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EVALUATION OF BASE SHEAR IN DIFFERENT SEISMIC ZONES

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ABSTRACT

Any structure must address two primary concerns: strength and stability. A structure necessitates a support system that possesses adequate strength to withstand loads and stability to safely transfer them to the ground. In seismic design for reinforced concrete framed structures, understanding the approximate magnitude of the probable maximum base shear relative to the structure's mass is crucial. This study presents an analysis conducted to examine the base shear force of multi-storied buildings across various seismic zones. To achieve this objective, four building models will be developed, each corresponding to structures built on rocky soil in seismic zones II, III, IV, and V of India (as defined by IS: 1893-2002). The base shear for these four models will be calculated manually, followed by a comparative analysis to show their relative differences.

Keywords: Framed Structure, Manual Base Shear Analysis, Seismic Design,

I. INTRODUCTION

An earthquake occurs when waves generated by a disturbance in the Earth's crust cause vibrations on the Earth's surface due to the release of energy. Earthquakes can be classified into two main categories based on their origins: tectonic and volcanic. Tectonic earthquakes occur due to the abrupt movement of significant rock formations along geological faults. Volcanic earthquakes, on the other hand, are linked to volcanic eruptions and typically have localized effects. When earthquakes happen beneath the ocean floor, they displace the water above, triggering a series of waves known as a tsunami. The origin point of seismic waves is referred to as the focus. Directly above the focus on the Earth's surface is the epicenter. The distance between the epicenter and a recording station is known as the epicentral distance. The earthquake magnitude is a numerical representation of the energy released during an earthquake. It is calculated as the base-10 logarithm of the maximum amplitude recorded in microns by a standard short-period torsion seismometer at an epicentral distance of 100 kilometers. The seismic intensity scale is a method used to evaluate the effects of an earthquake at different locations. Unlike measuring magnitude, determining intensity relies on observations rather than instrumental recordings. Intensity levels can be determined through visual observations, interviews, or questionnaires completed by residents. This data is essential for creating seismic risk maps. Intensity indicates the strength of shaking at a location during an earthquake and is represented by a number on the modified Mercalli Scale.

II. LITERATURE REVIEW

This chapter talks about past and recent studies by researchers on how buildings handle earthquake forces. It looks at different ways to analyze these forces, what building codes say, and how experts study them using both manual methods and computer programs.

Mahesh N. Patil, Yogesh N. Sonawane, This paper examines how a symmetric multistoried building responds to earthquakes. The study involves calculating responses both manually and using Etabs 9.7.1 software, following the seismic coefficient method recommended by IS 1893:2002. The results from manual calculations and computer analysis are compared. The paper offers a comprehensive guide for both manual and software-based seismic coefficient method analysis. Seismic analysis was performed using Etabs software and validated manually according to IS 1893-2002. Lateral forces gradually increase from the bottom floor to the top floor in both manual and software analyses. The seismic weight calculated manually and with software yields exactly the same result.

B. Srikanth, V. Ramesh, This thesis explores the earthquake response of a symmetric multi-storied building using two different methods. One method is the seismic coefficient method recommended by the IS code, while the other involves modal analysis using the response spectrum method outlined in the IS code. In the response spectrum method, the building's stiffness matrix is generated by representing it as a shear building with dynamic degrees of freedom. The study compares the responses obtained from these methods in two extreme seismic zones specified in the IS code, namely Zone II and Zone V. The results are compared in terms of base shears, lateral forces, and storey moments. Since storey moments are higher in the seismic coefficient method compared to the response spectrum method, the thesis suggests relying on the response spectrum method, even for symmetric multi-storied buildings, for seismic analysis and design.

Sunayana Varma, A. Malar and K. Karthikeyan, This study compares the base shear of reinforced concrete (RC) frames located in different seismic zones. Four building models were created to represent structures in seismic zones II, III, IV, and V of India, following IS: 1893-2002 guidelines. Base shear values for these models were calculated manually, as well as using the STAAD Pro and ETABS software packages, and then compared. It was found that the base shear calculated in ETABS was higher compared to STAAD Pro and manual calculations. However, the difference between STAAD Pro and manual calculations was minimal. Therefore, it is suggested that the STAAD Pro software package is more reliable than ETABS for determining base shear values.

Mr. S.Mahesh and Mr. Dr.B.Panduranga Rao (2014), This paper investigates the seismic and wind loads on a residential G+11 multi-story building using both ETABS and STAAD Pro V8i software. The analysis assumes linear static material properties and includes both static and dynamic analyses. Different seismic zones are considered, and for each zone, the behavior is evaluated using three types of soils: hard, medium, and soft. It's found that the base shear value is higher in zone V, especially in soft soil with irregular configuration. Comparing regular and irregular configurations, the base shear is higher in the regular configuration due to the structure's symmetrical dimensions. Similarly, comparing regular and irregular configurations, the story drift value is higher in the regular configuration because the structure has more dimensions.

Mohd Atif, Prof. Laxmikant Vairagade and Vikrant Nair (2015), This research focuses on comparing the seismic analysis of a G+15 building reinforced with bracings and shear walls. The building's performance is assessed in seismic zones II, III, IV, and V, aiming to understand factors that contribute to poor performance during earthquakes and ensuring appropriate behavior in future seismic events. The structure is modeled using STAAD Pro V8i software, and a comparative analysis is conducted concerning base shear, displacement, axial load, moments in y and z directions in columns, shear forces, maximum bending moments, and torsion in beams. Shear wall elements prove highly effective in reducing lateral displacement compared to braced frames and plane frames, as evidenced by lower drift and horizontal deflection. Additionally, using steel bracings doesn't significantly alter the total weight of the existing building.

III. METHODOLOGY

The analysis of the RC multistoried building is conducted using the following methodology:

1) The thoroughly examining and analyzing the body of literature that has already been researched and documented by multiple scholars or researchers. This examination typically includes studying various perspectives, methodologies, findings, and conclusions presented in these existing works.

2) Choosing specific structural types for analysis involves selecting categories based on factors like complexity, materials, function, vulnerabilities, and analysis requirements.

3) Choosing the areas of buildings for analysis involves carefully selecting specific sections or zones based on various factors such as structural integrity, usage patterns, potential risks, and the scope of the analysis required.

4) Calculations are conducted for both horizontal and vertical directions to ensure comprehensive analysis and evaluation.

5) Load considerations encompass a thorough assessment of various factors such as dead loads, live loads, environmental loads, and dynamic loads, among others, to ensure structural integrity and safety.

6) Determining the seismic weight of a building involves calculating its total mass, including all components, to understand its response to seismic forces during an earthquake.

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IV. MODELING AND ANALYSIS

A. Structural Modeling

This paper presents an analysis conducted on the typical structure of a G+5 storey RC building. The framework was designed for institutional use, featuring five bays in the x-direction and four bays in the y-direction, with a typical storey height of 3 meters, illustrated in Figures 1 and 2. Figure 3 displays the three-dimensional view of the building modeled in ETABS. The dimensions of the beams and columns were determined through optimization, and the preliminary data assumed for this investigation is detailed in Table 4.1.

The analysis commences by considering various models, which are discussed as follows:

Table 4.1: General Description of Models

Type of building	RCC
Type of structure	Ordinary RC moment-resisting frame OMRF
Length in X direction	20M
Length in Y direction	15M
No of storey	six
Floor to floor height	3M
Beam size	230MM X 400MM
Column size	230MM X 450MM
Depth of slab	150MM
Density of brick	20Kn/M3
Density of concrete	25Kn/M3
Soil type	1
Seismic Zone Factor (Z)	(0.1,0.16, 0.24 & 0.36) for Zone ii,iii, iv & v
Importance Factor	1
Response Reduction Factor (R)	3
Live load	3Kn/M2
Floor finish	13Kn/M2
Wall thickness External	230MM
Wall thickness Internal(Including Paster)	115MM
Damping ration	5%

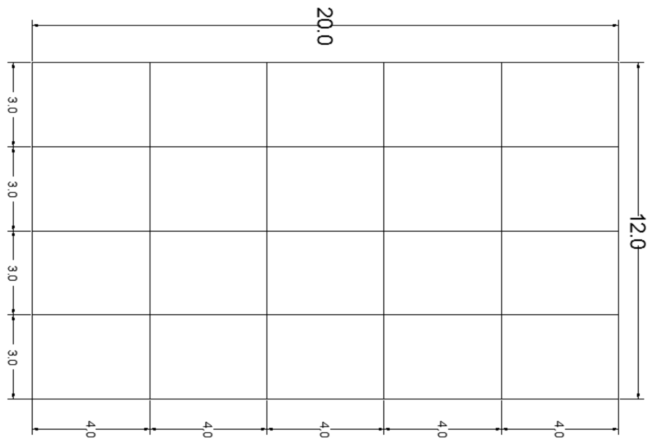

Figure 1: Building Plan

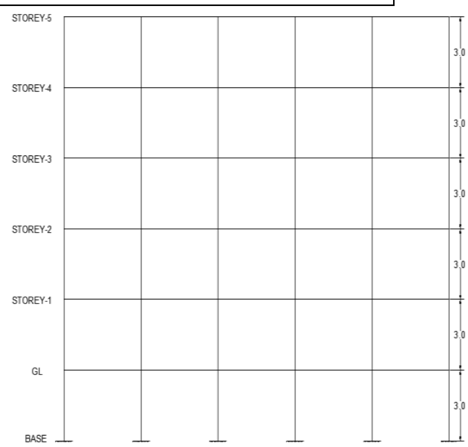

Figure 2: Elevation

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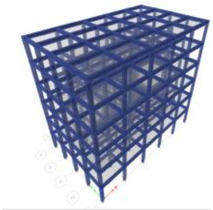

Figure 3: 3D view

Seismic Weight Calculation

As per IS 1893-2000 (Part 1) Seismic loads are calculated as follows:

- Seismic Zone Factor (Z) = (0.1,0.16, 0.24 & 0.36) for Zone ii,iii, iv & v
- Site Type = 1, for Fine sandy, Gravelly soil.
- Importance Factor = 1,
- Response Reduction Factor (R) = 3, Ordinary RC moment-resisting frame OMRF.

1. Computation of Seismic weights:

For Slab:-

DL due to self-weight of slab= (b x thickness x Ƴ x L)

= (20 x 0.15x 25 x 12)

= 900 kN

Floor finished Load = (b x L) x 1

= (20 x12) x1

=240 kN

So, Total weight of slab with floor finish = 1140 kN.

For Beams:-

Self-weight of beam per unit length = (b x (D - slab thickness) x Ƴ)

=0.23 x (0.4 - 0.15) x 25

= 1.4375 kN/m

Total length = (20x5+12x6)

= 172 m

Total weight = Total length x Self weight of beam per unit length

= 172 x 1.4375

= 247.25 kN

For Columns:-

Self-weight of each column per unit length = (b x D x Ƴ)

=0.23 x 0.45 x 25

= 2.5875 kN/m

Self-weight total of columns (30 Nos.) = 30 x 2.5875 x 3.0

= 232.875 kN

For Walls:-

Self-weight of wall per unit length (External)= (thickness x h x Ƴ)

= 0.23 x 2.6 x 20

= 11.96 kN/m

Total length= (20x2 + 12x2) = 64 m

Total weight = Total length x Self weight of wall per unit length

= 64x11.96

= 765.44 kN

Self weight of wall per unit length (Internal) = (thickness x h x Ƴ)

=0.115 x 2.6 x 20

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= 5.98 kN/m
Total length = (20x3 + 12x4)
= 108 m
Total weight = Total length x Self weight of wall per unit length
= 108X 5.98
= 645.84 kN
Total weight of wall on each floor = 765.44 + 645.85
=1411.28 kN

2. Live Load [Imposed load] on intermediate floors:-

Only 25 % of live load is taken as per IS:1893:2002
= (0.25 x 3) x 20 x 12
= 180 kN
Load on roof = (i) self-weight of slab + (ii) self-weight of beam + (iii) self-weight of parapet wall
Self-weight of parapet wall = 20x1x 0.115x62
= 142.6KN
Load on roof W1 = 1140+247.25 + 142.6
= 1529.85
Load on intermediate floor = (i) self-weight of slab + (ii) self-weight of beam + (iii) Self weight of wall (iv) Self weight of column + (v) Live Load
Load on intermediate floor (W2 to W5) = 1140+247.25+1411.28+232.875+180
= 3211.405KN
Load on GL (W6) = (i) self-weight of beam + (ii) Self weight of column
= 247.25 + 232.875
= 480.125 KN
Total seismic weight = W1+W2+W3+W4+W5+W6
= 14855.56 KN

Time period:

Natural period (in X direction), Ta = $0.09h/\sqrt{d}$
= $0.09 \times 18 / \sqrt{20}$
= 0.36224
Natural period (in Y direction), Ta = $0.09h/\sqrt{d}$
= $0.09 \times 18 / \sqrt{12}$
= 0.4677

3. Average response acceleration coefficient:

From IS: 1893:2002 part-1, cl. 6.4.5
For soil type hard soil
Hence, acceleration coefficient in x-direction Sa/g
Sa/g = 2.5
Similarly, in y-direction Sa/g
Sa/g = 2.138

4. Design horizontal seismic coefficient:

For zone ii :-

Horizontal acceleration spectrum value(X direction),
Ah = $Z/2 \times I/R \times Sa/g$
= $0.10/2 \times 1.0/3 \times 2.5$
= 0.04167
Horizontal acceleration spectrum value(Y direction),
Ah = $Z/2 \times I/R \times Sa/g$
= $0.10/2 \times 1.0/3 \times 2.138$
= 0.03563

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For zone iii:

Horizontal acceleration spectrum value(X direction),

Ah = Z/2×I/R×Sa/g

= 0.16/2×1.0/3×2.5

= 0.06667

Horizontal acceleration spectrum value(Y direction),

Ah = Z/2×I/R×Sa/g

= 0.16/2×1.0/3×2.138

= 0.05701

For zone iv :-

Horizontal acceleration spectrum value(X direction),

Ah = Z/2×I/R×Sa/g

= 0.24/2×1.0/3×2.5

= 0.10

Horizontal acceleration spectrum value(Y direction),

Ah = Z/2×I/R×Sa/g

= 0.24/2×1.0/3×2.138

= 0.08552

For zone v :-

Horizontal acceleration spectrum value(X direction),

Ah = Z/2×I/R×Sa/g

= 0.36/2×1.0/3×2.5

= 0.15

Horizontal acceleration spectrum value(Y direction),

Ah = Z/2×I/R×Sa/g

= 0.36/2×1.0/3×2.138

= 0.12828

5. Design seismic base shear:

Table 4.2: Base shear calculation in x-direction

Sr. no.	Zones	Ah	W(kN)	VB= Ah x W
1)	Zone ii	0.04167	14856	616.05
2)	Zone iii	0.06667	14856	990.45
3)	Zone iv	0.10000	14856	1485.60
4)	Zone v	0.15000	14856	2228.40

Table 4.3: Base shear calculation in y-direction

Sr. no.	Zones	Ah	W(kN)	VB = Ah x W
1)	Zone ii	0.03563	14856	529.32
2)	Zone ii	0.05701	14856	846.94
3)	Zone iv	0.08552	14856	1270.49
4)	Zone v	0.128	14856	1905.73

V. RESULTS AND DISCUSSION

Here are the results we found from the calculations above:-

- As the seismic zone increased, the base shear also increased.
- The base shear is greater in the longer direction compared to the shorter direction.
- Observing the building plan, it will be noticed that the building deflects more in the y direction compared to the x direction due to the width of the building in the y direction.

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- The observation indicates that as the time period increases, the building's size decreases, and vice versa.

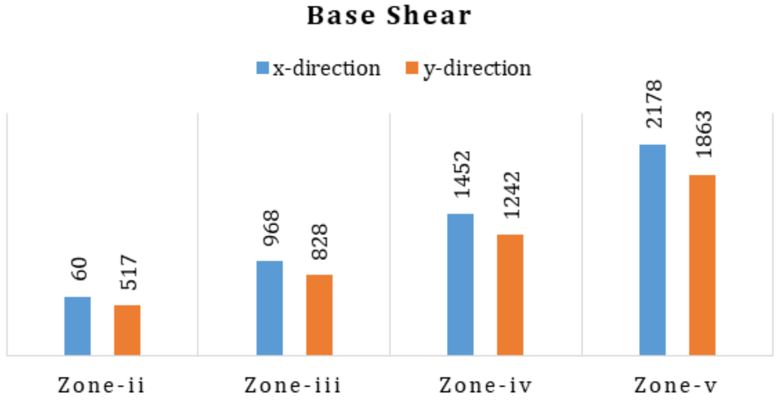

Figure 4: Comparison of Base shear

VI. CONCLUSION

Based on the observation above, the following conclusion has been drawn:-

1) The introduction of shear walls significantly diminishes lateral displacements in structures when subjected to earthquake forces. The presence of shear walls has a substantial impact on the seismic behavior of frame structures, markedly increasing both strength and stiffness.
2) Since the time period in the x-direction is shorter, the frequency of vibration is higher compared to other directions. Consequently, the base shear in the x-direction is greater across all respective zones.
3) The conclusion drawn is that when the building deflects more in the y-direction compared to the x-direction, the base shear force is less where the building experiences greater deflection.
4) The lateral forces experience a gradual increase from the bottom floor to the top floor.

VII. REFERENCES

[1] Siddharth Bankar, “Analysis Of High Rise Building In Different Seismic Zones In India: REVIEW” International Journal of Creative Research Thoughts (IJCRT), Volume 11, Issue 7 July 2023

[2] Kiran Devi , “A Comparative Study on Seismic Analysis of Multistorey Buildings in Different Seismic Zones”, Journal of Smart Buildings and Construction Technology, Volume 05, Issue 02, December 2023

[3] Sajala, Nadiya, “A Study and Comparsion of Base Shear in Different Zones and Soil Types for (G+4),(G+9),(G+14)”, International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181, Vol. 9 Issue 11, November-2020

[4] Kapil Dev, “Determination of Base Shear of RCC Structure under Different Zone”, International Research Journal of Engineering and Technology (IRJET), Volume: 07 Issue: 07 | July 2020

[5] Mahesh N. Patil, Yogesh N. Sonawane" Seismic Analysis of Multistoried Building" International Journal of Engineering and Innovative Technology (IJEIT) Volume 4, Issue 9, March 2015

[6] Sunayana Varma, A. Malar and K. Karthikeyan " Comparative Study of Seismic Base Shear of Reinforced Concrete Framed Structures in Different Seismic Zone " The International Journal Of Science & Technoledge (ISSN 2321 – 919X) Vol 2 Issue 8 August, 2014

[7] B. Srikanth, V.Ramesh “Comparative Study of Seismic Response for Seismic Coefficient and Response Spectrum Methods " B. Srikanth et al Int. Journal of Engineering Research and Applications ISSN : 2248-9622, Vol. 3, Issue 5, Sep-Oct 2013, pp.1919-1924

[8] Pankaj Agarwal, Manish Shrikhande, Earthquake Resistant design of Structures (Prentice Hall India Publication).

[9] IS 1893(Part1):2002, Criteria for earthquake resistant design of structures, Part 1 General provisions and buildings, Bureau of Indian Standard.

[10] IS 875 (Part 2): Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures. Part 2: Imposed Loads (Second Revision) (1987).