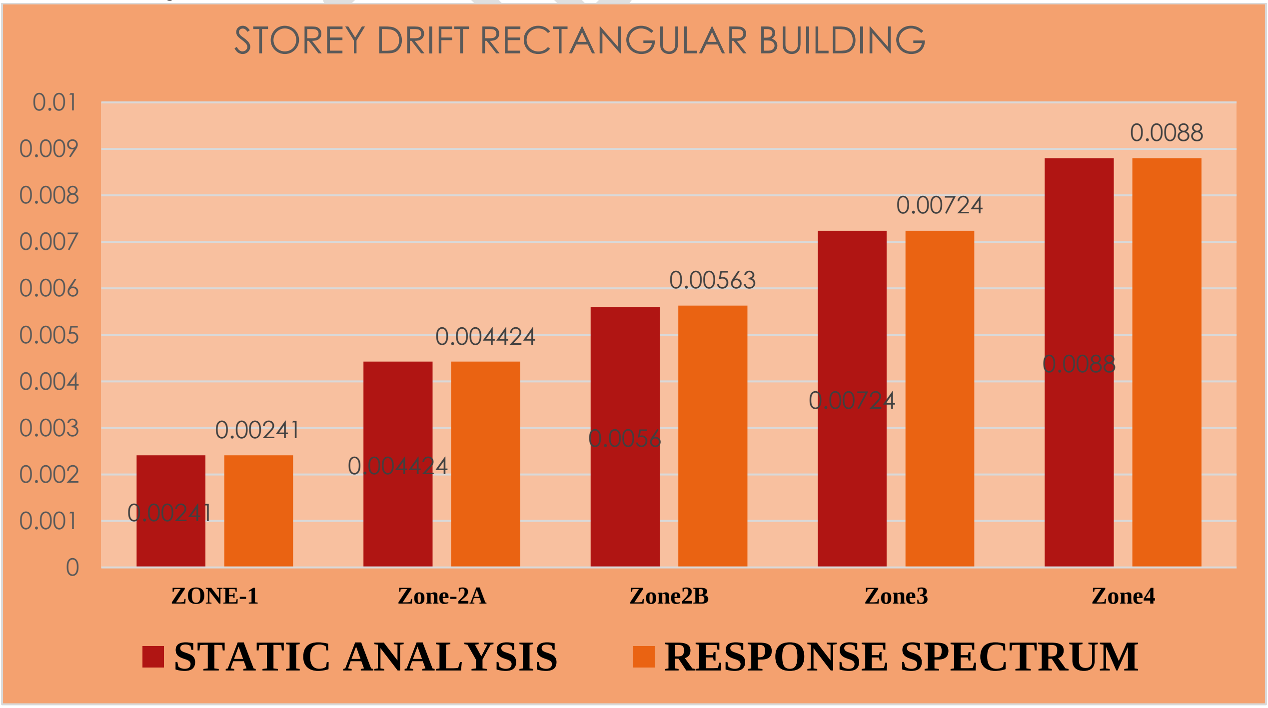
## 5.6 GRAPHICAL REPRESENTATION OF RESULTS

**RECTANGULAR BUILDING**

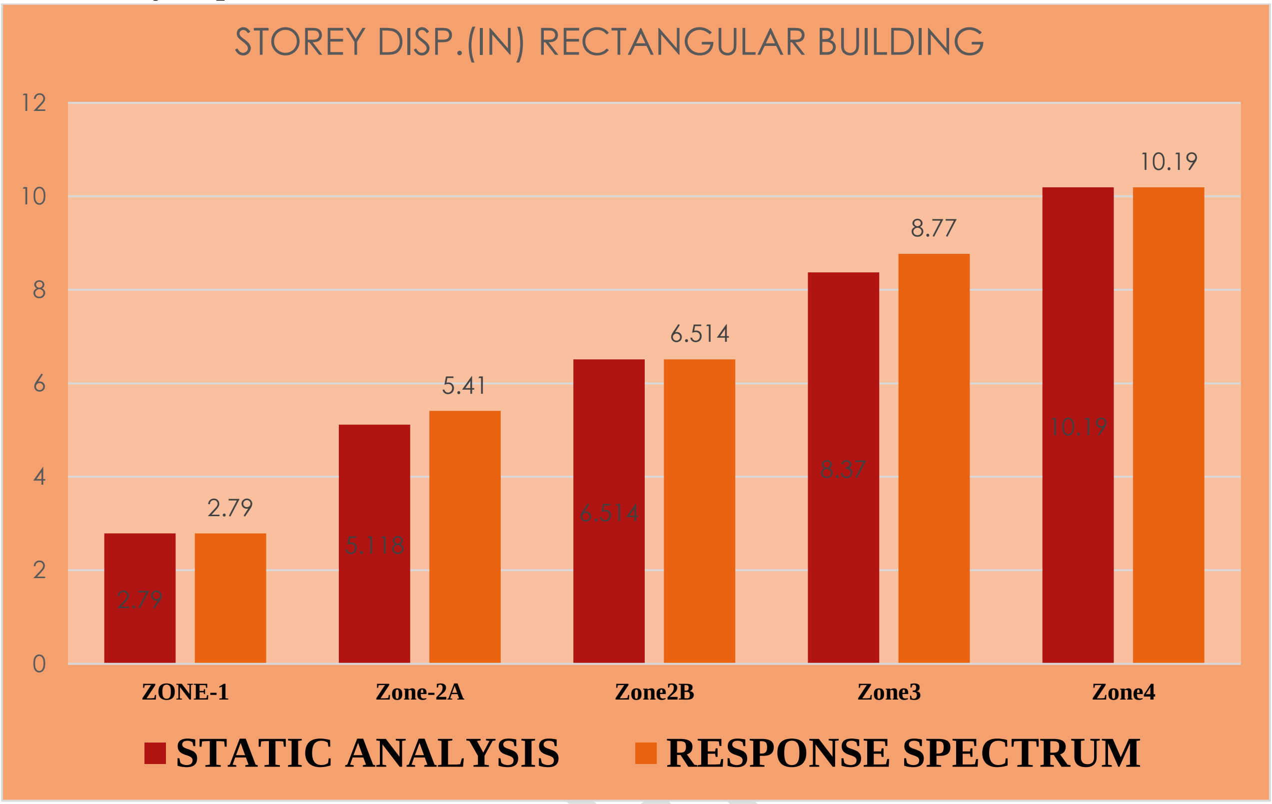
### 5.6.1 Base shear



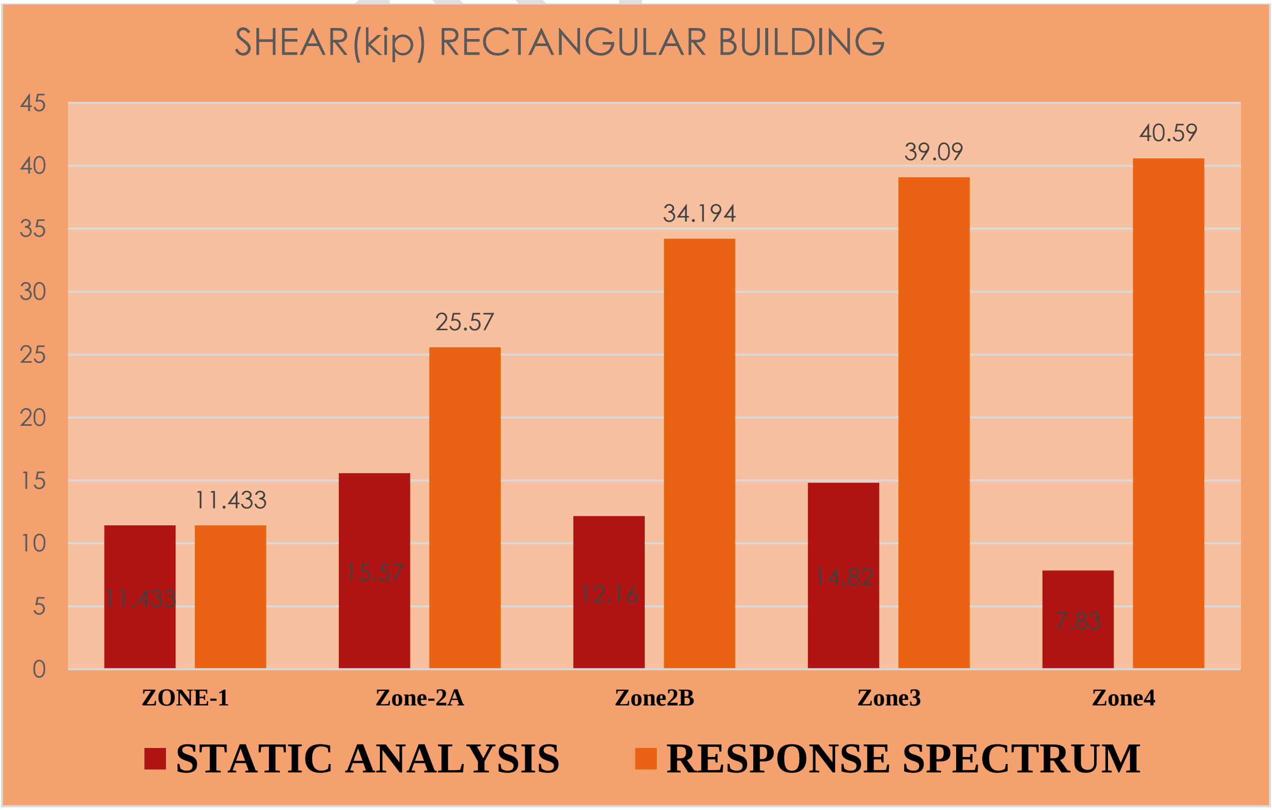

### 5.6.2 Storey drift



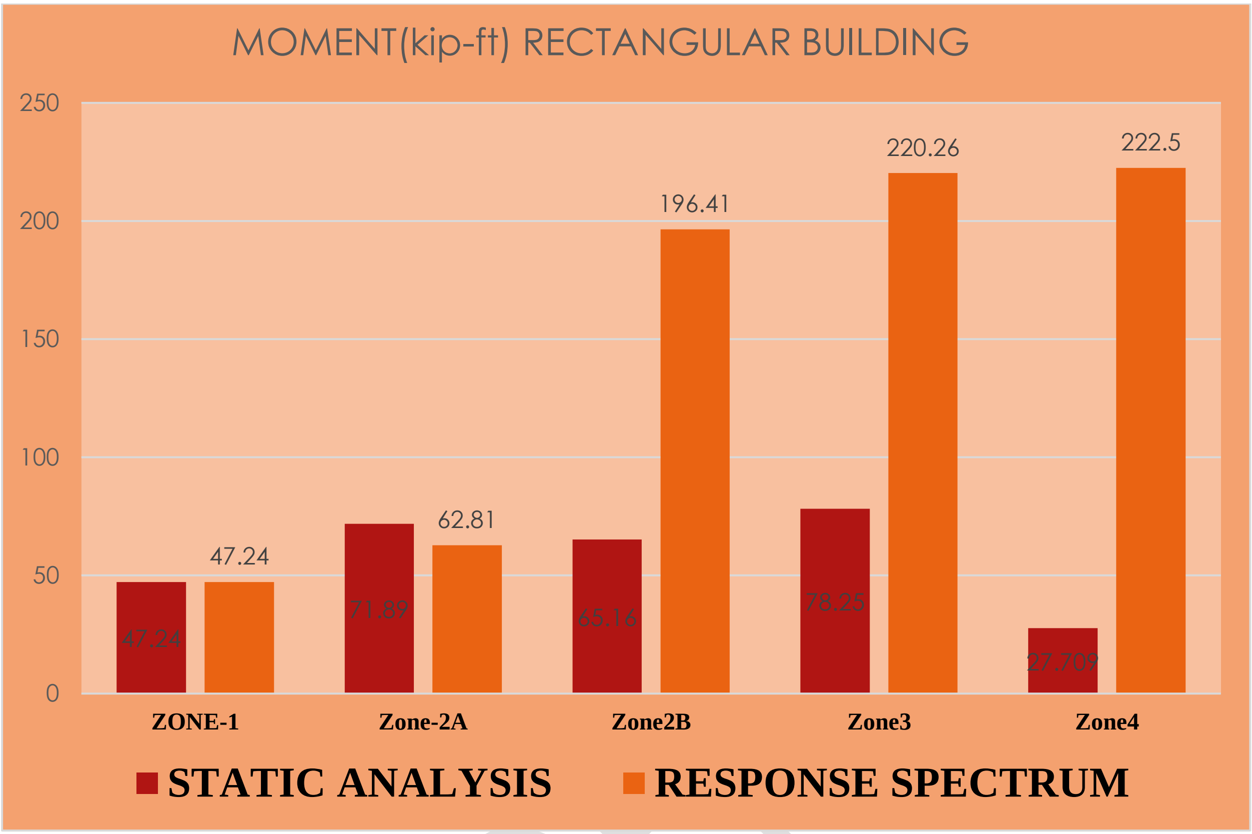
5.6.3 **Story displacement**




**5.6.4 Shear**



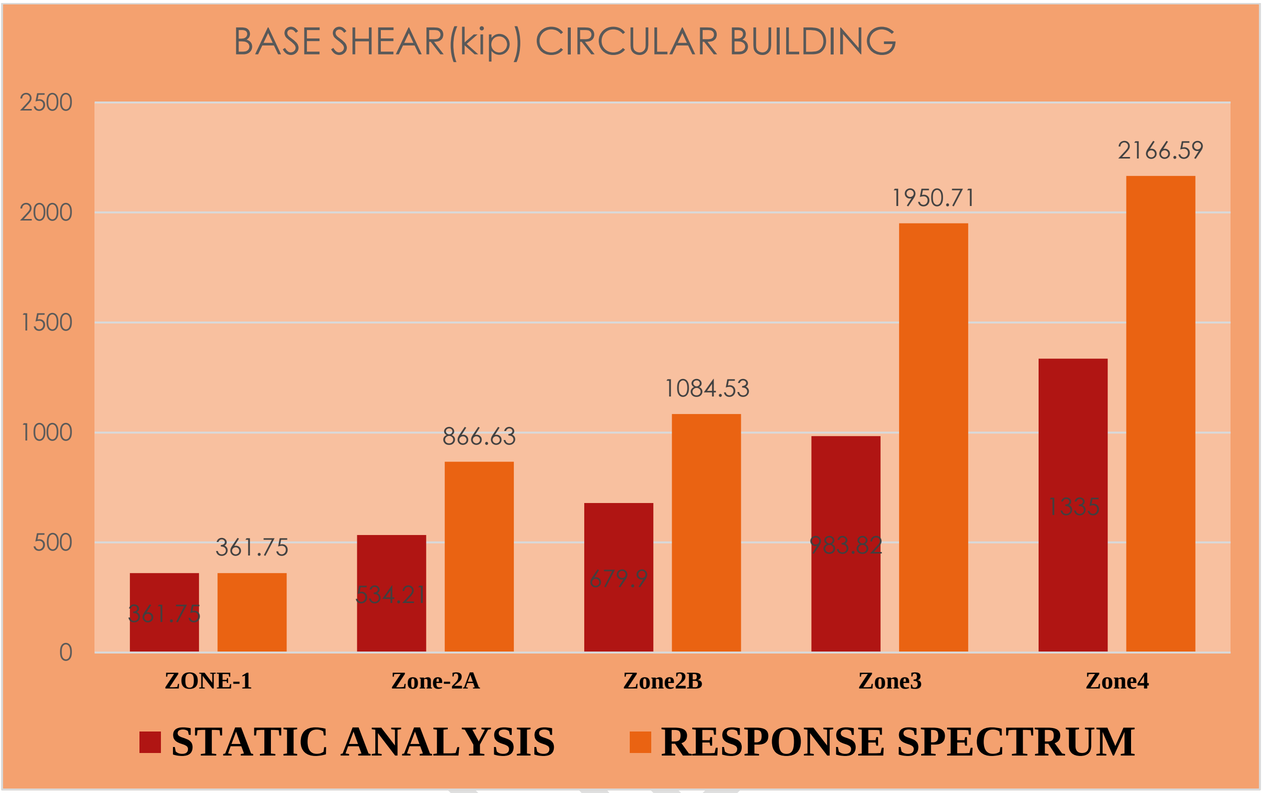
### 5.6.5 Moment



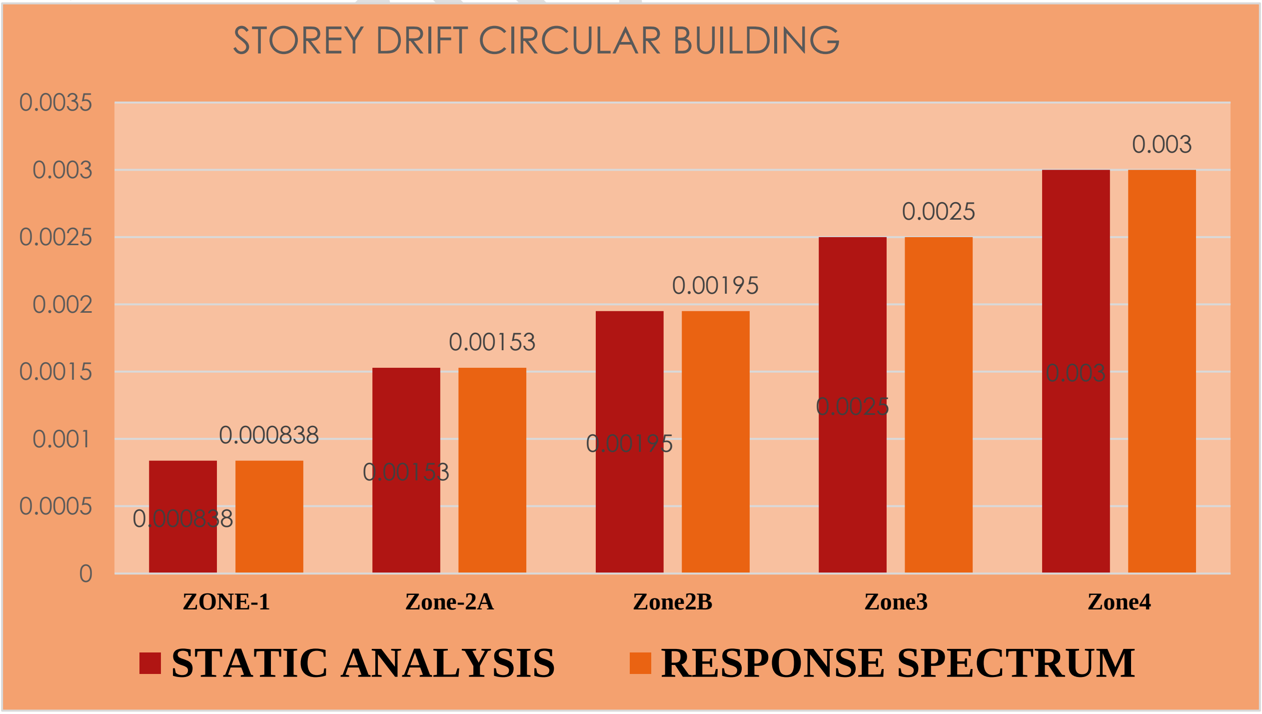
MOMENT(kip-ft) RECTANGULAR BUILDING
250
200
150
100
50
0
47.24
47.24
71.89
62.81
65.16
196.41
78.25
220.26
27.709
222.5
ZONE-1
Zone-2A
Zone2B
Zone3
Zone4
STATIC ANALYSIS
RESPONSE SPECTRUM

## CIRCULAR BUILDING

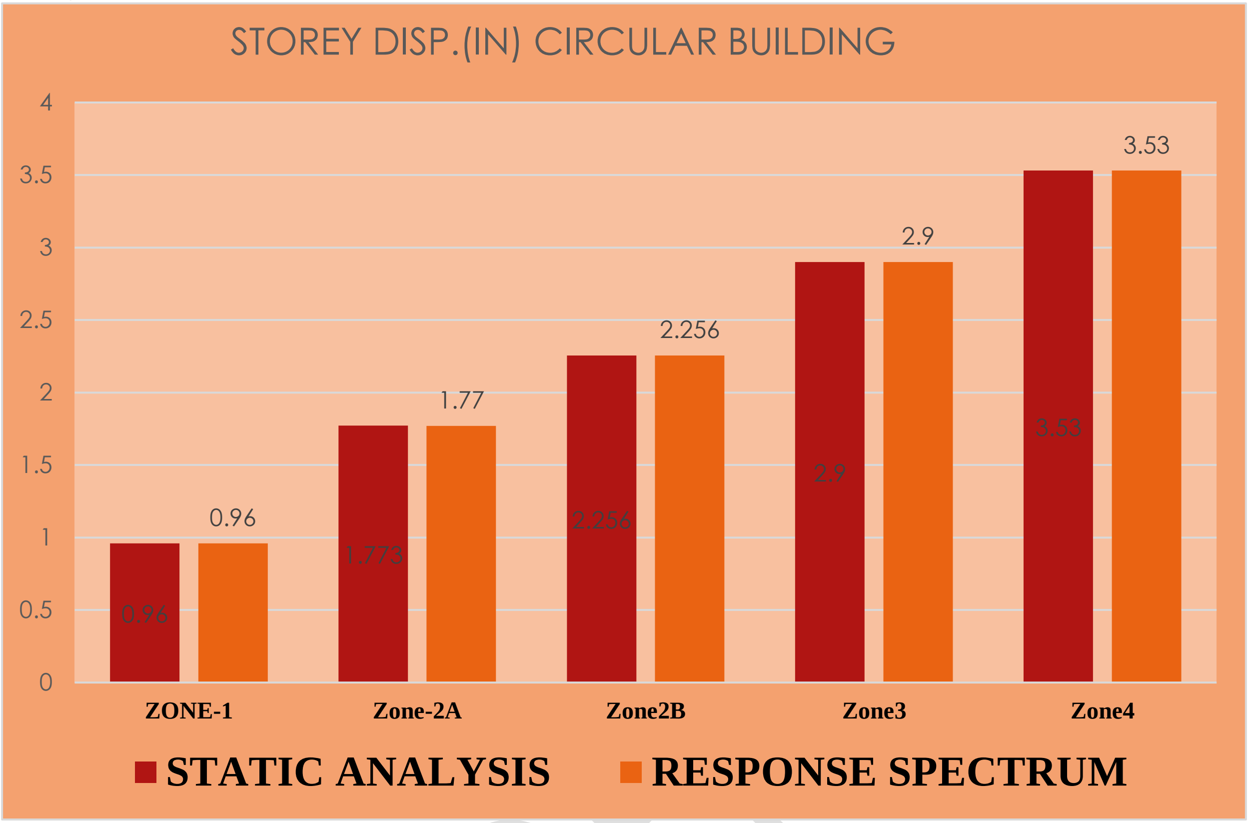
### Base shear



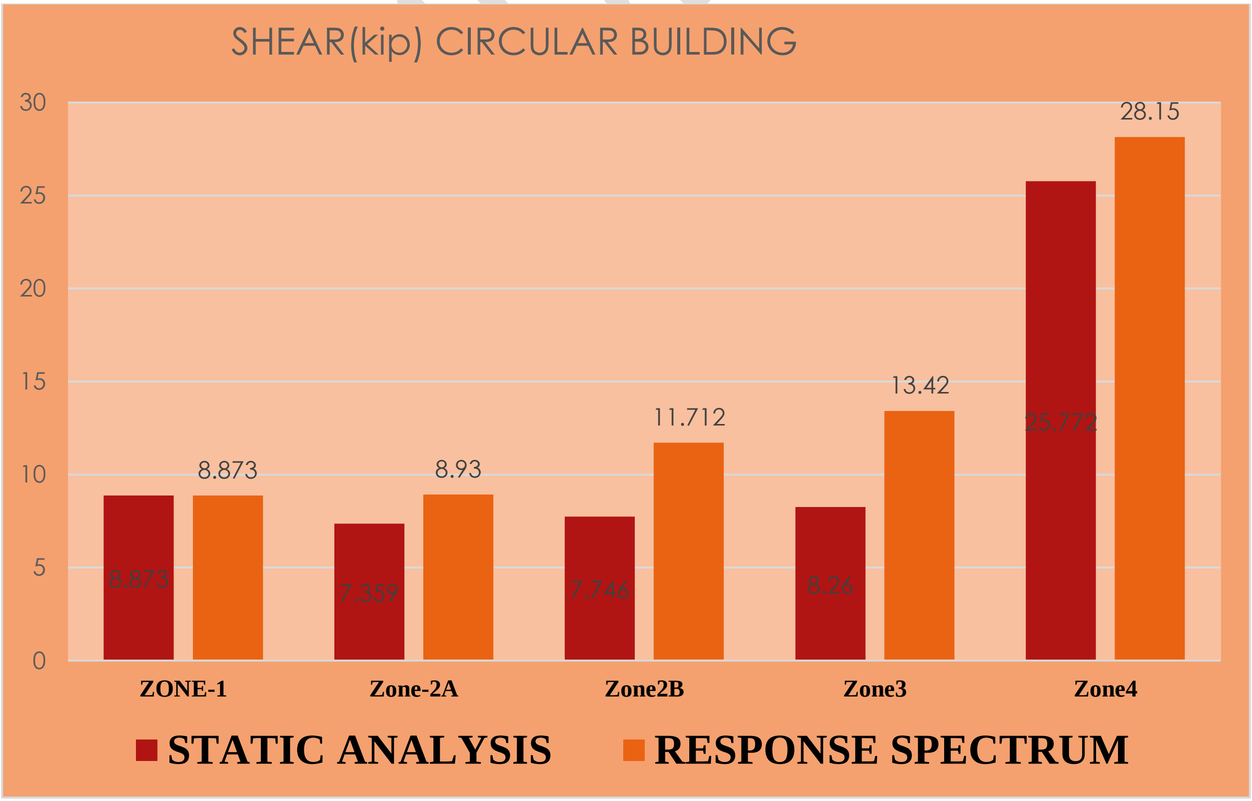

### Story drift



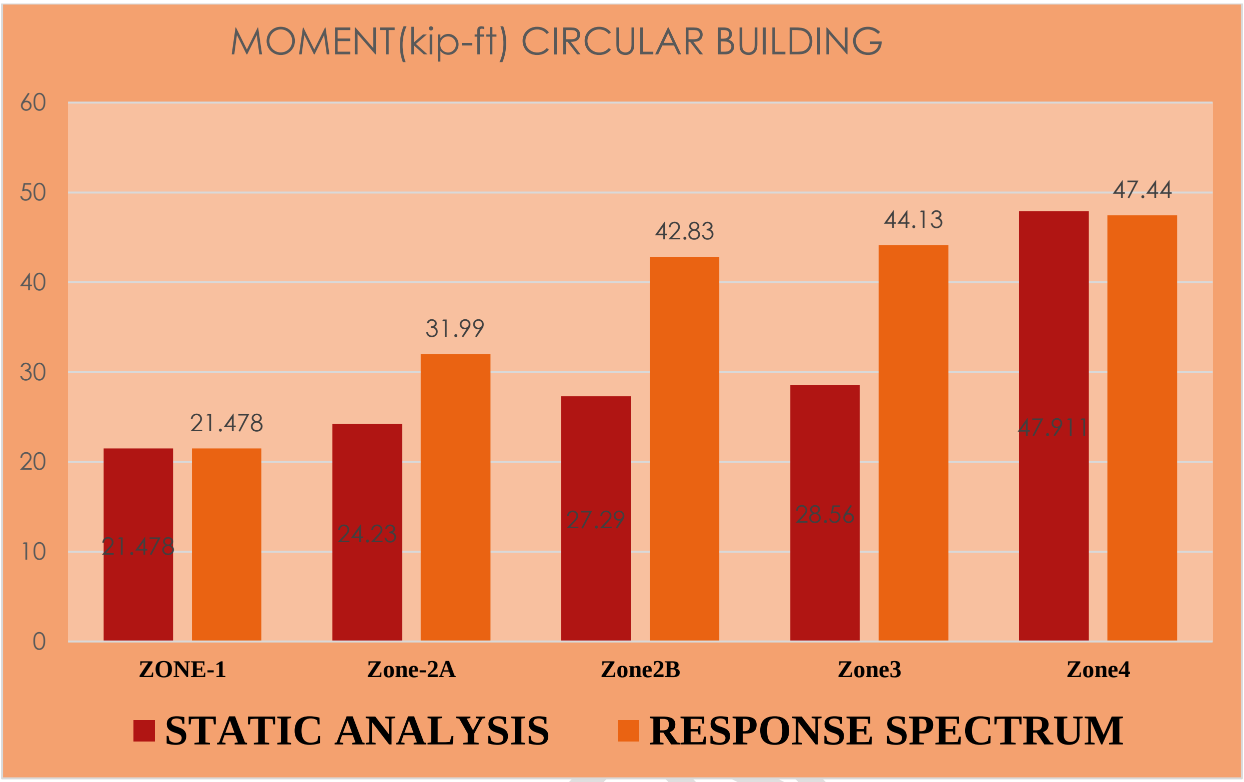
**Story displacement**




**Shear**



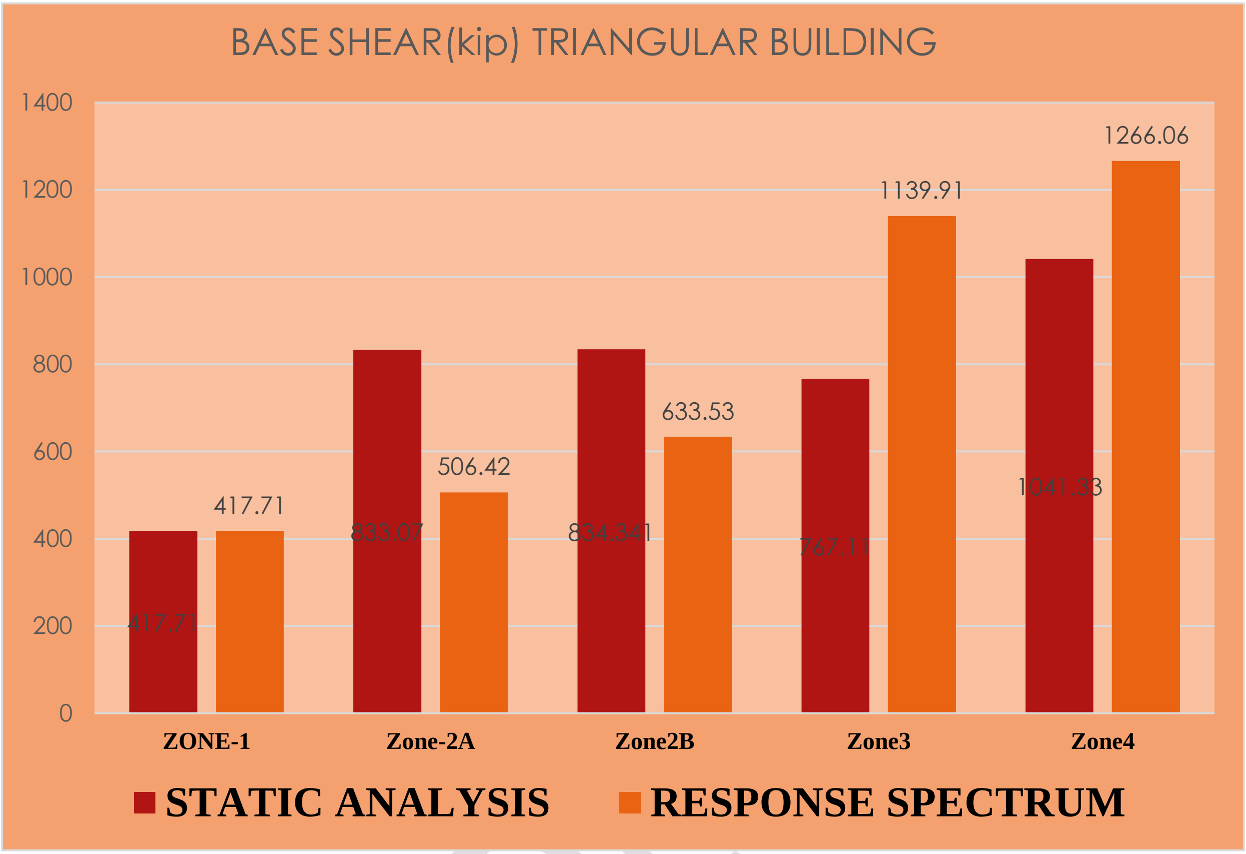

**Moment**



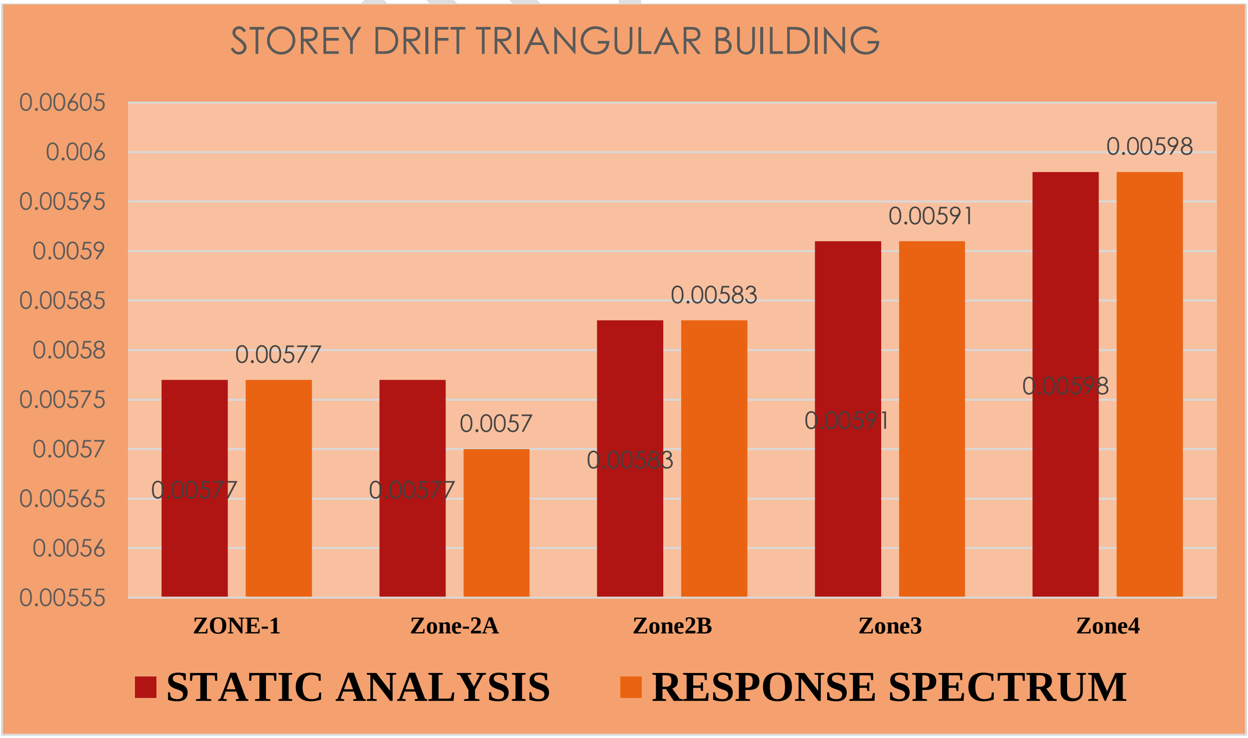



**TRIANGUALR BUILDING**

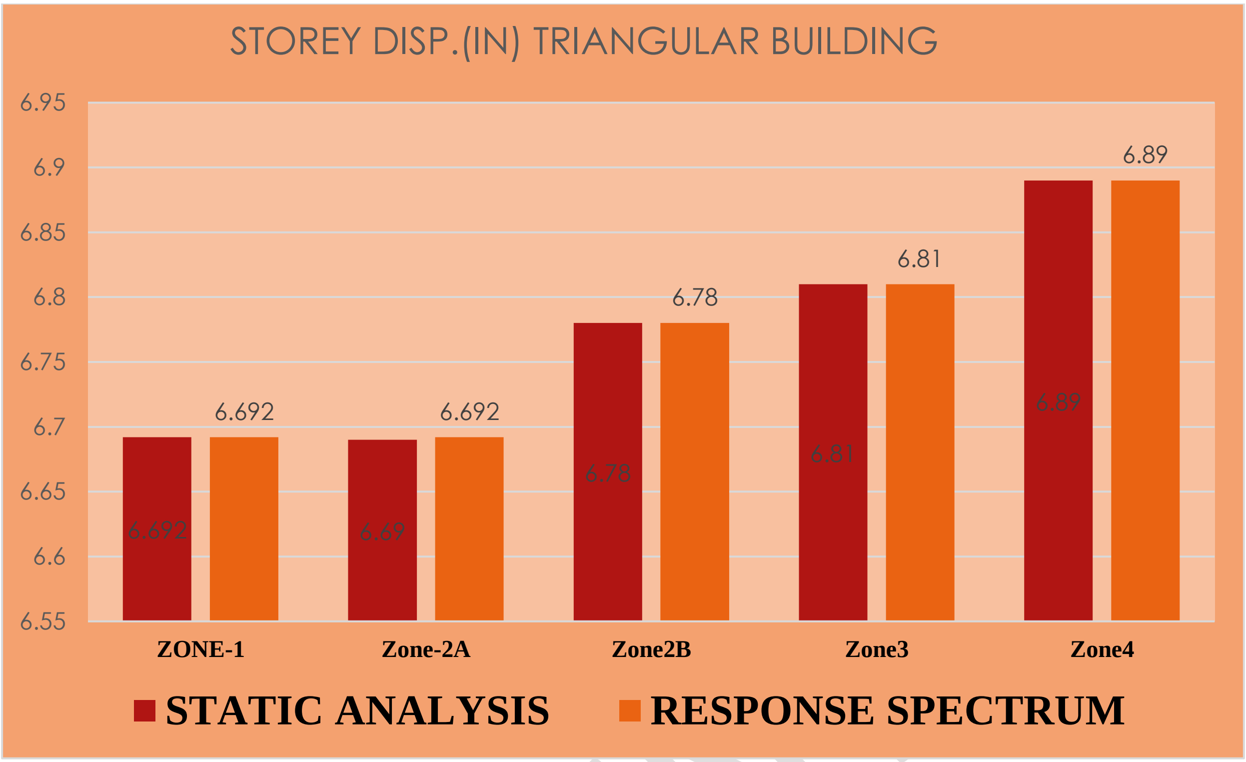
**Base shear**



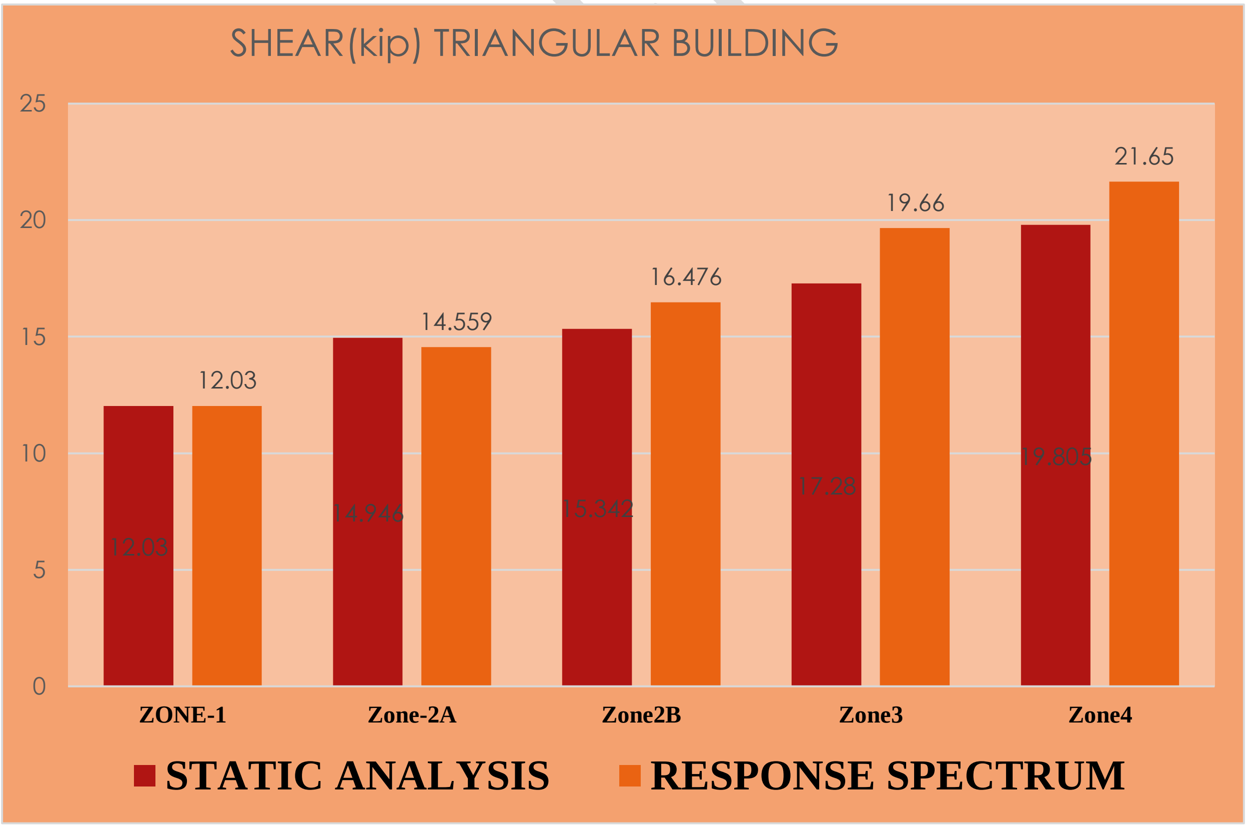

**Storey drift**



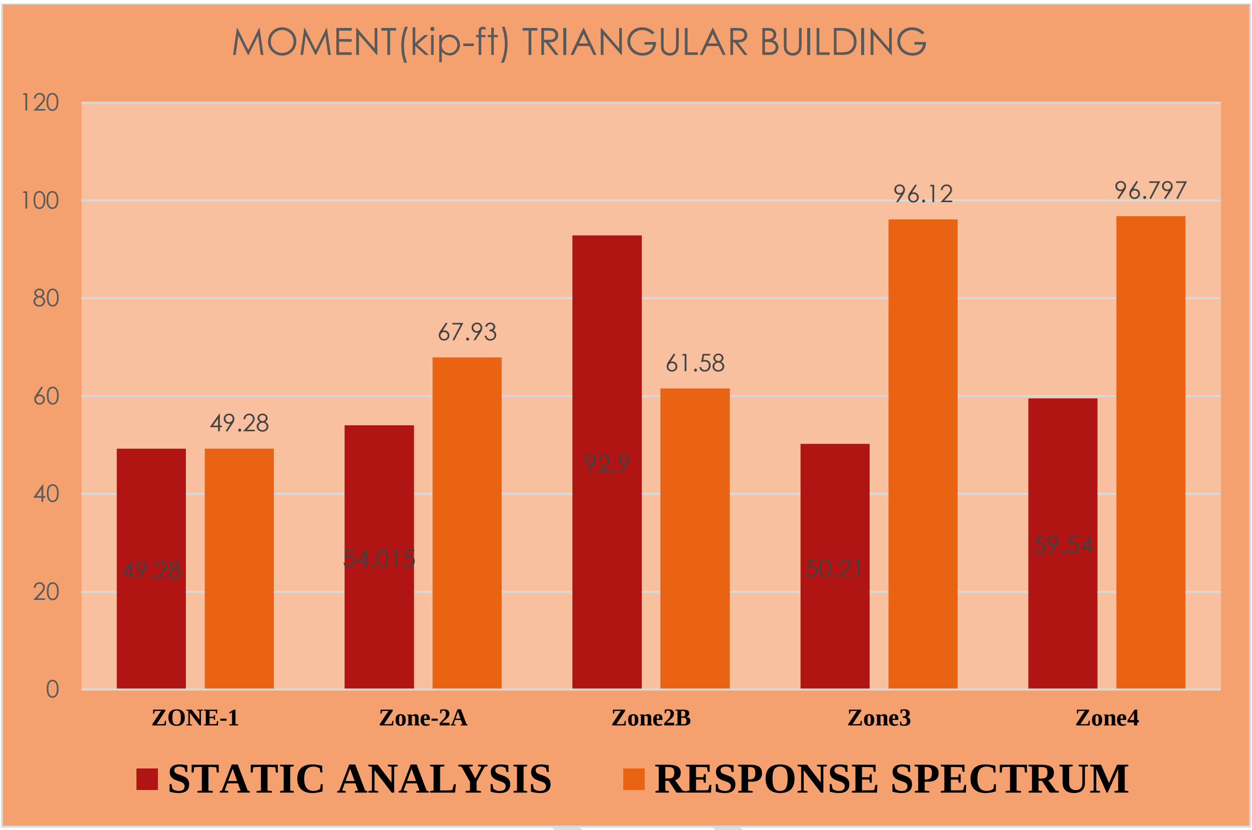

**Story displacement**




**Shear**




**Moment**


MOMENT(kip-ft) TRIANGULAR BUILDING
120
100
80
60
40
20
0
49.28
49.28
54.015
67.93
92.9
61.58
50.21
96.12
59.54
96.797
ZONE-1
Zone-2A
Zone2B
Zone3
Zone4
STATIC ANALYSIS
RESPONSE SPECTRUM

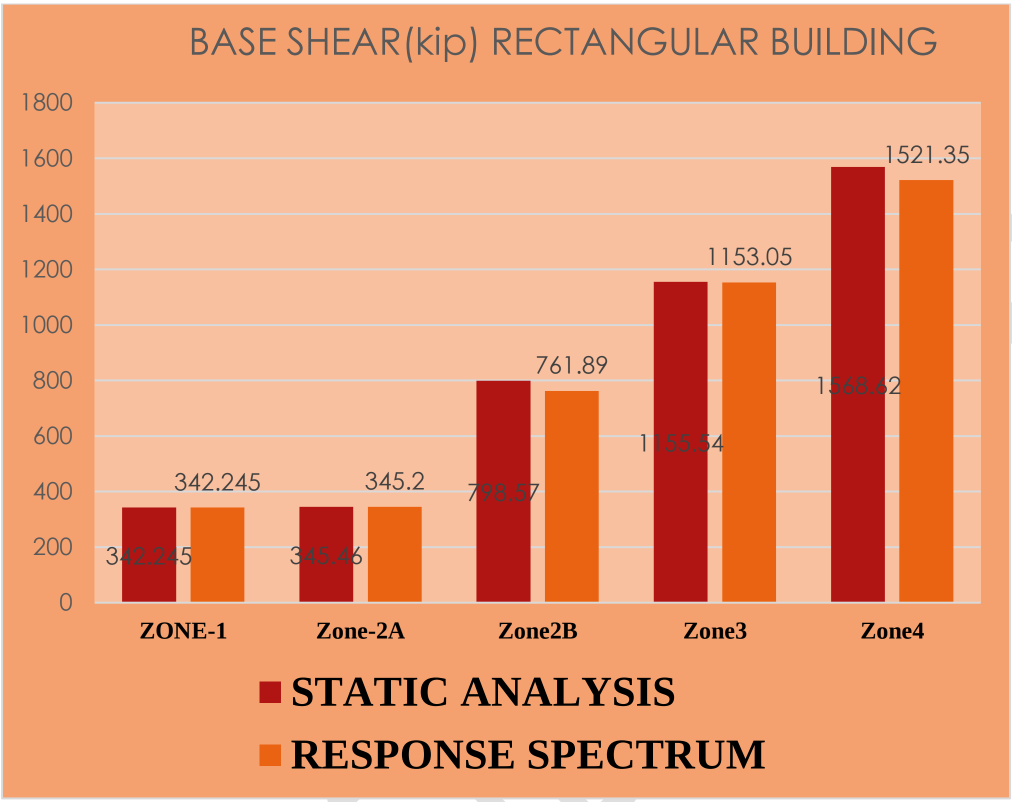


## CHAPTER 5

# 6 ANALYSIS OF RESULT

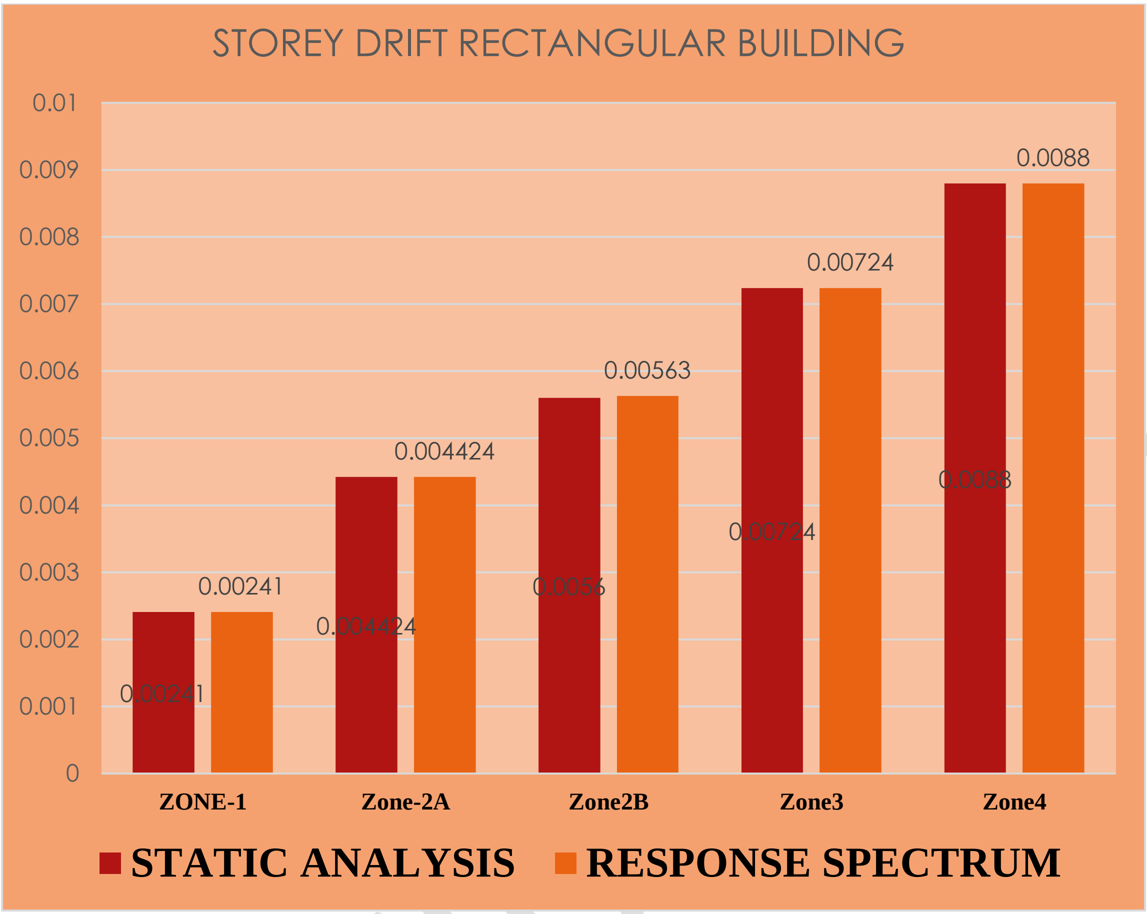
## 6.1 RECTANGULAR BUILDING

**BASE SHEAR**



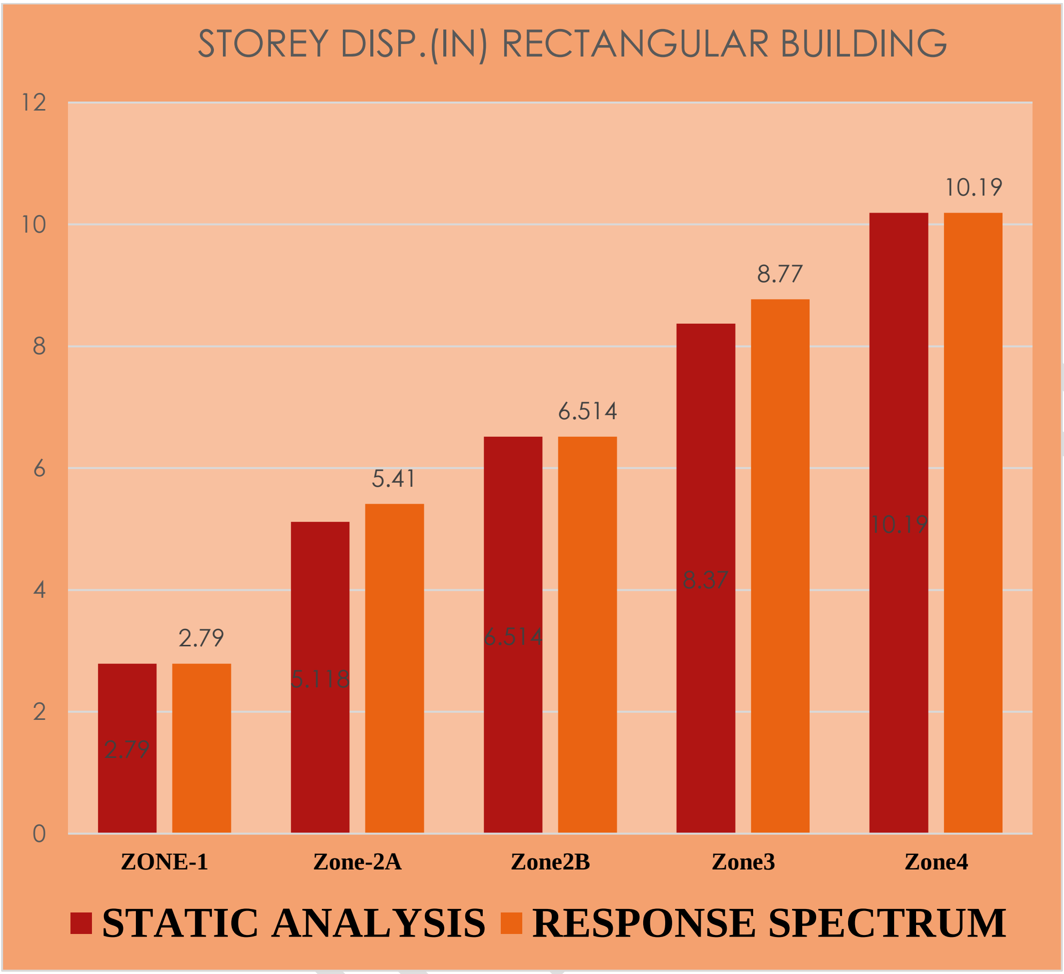

In this graph base shear value is increasing according zone severity i-e (Z1=0.075 < Z2A = 0.15< Z2B = 0.2<Z3= 0.3<Z4 = 0.4) m/s2 that is according to zone severity and is correct but the results are same in Z1 and Z2 why because we know RSA and ESA are different in their approach, they can produce similar results when the structure behaves linearly elastically under seismic loads but Z2B ,Z3 and Z4 static results are greater then RSA because the response spectrum method is an approximate analysis technique and its accuracy may vary depending on the specific characteristics of the ground motion and the structure being analyzed .It is possible that for certain scenarios ,response spectrum method may not capture all the nuances of the structural response accurately.

**STORY DRIFT**



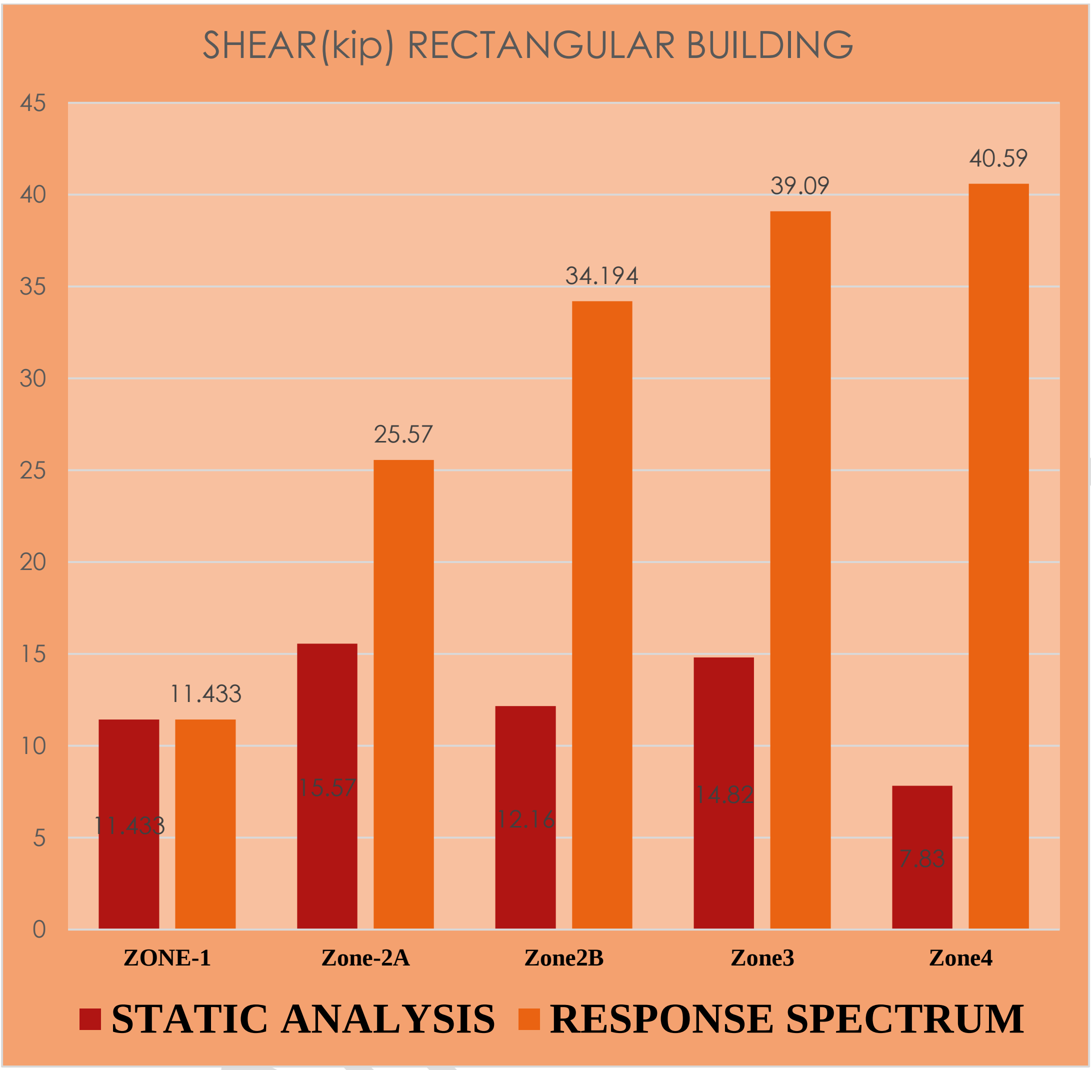

In this graph story drift is increasing w.r.t zones in sequence because severity is increasing (Z1<Z2A<Z2B<Z3<Z4) and results are same form both methods because they can produce similar results when the structure behaves linearly elastically under seismic loads, the structure predominantly responds in a single mode of vibration due to which results of RSA and ESA come closer.

**STORY DISPLACEMET**



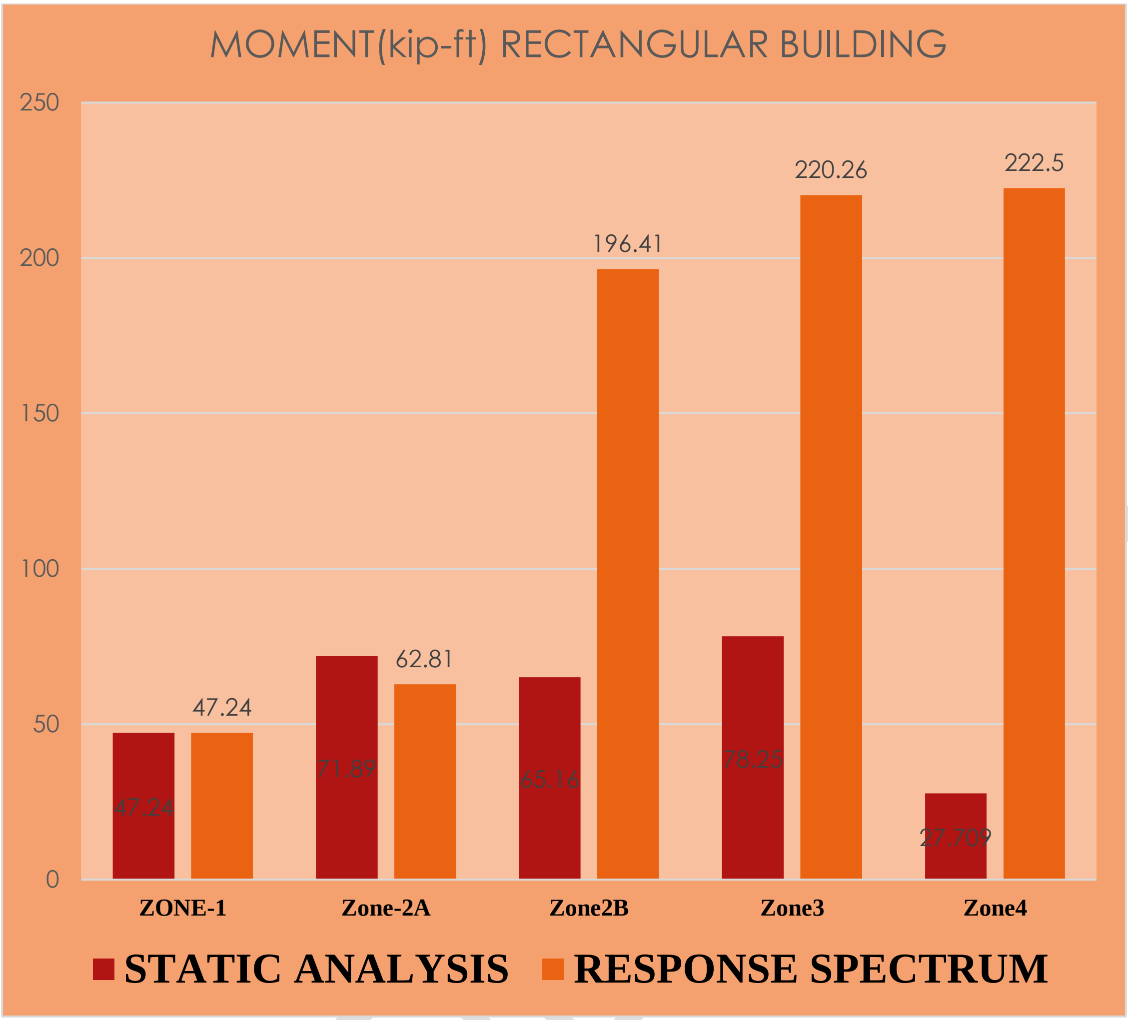

Again the values of storey drift is increasing according to zone severity which is reasonable. And the values from both analysis methods are same because they can produce similar results when the structure behaves linearly elastically under seismic loads, the structure predominantly responds in a single mode of vibration due to which results of RSA and ESA come closer.

**SHEAR**




In this graph values are also increasing according to this sequence (Z1<ZA<Z2B<Z4<Z3) here all zones values are according to sequence and that is reasonable,but RSA values are greater then static the reason is that because response spectrum analysis is a dynamic analysis that takes into account the dynamic characteristics of the structure and the input ground motion while static doesnot consider dynamic response

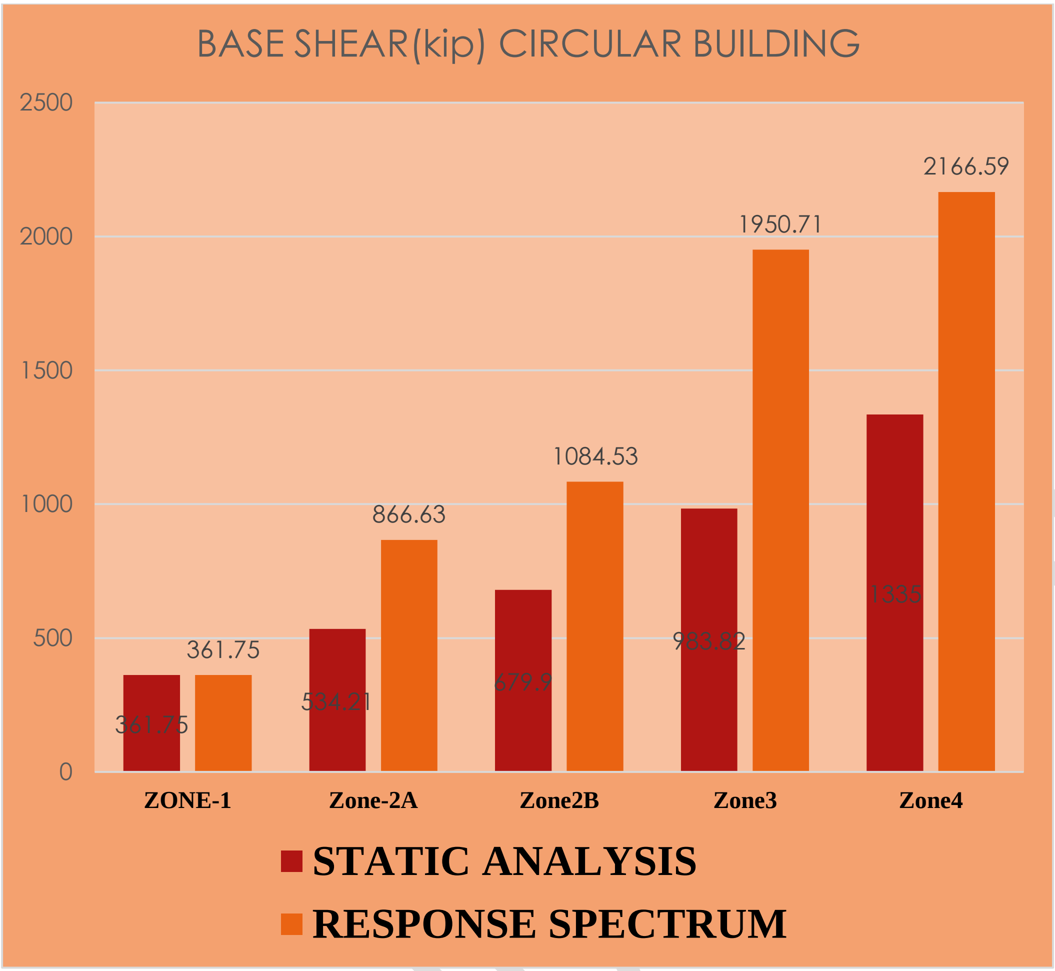
**MOMENT**




According to UBC97 zone 4= 0.4m/s2 severity of earthquake acceleration is more then zone3= 0.3 m/s2 similarly all the zones sequence(Z1<Z2<Z3<Z4) so the results are according to UBC97 define accelerations and are correct.But here static analysis gave safer result compare to RSA because static analysis is a simplified approach it doesnot consider the dynamic characteristics of the earthquake.so mostly static analysis results less then RSA, but in zone 1results from both methods are same because they can produce similar results when the structure behaves linearly elastically under seismic loads, the structure predominantly responds in a single mode of vibration due to which results of RSA and ESA come closer.

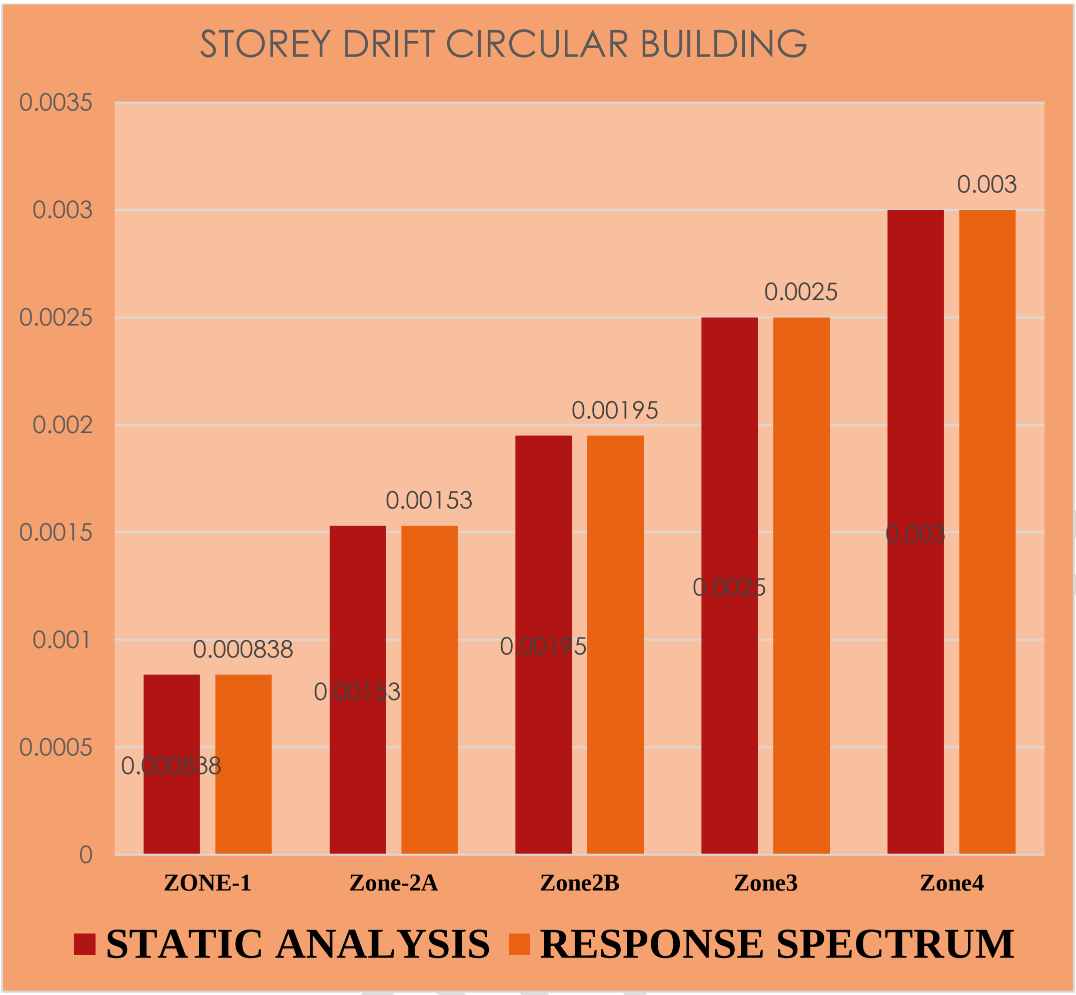
## 6.2 CIRCULAR BUILDING

### BASE SHEAR



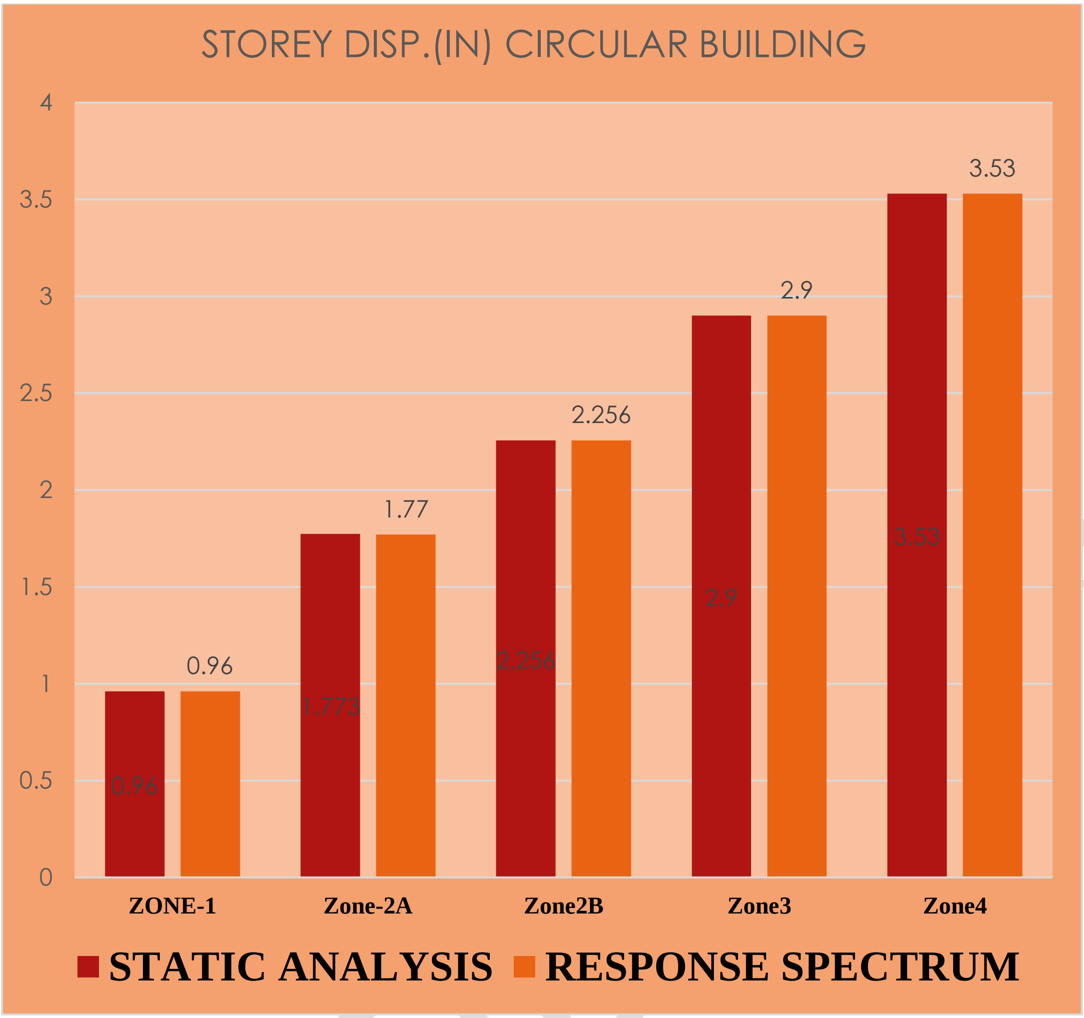

In graph the results are according to zone severity but static analysis give safer result then RSA because response spectrum analysis is a dynamic analysis that takes into account the dynamic characteristics of the structure and the input ground motion while static doesnot consider dynamic response ,but in zone 1 both analysis methods give same results because they can produce similar results when the structure behaves linearly elastically under seismic loads, the structure predominantly responds in a single mode of vibration due to which results of RSA and ESA come closer.

**STORY DRIFT**



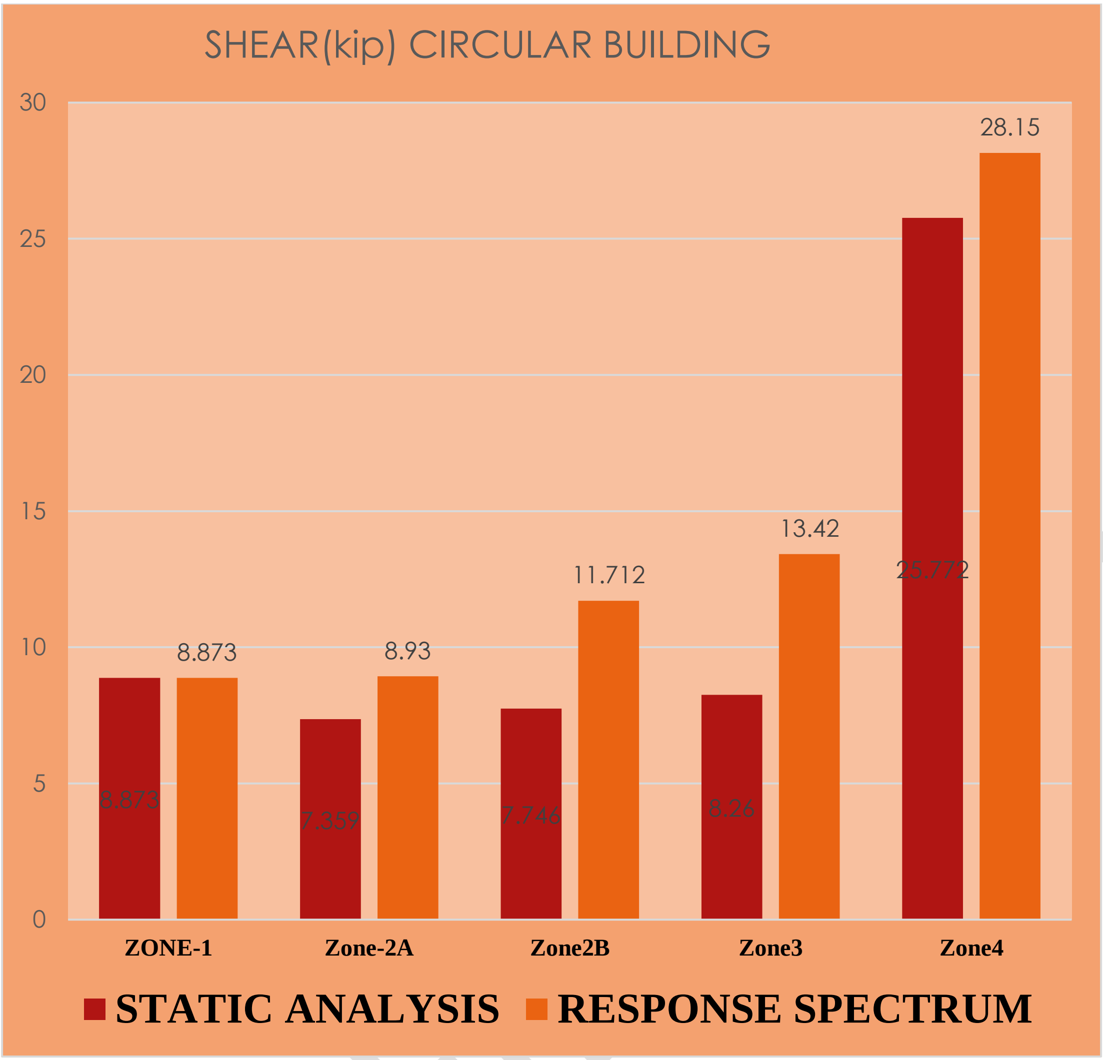

Results are according to zone earthquake acceleration and here results from both methods are same, RSA and ESA are different in their approach, they can produce similar results when the structure behaves linearly elastically under seismic loads.

**STOREY DISPLACEMENT**



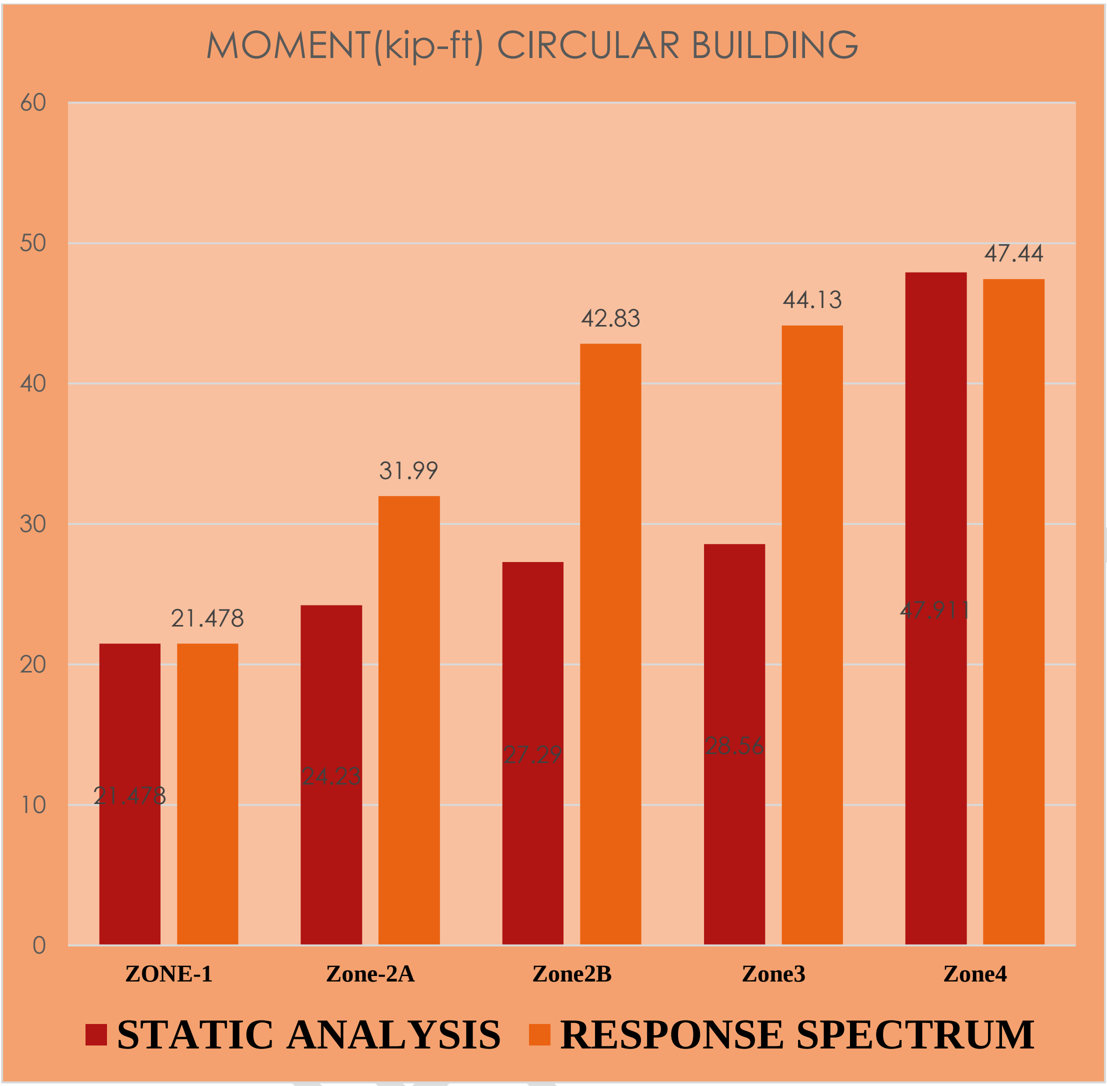

In this graph results are according to the severity of seismic zones but again the results are same from both the methods, they can produce similar results when the structure behaves linearly elastically under seismic loads and the structure predominantly responds in a single mode of vibration sue to which results of RSA and ESA come closer.

**SHEAR**




The results are according to the increase in earthquake acceleration but Static results are on safer side more then RSA because response spectrum analysis is a dynamic analysis that takes into account the dynamic characteristics of the structure and the input ground motion while static doesnot consider dynamic response and because RSA accounts for the interaction btw different modes of vibration in the structure. It consider multiple modes and their contributions to the overall response. This can lead to additional force demands that are not captured by ESA.

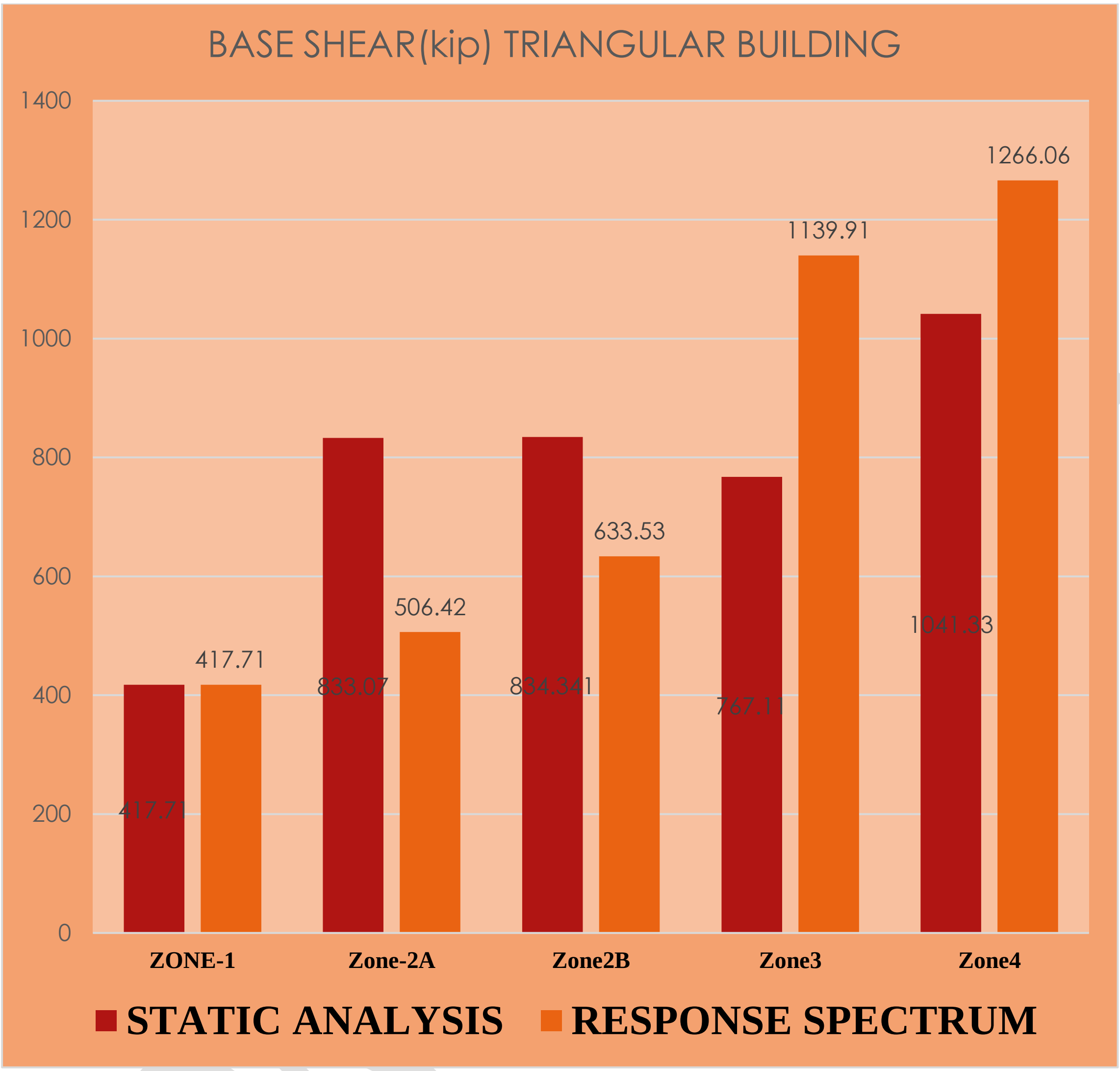
**MOMENT**




In this graph results increases when earthquake acceleration increases which is reasonable but static analysis gave safer results then RSA because response spectrum analysis is a dynamic analysis that takes into account the dynamic characteristics of the structure and the input ground motion while static doesnot consider dynamic response. But for complex structure RSA results is more significant then ESA because it covers wide range characteristics of building under seismic loadings, but in z1 and z4 both analysis methods give same results because they can produce similar results when the structure behaves linearly elastically under seismic loads, the structure predominantly responds in a single mode of vibration due to which results of RSA and ESA come closer.

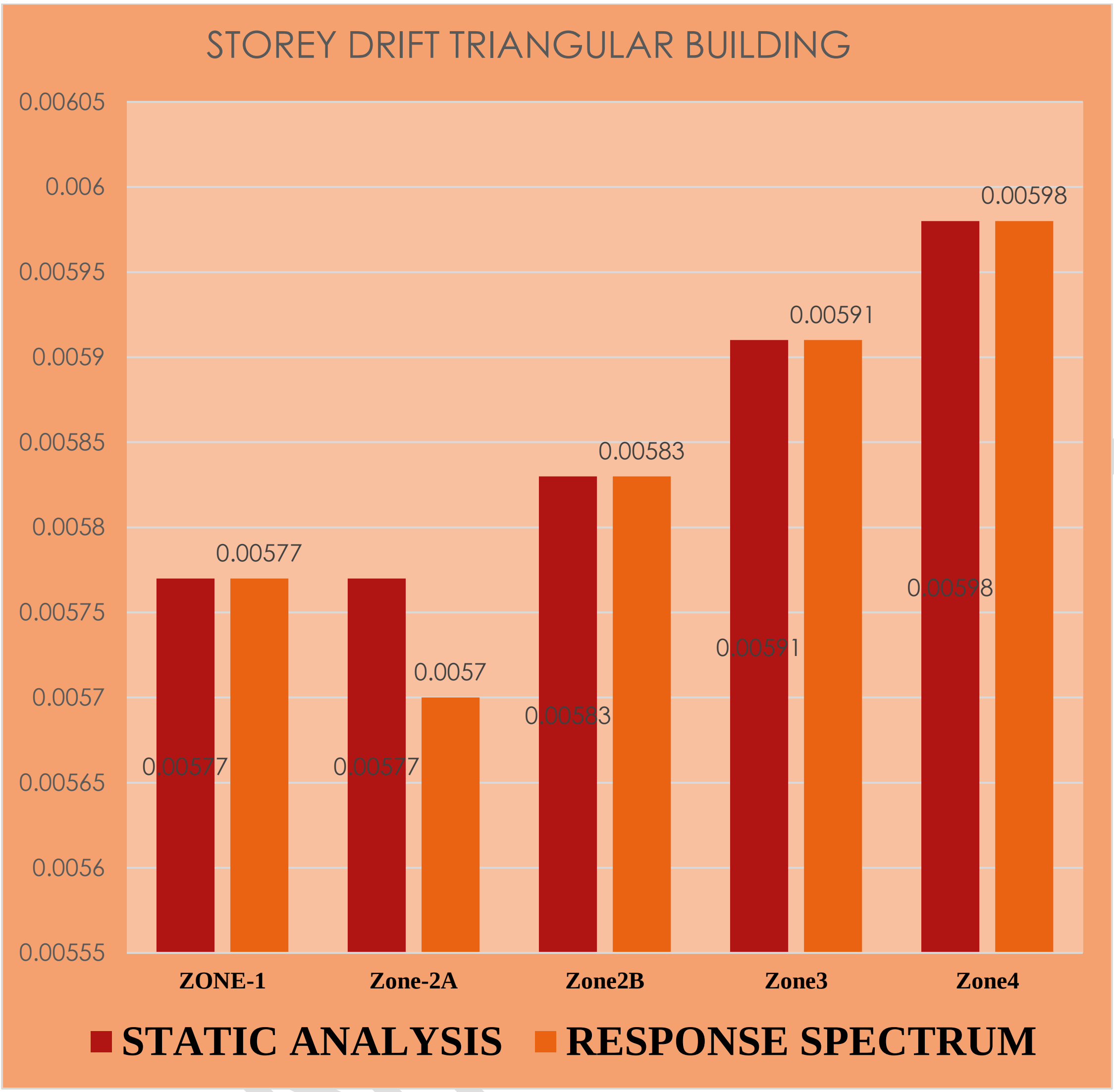
## 6.3 TRIANGULAR BUILDING

**BASE SHEAR**



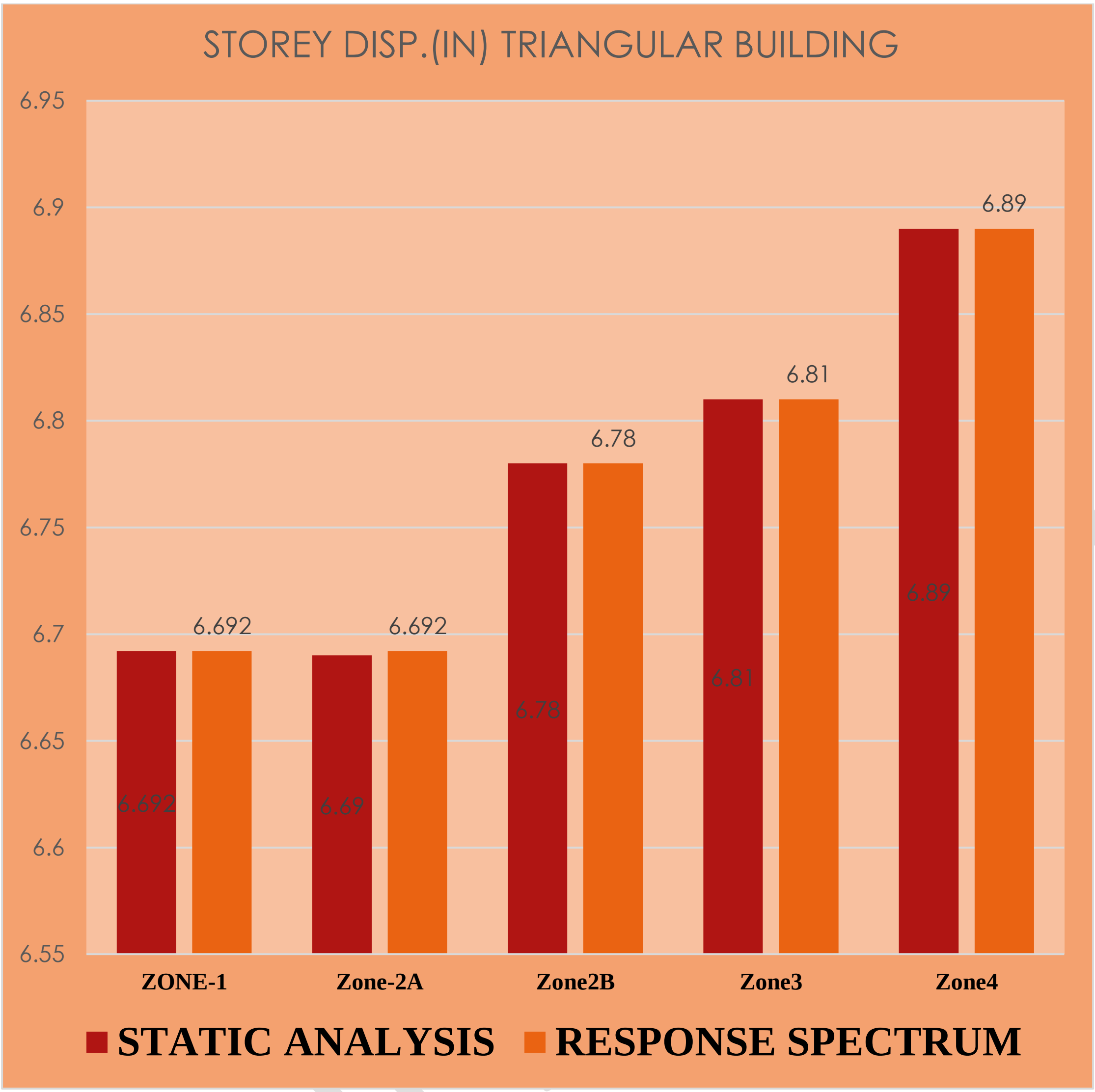

In this graph values increasing according to zone severity and is correct but in z1 values are same because , RSA and ESA are different in their approach, but they can produce similar results when the structure behaves linearly elastically under seismic loads.in zone 2A,2B static results are greater because the response spectrum method is an approximate analysis technique and its accuracy may vary depending on the specific characteristics of the ground motion and the structure being analyzed .It is possible that for certain scenarios ,response spectrum method may not capture all the nuances of the structural response accurately and zone 3,4 RSA values are greater response spectrum analysis is a dynamic analysis that takes into account the dynamic characteristics of the structure and the input ground motion while static doesnot consider dynamic response. But for complex structure RSA results is more significant then ESA because it covers wide range characteristics of building under seismic loadings.

**STORY DRIFT**



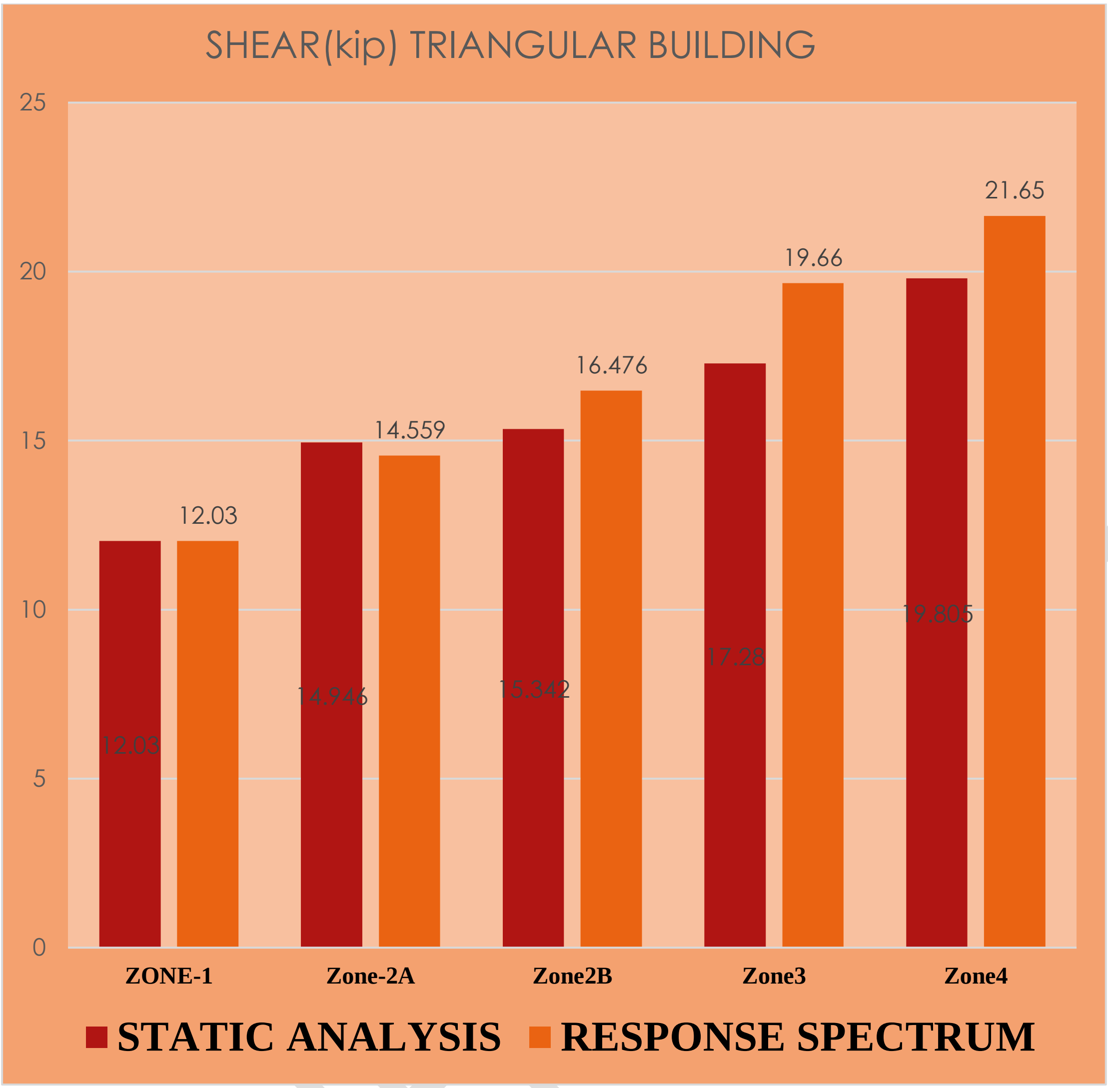

In this graph the storey drift value increases with sequence (Z1<Z2<Z3<Z4) and is reasonable but in Zone 3 RSA value is less then static analysis because RSA consider dynamic behavior of structure.RSA accounts for the interaction btw different modes of vibration in the structure. It consider multiple modes and their contributions to the overall response. This can lead to additional force demands that are not captured by ESA,but from other zones results are same form both methods reason they can produce similar results when the structure behaves linearly elastically under seismic loads the structure predominantly responds in a single mode of vibration sue to which results of RSA and ESA come closer.

## STOREY DISPLACEMENT



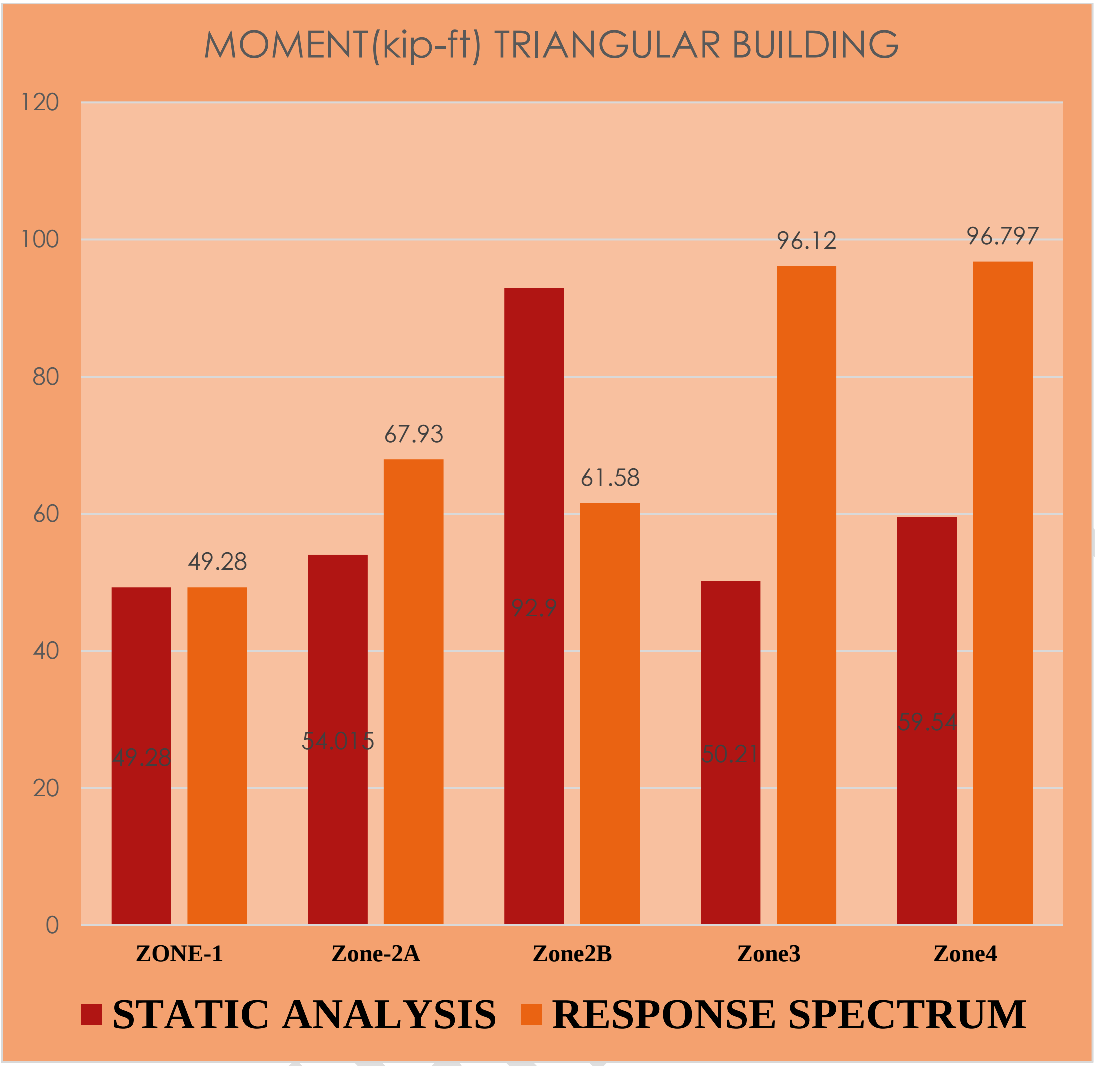

In this graph storey displacement increases with zone severity and is reasonable,but result from RSA and ESA are same because they can produce similar results when the structure behaves linearly elastically under seismic loads and the structure predominantly responds in a single mode of vibration due to which results of RSA and ESA come closer.

**SHEAR**




The values increase is according to zone severity which is correct. But the result of RSA is greater then ESA in overall zones why because RSA consider dynamic behavior of structure.RSA accounts for the interaction btw different modes of vibration in the structure. It considermultiple modes and their contributions to the overall response. This can lead to additional force demands that are not captured by ESA, but in zone 2A ESA value is greater then RSA the reason is same but in z1 results are same from both methods because they can produce similar results when the structure behaves linearly elastically under seismic loads, the structure predominantly responds in a single mode of vibration due to which results of RSA and ESA come closer.

**MOMENT**




The values in this graph is increasing according to zone severity(0.075<0.15<0.2<0.3<0.4) so these are correct but overall RSA values are greater then ESA because RSA consider dynamic behavior of structure.RSA accounts for the interaction btw different modes of vibration in the structure. It consider multiple modes and their contributions to the overall response. This can lead to additional force demands that are not captured by ESA,but in zone 2B static value is greater because the response spectrum method is an approximate analysis technique and its accuracy may vary depending on the specific characteristics of the ground motion and the structure being analyzed.It is possible that for certain scenarios,response spectrum method may not capture all the nuances of the structural response accurately

## 6.4 DISCUSSION W.R.T ANALYISIS METHODS (Response Spectrum and Static Analysis)

### 6.4.1 ZONE-1

**Rectangular building**

Base shear, story drift, story displacement, moment and shear, **RSA(Response spectrum analysis gives less values (more suitable values)** compare to ESA (equivalent static analysis).

**Circular building**

Base shear , story drift, story displacement , moment and shear **,RSA and ESA both gives same results, safer results .**

**Triangular building**

Base shear , story drift, story displacement , moment and shear, **both RSA and ESA gives safer results and same results.**

### 6.4.2 ZONE-2A

**Rectangular building**

Base shear, story drift, story displacement, moment and shear, **ESA gives better results then RSA.**

**Circular building**

Base shear , story drift, story displacement , moment and shear ,**ESA gives better result then RSA.**

**Triangular building**

Base shear, story drift, story displacement, moment and shear**, RSA gives better result then ESA.**

### 6.4.3 ZONE-2B

**Rectangular building**

Base shear , story drift, story displacement , moment and shear, **ESA and RSA results are same .**

**Circular building**

Base shear , story drift, story displacement , moment and shear ,**ESA gives better result then RSA.**

**Triangular building**

Base shear , story drift, story displacement , moment and shear**, RSA gives better result then ESA.**

### 6.4.4 ZONE-3

**Rectangular building**

Base shear , story drift, story displacement , moment and shear, **ESA gives better results then RSA .**

**Circular building**

Base shear , story drift, story displacement , moment and shear ,**ESA gives better result then RSA**

**Triangular building**

Base shear , story drift, story displacement , moment and shear**, RSA gives better result then ESA.**

### 6.4.5 ZONE-4

**Rectangular building**

Base shear , story drift, story displacement , moment and shear, **ESA gives better results then RSA .**

**Circular building**

Base shear , story drift, story displacement , moment and shear ,**ESA gives better result then RSA.**

**Triangular building**

Base shear , story drift, story displacement , moment and shear**, ESA gives better result then ESA.**

## 6.5 DISCUSSION ON PERFORMANCE OF GEOMETRY OF BUILDING IN ALL FIVE ZONES.

- On the basis of design parameters the shapes of structure preferable in Zone 1 and 2A (circular> rectangular >triangular) while zone 2B and 3 and 4 (circular>triangular>rectangular) according to analysis method.
- **As a result circular shape of structures are preferable in all zones on the behalf of analysis methods. They showed high stability in all seismic zones of Pakistan.**
- Final recommendation will be after cost analysis of structures.



**CHAPTER 6**

# 7 BUDGETING AND COSTING

**All the rates are used according to MES rates Pakistan.**

**All results of cost estimation are in tabular form.**

| BUILDING SHAPE | COL+BEAM CONCRETE 5000PSI (CUM) | CONCRETE SLAB+RAFT 3000PSI (CUM) | MES RATES (5000PSI) CONCRETE | MES RATES (3000Psi) concrete | COST OF TOTAL CONCRETE (Rs) | TOTAL STEEL (KG) | MES RATES OF STEEL (KG) | COST OF STEEL (Rs) | TOTAL COST OF BUILDING CONCRETE+STEEL IN (Rs) |
|---|---|---|---|---|---|---|---|---|---|
| Rectangular | **1337.79** | **5693.45** | **16864** | **13547** | **114136705.5** | **41923.33** | **154** | **6456208.68** | **120592913.3** |
| CIRCULAR | **2508.98** | **5693.45** | **16864** | **13547** | **133888495.9** | **45970.08** | **154** | **7079392.32** | **140967888.2** |
| TRIANGULAR | **2486.43** | **5693.45** | **16864** | **13547** | **133514958.1** | **45728.214** | **154** | **7042144.95** | **140557103.1** |

*TABLE 6.1 1*

After estimation process it is resulted that the most economical building in all three shape with same covered area and dimensions is rectangular then triangular then circular building comes.

The sequence is (**rectangular > circular> triangular**) building with respect to cost.

**CHAPTER 7$^{th}$**

# 8 CONCLUSION

it is concluded that in each zone ,zone 1 with earthquake acceleration factor 0.075 m/s which is very low compare to other zones and zone 2A having earthquake acceleration factor 0.15, zone 2B earthquake acceleration factor is 0.2 m/s and in zone 3 earthquake acceleration factor is 0.3 m/s and in zone 4 earthquake acceleration factor is 0.4 so according to design strength of building the sequence is ( circular building> triangular building> triangular building) with respect to analysis methods in all seismic zones but with respect cost analysis of these three building circular ,rectangular and triangular building the sequence w.r.t most economical is (rectangular >triangular>circular) building so in zone 1,zone 2A,2B there earthquake acceleration factor is in moderate range so we recommended rectangular shape of building its have safe results in these zones and it is most economical building and in zone 3 and zone 4 we recommended safety over cost because these zone having high severity w.r.t earthquake so we recommended circular building because circular building showed high stability and most safer results in all seismic zones of Pakistan.

**CHAPER 8$^{TH}$**

# 9 RECOMMENDATION AND FUTURE

In zone 1,zone 2A,2B there earthquake acceleration factor is in moderate range so we recommended rectangular shape of building its have safe results in these zones and it is most economical building in all three shapes of building (circular, triangular and rectangular) and in zone 3 and zone 4 we recommended safety over cost because these zone having high severity w.r.t earthquake so we recommended circular building because circular building showed high stability and most safer results in all seismic zones of Pakistan.

And in future this research will be helpful in selecting the most economical and most stable building shape in all seismic zones of Pakistan.



**CHAPTER 9$^{TH}$**

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