LATERAL LOAD ANALYSIS OF MULTI-STOREYED FLAT SLAB BUILDING WITH DIFFERENT BRACING AND SHEAR WALL

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Abstract: The usage of flat slab systems in concrete reinforced structures is now common place in modern construction. The flat slab technique in RC structures has several benefits over traditional moment resistant frame works. Flat slab technology may lower floor height to fit needs of building's design & budget. Purpose of shear wall is to withstand lateral forces that are perpendicular to wall's plane. High in-plane stiffness and strength of a shear wall can withstand the large forces produced by seismic activity. As a flexural member, shear walls prevent structures from collapsing entirely when subjected to seismic stresses. In this thesis an attempt is made to study the behaviour of flat slab building with different bracing and shear wall. A total of 6 models were prepared three with bracing and three with shear wall with different shape. Response spectrum method is applied for analysis and evaluates time period, displacement, base shear, and storey drift and finally comparison is made among all models.

I. INTRODUCTION

An earthquake (sometimes called a quake, tremor, or temblor) is the severe shaking of the Earth's surface that may cause widespread damage and result in the deaths of millions. For thousands of years, humans have recognized earthquakes as one of the most devastating natural calamities. Due in large part to structural collapses resulting in damage to persons and property, recent significant earthquakes have caused considerable societal disruption in the region around the epicentre. Shopping centers, theatres, and other buildings with big, column-free areas often use flat slab flooring. When designing for earthquake resilience, flat slabs need shear walls. IS 1893 Part1:2002 allows for both vertical and lateral load resistance in flat slab buildings in low seismicity (Zone II) locations. However, in seismically active zones (Zones III, IV, and V), the code prohibits the use of flat slabs without some kind of lateral load resisting system or lateral force resisting system. This study modelled and analysed the seismic response and earthquake stresses on a flat slab multi-story structure with a height of twenty stories (G+19) in both the absence and presence of a shear wall. For each stated model, effectiveness & utility under Indian standard circumstances in seismic zone 'V' have been analysed. Shear walls are first erected at building's core, then at its corners, and lastly at the walls' centers, all outside of the building's interior.

1.1 Flat Slab:

Architects and clients alike tend to choose flat slab construction due to its many practical and monetary benefits. While there are many benefits to using reinforced concrete over a framed structure, there are also drawbacks, such as the potential for brittle punching failure at the slab column connection and significant horizontal displacement. Several studies have suggested that, in more seismically active areas, flat slabs should be built to withstand solely gravity loads, with the lateral force resistant system taking care of everything else. A column capital and drop panel, or just the column itself, may support a flat slab. Lack of frame action causes severe lateral distortion, making flat slab buildings perform poorly under seismic loads compared to framed structures. The slab column junction is the weakest point in a flat slab construction. The behavior of flat slab column connection has been the subject of much study. The failure mechanism is sensitive to the kind and level of stress applied. The gravity shear ratio greatly affects the punching shear strength of the slab column connection. Transfer of shearing force and imbalanced moment between the slab and column may lead to punching failure of the flat slab.

1.2 Types of Flat Slab Construction:

1. Simple flat slab
2. Flat slab with drop panel
3. Flat slab with column head
4. Flat slab with drop and column head

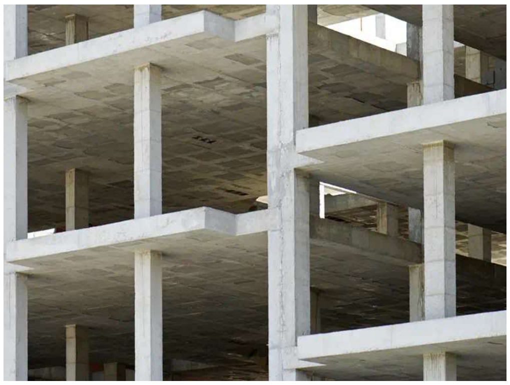


Fig 1: Simple Flat slab

Fig 2: Flat Slab Drop panel in Building

Fig 3: Flat slab with column head

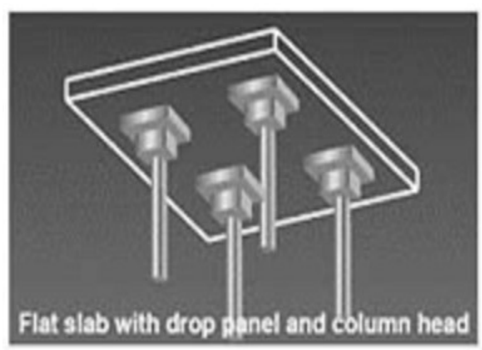
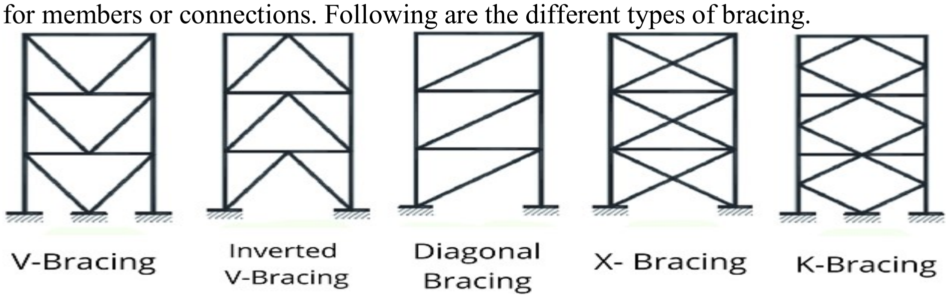


Fig 3: Flat slab with drop and column head

1.3 Bracing: Braced frames are structural systems that can withstand natural disasters like hurricanes and earthquakes. Using shear walls or diagonal steel sections, a braced frame prevents its members from swaying laterally. The majority of braced frames are round. This signifies that the centroid of each component intersects at the same position where the members meet at a node. There are two further types of concentrically braced frames: standard and exceptional. Common in regions with minimal seismic risk, ordinary concentric braced frames (OCBFs) don't have stringent standards for members or connections. Following are the different types of bracing.



1.4 Shear wall: When it comes to high-rise buildings, shear walls are one of the most popular methods of resisting lateral loads. A shear wall's strong in-plane stiffness and strength make it suitable for supporting gravity load while also withstanding substantial horizontal loads. R.C. shear walls are used to strengthen a structure against lateral forces like wind and earthquakes. Stairwells, elevator shafts, and other utility shafts often have them installed between the tiers of columns. By redirecting the force of the wind or an earthquake down to the base, shear walls offer lateral load resistance. They also bear the weight of gravity and provide the system with lateral rigidity. Used to prevent the collapse of skyscrapers, they are a familiar sight. From the perspectives of cost-effectiveness and managing lateral deflection, shear walls may eventually be required. Shear walls may be an effective lateral force resisting structure when placed in strategic locations inside a building. To ensure the safety and stability of buildings, several rules mandate the installation of such barriers. The column-slab system in a flat slab structure must be able to withstand gravity loads as well as lateral inertia stresses caused by an earthquake. Because the thin slabs linking the columns have limited lateral stiffness, flat slab structures sway by substantial amounts elastically even during low intensity earthquake shaking. Due to the low lateral stiffness and lateral load resistance of the column-slab system, the substantial overall lateral drift of the flat slab structure results in secondary moments that are too big for the columns to support. As a result, flat slab construction raises significant issues in Seismic Zones IV and V.

II. LITERATURE REVIEW

2.1 Dharanya , Gayathri , Deepika(2017)" Multi-story Residential Building Shear Wall & Bracing Analysis with Seismic Load"[1] When a seismic event hits, nearly every structure in region is going to experience tremors. Whenever tall structure experiences horizontal or torsion detours as a consequence of seismic loading, accompanying oscillatory movement may cause a broad variety of responses in building's inhabitants. Therefore, longitudinal rigidity is crucial in construction of buildings with multiple floors. Shear walls & diagonal bracing may strengthen concrete-reinforced frame's resistance to lateral loads. A G+4 soft-storey residential RC structure featuring transverse bracings & shear wall is the subject of this investigation. Following the guidelines laid down in IS 1893:2002, we ran the numbers through ETABS1 to see how everything stacked up. Outside column shear walls & bracings, like X bracing, are required. ETABS program is used for equivalent stiffness analysis of building models. Principal variables examined include lateral movement, base strain, storey drifting, axial, shear force, etc.

2.2 Vivek Kumar, et.al (2019) "ETABS Pushover Analysis of the Seismic Response of Flat Slab Structure by Steel Brace Mechanismv17"[2] Commonplace in modern day is application of tried and true RC Frame design. When compared to traditional RC Frame structures, flat slab building has several benefits in areas of architectural freedom, space efficiency, simplicity of structure, & speed of construction. In this study, we examine three different types of flat slab construction: (1) a slab by drop, (2) a slab with a 'X' bracing system, and (3) a slab with an inverted '/' bracing system. It's kind of non- linear static analysis kind, and it involves stressing structure above its limit of elasticity. We use ETABSv17 for analysis. The G+10 height & 15 x 25 meter footprint are standard for all 3 building variants. We evaluate the obtained findings by contrasting base shear, displacement, and storey drift values. Studying influence of various lateral force resistant infrastructure, like steel bracings, upon flat slab buildings during seismic stimulation as well as non linear behavior of such buildings by major goal of this research. Examine how various models fare in terms of base shear, displacement, storey drifting, as well as additional criteria defined by IS-1893:2016.

2.3 Athira.M.V., et.al (2017) Seismic Analysis of Flat Slab Structure by ShearWall[3] These days, it's common for reinforced concrete structures to employ slab-like technologies. The flat slab technique in RC structures has various benefits over traditional stress resistant frames. When it comes to aesthetics & cost, flat slab solution is way to go.Yet, flat slab's supposedly lower stability under seismic loads reduces building's structural efficacy. Purpose of shear wall is to withstand lateral forces that are perpendicular to wall's plane. Shear walls with high in-plane strength & stiffness can withstand the large forces created by seismic activity. Shear walls function as flexural part primarily to prevent complete collapse of structures under seismic stresses. In this research, we evaluate a 14-story structure in zone IV and analyze it with flat slab using several shearwall forms to get handle upon things like shear, & time. With ETABS V.16.Software, we do our analyses. Analyzing the Spectrum of Responses In order to determine theseismic behavior, linear dynamic evaluation of system is carried out.

2.4 Javed Ul Islam, et.al (2020)" Designing for Earthquake Resistance: A Proportional Analysis of RC-frame Bracing Systems"[4] This research focuses on analyzing the structural performance of metal buildings using a variety of bracing configurations. Researchers have also looked at the effectiveness of various brace system types. Here, we examine and construct a 10-story frame building to withstand lateral loads. Research into the structural effectiveness of RC frame construction has focused on the use of unique types of bracing systems, such as X bracing, Inverted V-type bracing, K bracing, and single Diagonal bracing. We have analyzed the differences in lateral displacement and beam moments between braced, story drift, and un-braced buildings at different floor levels. The results of the study show that a braced frame would experience less lateral movement than an equivalent RC frame, and that the X-Bracing system is superior to conventional bracing methods. The highest displacement (35% reduction) in the X-bracing frame construction greatly aids in the addition of structural rigidity. Finally, its designation as an X-diagonal braced structure is indicative of better structural overall performance than any of the other structures considered here under the same conditions. The addition of bracing structures makes them more earthquake-resistant. Designing buildings to withstand earthquakes might be a cost-effective option in certain cases.

2.5 Sanjeev et.al (2019)) "Multi-Story Building Seismic Analysis With and Without Shear Walls and Bracing"[5] Aesthetics & architectural needs go hand in hand in today's construction projects. Many common architectural forms, such as letter "X" & letter "V," have non-parallel x & y coordinates. Buildings with unusual layouts & high percentage of thinness are particularly vulnerable to earthquake damage. Primary objective of this research is to compare fluid movement of structures with varying structural configurations across all seismically active regions & soil types. Twenty-story, 70-meter-tall skyscraper with 3.5-meter-tall storeys, Shear wall & bracing at various points throughout the building are examined in this research. We analyzed the building's dynamic performance in Seismic Zones II, III, IV, & V, as well as on harshly, substrate, & sandy soils.Beams on the building's edge support a R.C shear wall 200 mm thick. Utilizing ETAB 9.7.4 software, we analyzed response spectrum at many points in structure, each time taking into account effects of bracing & shear wall. We conducted in-depth studies of building's behavior & examined its subsequent seismic characteristics.

2.6 Dhiraj Naxine, et.al(2018) "Analysis of Multiple-Story RCC Buildings with Various Concentric Bracing Systems"[6] Historically, lateral load has been the primary cause of failure for RCC structures. One mechanism for reducing lateral loads, bracings are particularly important in construction of Rc structures. The earthquake reactions of various bracing systems are adequate. The benefits of steel bracing systems extend to both efficiency and cost. Steel bracings are easier to install and take up less time overall. Steel struts are often inserted between pre-existing vertical elements. The goal of studying a building's seismic reaction is to planning and building it such that it sustains as little damage as possible during earthquake. This paper's focus is on critical examination of the historical research and analysis of both braced & unbraced multi-story RCC buildings by wide range of specialists.

2.7 Shahzeb Khan, et.al "Methods of Software-Aided Earthquake Resistance for a G+10 Building with Shear Walls and Bracings"[7] Natural disasters have been a major source of loss of property and lives for humans almost by start of recorded history upon Earth. Earthquake is a significant natural event. Any building still standing after an unexpected tremor presents a formidable task. There have been numerous fatalities from structure collapses caused by disasters because of poor building layouts that lacked seismic resilience. In order to make structures strong enough to resist earthquake, architects have experimented using a wide variety of construction forms and materials.

There are a variety of methods utilized for rendering buildings quake proof in the current day. Among these methods are installation of shear walls and bracings, as well as isolation of base and column jacketing. In this research, I provide a software-based comparative study of earthquake-resistant strategies using various shear walls and bracings on a G+10 structure. This study evaluates the differences between a non-Resisting building and many others. The addition of shear walls and bracings to a structure increases its strength and earthquake resistance. The IS 1893:2002 guidelines state that a G+10 building must undergo seismic zone III analysis.. For this investigation, I utilized the software program Staad pro v8. As expected, improving building's strength and stiffness via shear walls & bracing helps reduce deflection. Findings from this experiment may be utilized to improve seismic durability of structures by using a number of different seismically resistant methods.

2.8 Ms. Deepa et.al (2018)" Multi-Story Reinforced Concrete Buildings With & Without Shear Walls Examined Against Conventional Frame Buildings in Seismic Environments"[8] There has been a dramatic growth in number of skyscrapers in modern age. Until recently, conventional reinforced concrete (RC) buildings were the norm in the construction business. Usage of flat slabs system is widespread in government structures. Flat slab's structural effectiveness is low when subjected to seismic loads. It's not really stiff. Addition of a shear wall, which provides resistance to lateral loads, may increase their stiffness. The current study examines a G+9 multi-story commercial building with flat slab construction as well as without shear walls.

III. OBJECTIVES AND SCOPE OF WORK

3.1 Objective:

1. To analyse the G+11 Multi-Storey Commercial building using M30 Grade of concrete according to IS 1893-2016(part 1) code and studying response using flat slab having drop panel , & different types of braced system and shear wall.
2. Second, in seismic zone V, examine the parameters of a multi-story structure with a flat slab, including storey displacement, drift, and base shear.

IV. METHODOLOGY

The purpose of this study is to examine the effects of earthquakes on 12 framed models. In order to produce the models for the G+11 building, the programmers use ETABS. The standard height of each level is 3.6 meters. Seismic studies conform to IS 1893 - 2016 'Part I' code. The soil is medium in both seismic zones II and V.

The dead load is applied in accordance with IS 875, Part I specifications. We use live loads in accordance with IS 875 Part II standards.

Application of earthquake load in accordance with IS 1893 - 2016 standards. Seismic analysis is performed using RSA.

After calculating and tabulating variables such storey drift, displacement, and base shear, we can visually compare our findings by drawing parallels between them.

1) The purpose of this research is to examine the effects of a seismic event on framed 12-story building.
2) Each model of the structure will undergo lateral load study.
3) In-depth seismic study of each model allows for the examination of several elements, including drifting floors, displacement, and time.
4) This process culminates in selection of most optimal model.

4.1 DESCRIPTION OF MODELS:

Here a total of six models are prepared.

1) Multi storey building of flat slab with X bracing at corner side of building
2) Multi storey building of flat slab with V bracing at corner side of building
3) Multi storey building of flat slab with X bracing at corner side and at the centre of building
4) Multi-storey structure of flat slab with L-type shear wall
5) Multi-storey structure of flat slab with straight type shear wall
6) Multi-storey structure of flat slab with Box type shear wall

4.2 Load applied: Gravity loads:

1. Live load = $4kN/m^2$
2. Dead load = $6.25kN/m^2$

3. Earthquake inputs as per IS 1893 (Part 1): 2016: Soil type-II, Importance factor-5, Seismic zone-V

4.3 GEOMETRY OF THE MODELS

1. Considered structures are 12 story moment resistance frame structures.
2. The story height is 3.6m and base 2m
3. Structure height is 41.6m
4. Number of Bays in X- & Y-direction is 7
5. Spacing of columns along X-direction is 4m & along Y-direction is 5m
6. Columns size 600mmx600mm
7. Size of the building 24mx30m
8. Section property for X Bracing: ISMB 200
9. Thickness of flat slab is 200mm
10. Size of the drop panel is 2mx2m
11. Thickness of drop panel is 250mm
12. Thickness of shear wall taken: 250mm

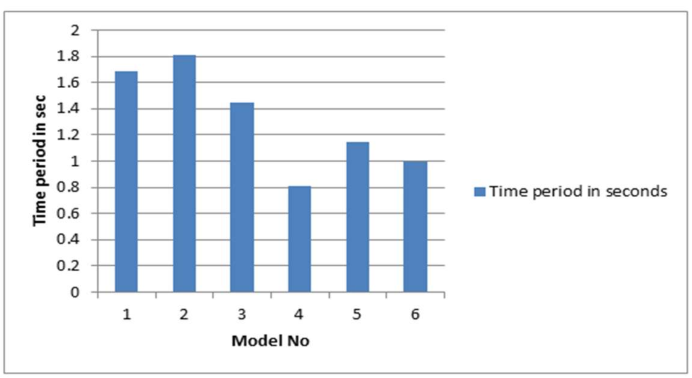
4.4 MATERIAL PROPERTIES

PROPERTIES	VALUES
Concrete Young's modulus	25×10^6kN/m²
Reinforced concrete density	25 kN/m²
Steel density	76.59 kN/m³
Poisson's ratio of steel	0.3
Concrete Grade	M30
Steel Grade	Fe 500

V. RESULT AND DISCUSSION

Response Spectrum techniques are used to analyze various structural models. We use ETABS software to analyze wide variety of model structures. We present andanalyze findings of inquiry, including things like degree to which each model of structure shifted in height & direction.

5.1 Time Period: Its described as time it takes for completing a cycle of vibration to move to very particular point.

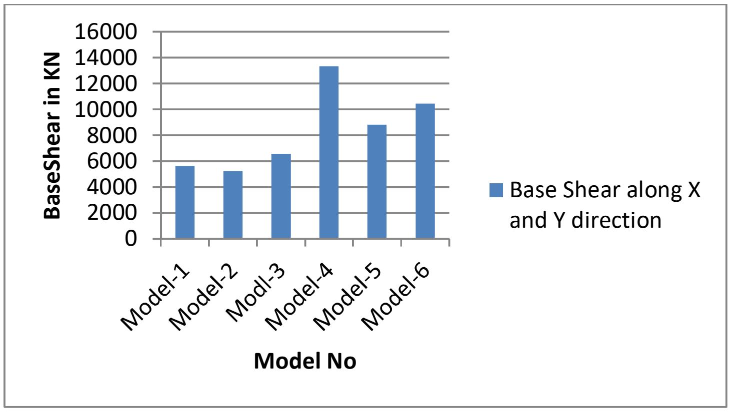


Graph 1: Maximum time period of all models

From the above graph it is observed that:

1. Time period for Cross bracing is 8% less than the V-bracing and time period for V bracing is 55% more than the L-type shear wall in zone V.
2. Time period for Straight Shear wall is 13.16 % more than box Type Shear wall in zone V.

5.2 Base shear: It's an approximation of most anticipated lateral forces so as to arise because of seismic floor movement at the bottom of a structure.



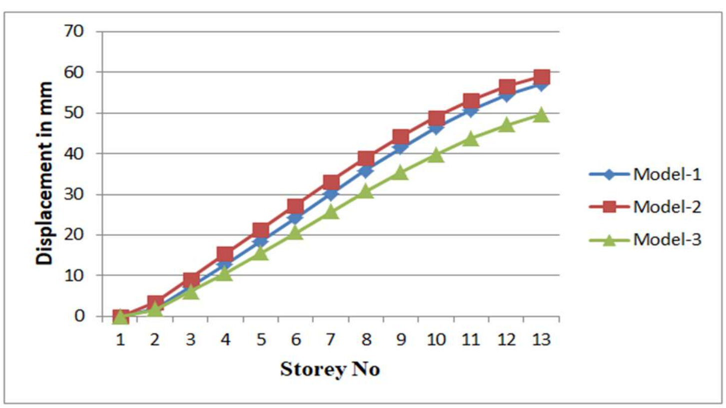
Graph 2: Maximum Base Shear of all models in zone-V

From the graph it is noticed that Base Shear of Cross bracing (model-1) is 6.76 % more than the V bracing (model-2) and 16.95 % less than the model-3 & base shear of L-type shearwall (model-4) is 33.78 % more than the straight type shear wall (model-5) and 21.58% more than the box type shear wall (model-6) in zone V.

5.3 Displacement: Storey displacement is defined as its displacement of considered floor with reference to base of building, usually base of a building being aground.

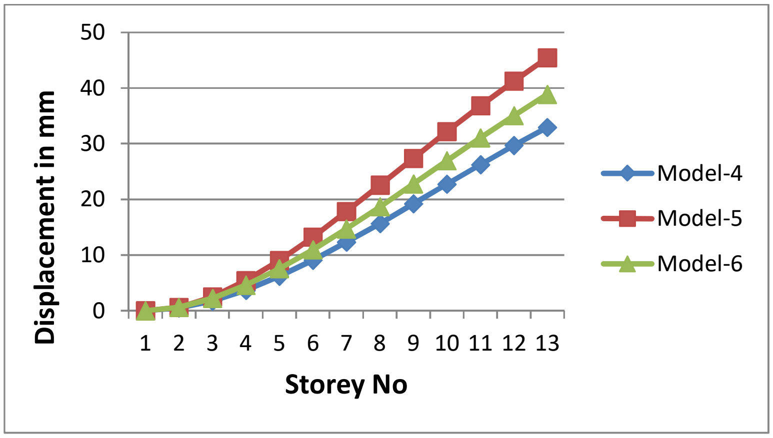
Deflection limit is H/500 here H-is structure height as per clause 5.6.l Indian standard -800:2007

Allowable deflection is 41.6/500=0.0832m = 83.2mm



Graph 3: Storey wise displacement for model 1, 2 and 3 in X-direction

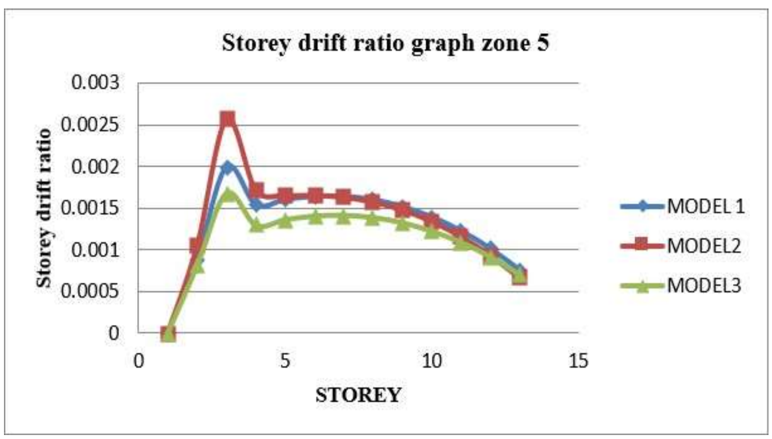
From the graph it is seen that Storey displacement uniformly increasing when Cross bracing is provided with every floors. When we go with cross bracing in model-1 there is a 3% less displacement compare to V-bracing in model-2.when we go with cross bracing at corner and at Centre in model-3 there is a 13.34% less displacement compare to model-1



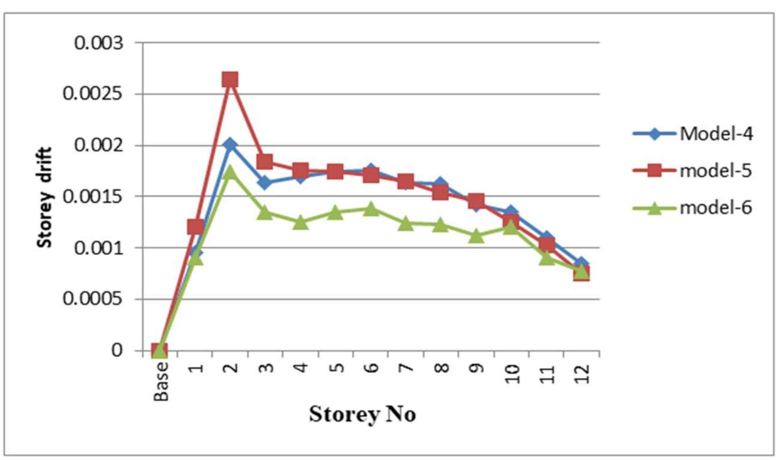
Graph 4: Storey wise displacement for model 4,5 and 6 in X-direction

From the graph it is observed that when we go with L-type shear wall the displacement is less compared to other models. When we go with straight type shear wall there is an increase in displacement of about 37.74%, and when we go with box type shear wall there is an increase in displacement of about 17.75% compared to model-4 in seismic zone-V

5.4 Storey Drift: Maximum allowable drift for any building is =0.004H. For our models greatest permissible drift = 0.004*3.6=0.014m = 14mm



Graph 5: Storey wise storey drift for model 1, 2 and 3



Graph 6: Storey wise storey drift for model 4, 5 and 6

VI. SUMMARY AND CONCLUSION

Current research is to investigate seismic analysis of tall building located in zone II and zone-V. In study all important parameter like time period, base shear, storey displacing & drifting for the different models which is included that flat slab with bracing system and shear wall at different location.

1. Time period for Cross bracing is 8% less than the V bracing and time period for Vbracing is 55% more than the L shaped shear wall in zone V.
2. Time period for Straight Shear wall is 13.16% more than Box Type Shear wall in zone V.
3. Base shear of Cross bracing is 6.76% more than the V bracing & base shear of L Shaped shear wall is 33.78 % more than the straight shear wall in zone V.
4. Base shear for Box Type shear wall is 18.42% more than the Straight Shear wall in zone V.
5. Storey displacement uniformly increasing when Cross bracing is provided inevery floor. From model 1 i,e Cross bracing is 3% less than the V bracing in zone V.
6. Storey displacement uniformly increasing whenever shear wall is provided inevery floor. From model 5 i,e Straight Shear wall is 17.9 % more than the Box Type Shear wall in zone **V**.
7. Most of drifting storey values are below threshold of 0.004 times floor height allowed by IS 1893:2016 (part 1) in zone V.

6.1 Scope for further study:

1. Current research assesses Response spectrum analysis, later in future study can be performed via time history and push over analysis.
2. Outcomes of all the models in Etabs will be compared. The study undertaken is performed under seismic zone 5 and zone 2, later in future study might be performed in other zones.
3. The work can be carried out by taking different dimension.

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