CAPACITY SPECTRUM ANALYSIS OF R.C.C STRUCTURE WITH & WITHOUT SHEAR WALL IN PLAN SYMMETRY & ASYMMETRY

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***Abstract*: The capacity spectrum analysis is a widely used technique in earthquake engineering to evaluate the seismic performance of reinforced concrete structures. In this study, the capacity spectrum analysis was applied to compare the seismic behavior of reinforced concrete structures with and without shear walls, both in plan symmetry and asymmetry. The study utilized a numerical model of a 10-story reinforced concrete building, designed according to the Indian Standard Code of Practice for seismic design. The model was subjected to a set of ground motion records with different seismic intensities, and the seismic response was evaluated using the capacity spectrum analysis.**

The results of the study revealed that the presence of shear walls significantly enhanced the seismic performance of the building, reducing the displacement and acceleration response to seismic loads. Furthermore, the presence of plan symmetry in the building layout resulted in improved seismic performance compared to asymmetric layouts. The study also highlights theimportance of considering the higher modes of vibration in the capacity spectrum analysis, especially for asymmetric structures, as the higher modes significantly contribute to the seismic response. Overall, this study demonstrates that the capacity spectrum analysis is a useful tool for evaluating the seismic performance of reinforced concrete structures with and without shearwalls, and can aid in the design of more earthquake-resistant structures.

***Keywords*: Shear wall, pushover analysis, capacity spectrum analysis, RCC structure**

INTRODUCTION

GENERAL: –

Amongst the natural hazards, earthquakes have the potential for causing the greatest damages.Since earthquake forces are random in nature & unpredictable, the engineering tools needs to be sharpened for analyzing structures under the action of these forces. In recent times, world has some severe earthquake, which suggest that the level of ground acceleration is increased as compared to past. Therefore there is need to assess the capacity of the structure and take the necessary measure to improve the capacity of them as and when required. Although an elasticanalysis provides a good estimation of the elastic capacity of structure and indicates where first yielding will occur, it cannot predict failure mechanism and account for redistribution of forcesduring progressive yielding. Inelastic procedure help demonstrate how building really behaveby identifying modes of failure and the potential for progressive collapse. Since structure willrespond to the earthquake induced ground motion in an inelastic manner, the linear elastic equivalent lateral procedures do not provide a direct method to assess the resulting maximum displacement and true failure modes. Capacity Spectrum Method is gaining a new dimension in the non-linear static analysis wherein pushover analysis and response spectra is to be considered. The Capacity Spectrum Method (CSM) was first introduced in the 1970s as a rapid evaluation procedure in a pilot project for assessing seismic vulnerability of buildings at the Puget Sound Naval Shipyard. In the 1980s, it was used as a procedure to find a correlation between earthquake ground motion and building performance.

The method was also developed into a design verification procedure for the Tri services (Army,Navy, and Air Force) "Seismic Design Guidelines for Essential Buildings" manual (Freeman et al., 1984; Army, 1986).

Capacity Spectrum Method is seismic Analysis philosophy wherein pushover analysis and response spectra are to be considered. The procedure compares the capacity of the structure (in the form of a pushover curve) with the demands on the structure (in the form of response spectra). The graphical intersection of the two curves approximates the response of the structure. In this context capacity spectrum analysis, which is an iterative procedure shall be looked upon as an alternative for the orthodox analysis procedures.

In order to use the Capacity Spectrum Method, it is necessary to convert the capacity curve obtained from pushover

analysis in terms of base shear V_b and roof displacement $\Delta_{roof}$to the capacity spectrum. Capacity spectrum is the representation of the capacity curve in ADRS(Acceleration Deformation Response spectra) format. To get the demand spectrum Response spectrum is converted from the standard S_a vs. T into ADRS format. After getting the Capacity spectrum and Demand spectrum curve they are superimpose with each other to get the performance point. The performance point gives the behavior of structure to earthquake.

This study focuses on pushover analysis (Capacity spectrum) & Response spectrum (Demand spectrum) of multi-storey RC framed buildings. To develop pushover analysis the building subjecting them to monotonically increasing lateral forces with an invariant height wise distribution until the preset performance level (target displacement) is reached. Pushoveranalysis is a static, nonlinear procedure in which the magnitude of the structural loading is incrementally increased in accordance with a certain predefined pattern. With the increase in the magnitude of the loading, weak links and failure modes of the structure are identified. Staticpushover analysis is an attempt by the structural engineering profession to evaluate the real strength of the structure and it promises to be a useful and effective tool for performance-baseddesign. In the capacity spectrum method, the multi-story buildings are converted into the equivalent single degree of freedom (1-DOF) systems based on the outputs of pushover analysis. And the structural performance of buildings is represented by a base shear versus horizontal displacement relationship of the equivalent 1-DOF systems. The relationship is referred to as the capacity spectrum.

R.C.C STRUCTURE: -

Reinforced Concrete Cement (RCC) is a common material used for construction of buildings.A typical RCC building structure consists of a foundation, columns, beams, and slabs. The foundation is the lowest part of the building that distributes the load of the building to the ground. The foundation is usually made of concrete and is designed to transfer the load of thebuilding to the soil. Columns are vertical members that support the weight of the beams and slabs. They are made of reinforced concrete and are usually placed at regular intervals throughout the building.

Beams are horizontal members that support the weight of the slab and transfer it to the columns.They are also made of reinforced concrete and are placed between the columns. Slabs are the floors and ceilings of the building. They are supported by beams and columns and are made ofreinforced concrete. The combination of these elements provides a strong and durable structurethat can withstand the weight and stress of the building. The size and shape of each element are designed based on the load it will carry, and the building codes and standards set by local authorities.

The major criteria now-a-days in designing RCC structures in seismic zones is control of lateraldisplacement resulting from lateral forces. In this thesis effort has been made to investigate theeffect of Shear Wall position on lateral displacement and Base Shear in RCC Frames. RCC Frames with stilt + G+4 are considered with varying shear wall levels and increased stilt column dimensions. Non-linear static analysis (pushover analysis) was carried out for the frames and the frames were then compared with the push over curves. Displacement and Baseshear is calculated from the curves and compared. The nonlinear analysis of a frame has become an important tool for the study of the concrete behavior including its load-deflectionpattern and cracks pattern. It helps in the study of various characteristics of concrete member under different load conditions.

SHEAR WALL: -

A shear wall is a structural element in a building that is designed to resist lateral forces such aswind or earthquake loads. It is typically a vertical wall that is designed to provide additional stiffness and strength to the building. Shear walls are commonly made of reinforced concrete or masonry and are strategically placed throughout the building to provide a continuous load path from the roof to the foundation. They can be placed at the perimeter of the building or inthe interior, depending on the building design and load requirements.

The primary function of shear walls is to resist lateral loads that are perpendicular to the planeof the wall. When a lateral load is applied to the building, the shear wall absorbs the force andtransfers it to the foundation, which then distributes the load to the soil. This helps to prevent the building from overturning or collapsing during an earthquake or high winds. Shear walls are often designed to work in combination with other structural elements such as columns, beams, and slabs, to provide a robust and resilient building structure. The design of shear wallsis highly dependent on the building code and standards set by local authorities, as well as the specific requirements of the building design and location.

1.5 CAPACITY SPECTRUM METHOD OF ANALYSIS: -

The Capacity Spectrum Method (CSM), a performance-based seismic analysis technique, canbe used for a variety of purposes such as rapid evaluation of a large inventory of buildings, design verification for new construction of individual buildings, evaluation of an existing structure to identify damage states, and correlation of damage states of buildings to various amplitudes of ground motion. The procedure compares the capacity of the structure (in the form of a pushover curve) with the demands on the structure (in the form of response spectra).The graphical intersection of the two curves approximates the response of the structure. The purpose of Performance-Based Seismic Design (PBSD) is to give a

realistic assessment of howa structure will perform when subjected to either particular or generalized earthquake ground motion. While the code design provides a pseudo-capacity to resist a prescribed lateral force, this force level is substantially less than that to which a building may be subjected during a postulated major earthquake. It is assumed that the structure will be able to withstand the majorearthquake ground motion by components yielding into the inelastic range, absorbing energy, and acting in a ductile manner as well as by a multitude of other actions and effects not explicitly considered in code applications. The Capacity Spectrum Method (CSM) is a procedure that can be applied to PBSD. The CSM was first introduced in the 1970s as a rapid evaluation procedure in a pilot project for assessing seismic vulnerability of buildings at the Puget Sound Naval Shipyard. In the 1980s, it was used as a procedure to find a correlation between earthquake ground motion and building performance (ATC, 1982). The method was also developed into a design verification procedure for the Tri-services (Army, Navy, and AirForce) "Seismic Design Guidelines for Essential Buildings" manual (Freeman et al., 1984; Army, 1986). The procedure compares the capacity of the structure (in the form of a pushovercurve) with the demands on the structure (in the form of a response spectrum). The graphical intersection of the two curves approximates the response of the structure. In order to account for non-linear inelastic behavior of the structural system, effective viscous damping values areapplied to the linear-elastic response spectrum similar to an inelastic response spectrum. In themid 1990s, the Tri-services manual was updated by converting the base shears and roof displacements from a non-linear pushover to equivalent spectral accelerations and displacements and superimposing an earthquake demand curve, the non-linear pushoverbecomes a capacity spectrum. The earthquake demand curve is represented by response spectra, plotted with different levels of "effective" or "surrogate" viscous damping (e.g. 5%, 10%, 15%, 20% and sometimes 30% to approximate the reduction in structural response due to the increasing levels of damage). By determining the point, where this capacity spectrum "breaks through" the earthquake demand, engineers can develop an estimate of the spectral acceleration, displacement, and damage that may occur for specific structure responding to a given earthquake. A number of changes have been proposed to the capacity spectrum method that increase the complexity and computational effort associated with this method, usually requiring iteration to find the "exact" point where the capacity spectrum intersects the "correct"level of damping. The author believes that iteration is unnecessarily complex and clumsy for the intended use of this procedure. Rather, the author views the capacity spectrum method as atool for estimating and visualizing the likely behavior of the structure under a given earthquakein a simple graphical manner. By formatting the results in the acceleration- displacement response-spectrum format in lieu of the traditional spectral acceleration (Sa) versus period (T) format, the graphical and intuitive nature of the capacity spectrum method become even more apparent.

ORIGIN OF THE CSM

The CSM can trace its roots to John A Blume's Reserve Energy Technique (RET) (Blume et al., 1961), which estimated the inelastic displacement by equating elastic energy (or work) withinelastic energy (or work) as illustrated in Figure 1. In other words, the area within the green trapezoid is equated to the area in the red triangle. The green line plateau is equal to the peak of the triangle divided by R. The ductility, μ (mu), is equal to the displacement at the end of the green line divided by the displacement at the bend in the green line. In the example shownin Figure 1, the elastic period is 0.70 sec and the inelastic secant period is 1.4 sec. The μ is equal to 4.0 and R is equal to 2.65. It should be noted that this procedure is consistent with theforce/acceleration reduction factor R = (2μ − 1)½ associated with Newmark's equation for theconstant acceleration range of response spectra.

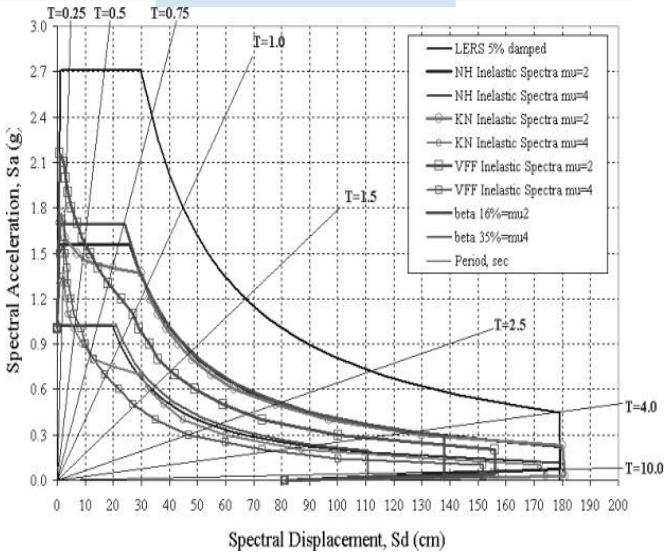


Fig 1. 1 Spectral Displacement, Sd (cm)

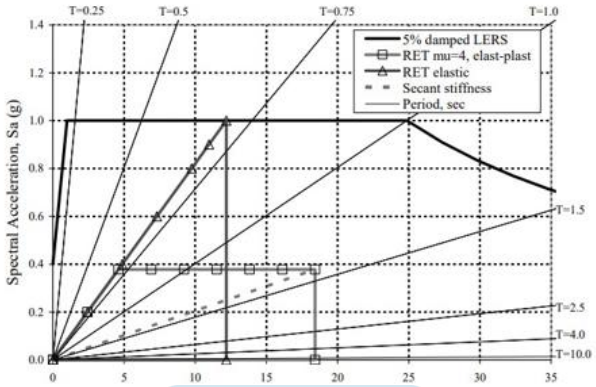


Fig 1. 2 Inelastic response spectra and damped spectra

LITERATURE REVIEW

In literature review we will study the research papers which are related to capacity spectrum methodfor R.C.C. building to determine the performance level of structure subjected to earthquake.

"RESPONSE SPECTRUM ANALYSIS OF SYMMETRIC AND ASYMMETRICSTRUCTURES IN SEISMIC ZONES" by Shruthi Indaragi1, at IRJET (2019)

In this paper the different irregularities if structure are listed like plan irregularity and verticalirregularity. The objective of the study is To study the response spectrum method for Analysis of symmetric and asymmetric building structures and to study the effect of plan irregularity on the fundamental natural period of the building, its effects on performance of the structure during earthquake for different building models. Analyzing the regular and irregular structure and Comparing the response parameters for both structures.

The various conclusions are Story shear has maximum values in all cases in irregular building as compared to regular structure due to earthquake forces in seismic zones. Displacement in X and Y direction increases with Increase in height of the structure in both buildings. Displacement is more in asymmetric structures as compared to symmetric structures in all zones. Storey drifts are Maximum insymmetric structures G+12 and G+15 and increases with increase in height of the structure in both zones. Overturning moment has maximum values in symmetric structures for G+15 at zone3 due to maximum number of storeys. Moment has maximum values in asymmetric structure or G+12 at zones 3&4 and for G+15at zone4 respectively. From results and graphs observed that maximum displacement, storey drifts, storey shear, and moments occurs in asymmetric structures not in regular building due to earthquake forces and irregularity of structures.

"COMPARATIVE ANALYSIS ON ASYMMETRICAL AND SYMMETRICAL STRUCTURES SUBJECTED TO SEISMIC LOAD" by N. Lingeshwaran, at el (2018)

The Objective Of Study Is To study the performance of different structures on application of loads. Analysis of buildings in ETABS software for storey drift, displacement of symmetric and asymmetric structures. Comparing storey displacement and storey drift.

Here the study is carried out with different shapes for G + 9 building behavior. For the modelling general software ETABS was used. More user-friendly and versatile program offering a wide range of features such as static and dynamic analysis, non-linear dynamic analysis and non-linear static pushover analysis, etc.The Conclusion O fthe Study Was Symmetrical building perform better than asymmetrical buildings. As per results shown above T shaped building is more susceptible to seismic load compared to symmetrical building. The storey displacement at the first floor is relatively lower when compared to that of the top floor. L shaped and H shaped buildings are showing similar displacement under seismic load. Displacement is less for symmetric building than asymmetric building.

"STRUCTURAL ANALYSIS OF MULTISTORY BUILDING OF DIFFERENT SHEAR WALLS LOCATION AND HEIGHTS" by Ms. Priyanka Soni1*, at IJETT (2016)

In this paper the different purposes of providing the shear wall in explained. The stiffness of the shear wall, just like its strength, depends on the combined stiffness of its three components: lumber, sheathing and fasteners. The size and grade of end stud(s), thickness and grade of sheathing, and the sheathing fastener diameter determine how flexible a wood shear wall will be. When present, holdown devices also contribute to the overall stiffness of the shear wall. If holdown devices stretchor slip, the top of the shear wall will move horizontally. This horizontal movement adds to the movement allowed by the lumber, sheathing and fasteners. Any additional movement from the holdown will reduce the effective stiffness of the shear wall.

In this chapter a multistory building has been modelled and analyze with considering all loads like Dead load, Live load, Wind Load as per as Is standard and Seismic load as per as IS standard. With Deferent Position Of Shear wall
In this project it is concluded that the G+10 structure shear wall is generated less value of von-misses stress and deformation on structure at location 1 as compare to location 2.

"PUSHOVER ANALYSIS OF R.C. FRAME BUILDING WITH SHEAR WALL" by Nitin Choudhary1 at IOSR (2014)
In this paper the description of pushover analysis FEMA, ATC 40 are given. Also, different methodsof pushover analysis such as inelastic component behavior, Capacity spectrum method, Time history method are explained. Analysis in done for given building and conclusions are Provision of shear wall results in a huge decrease in base shear and roof displacement both symmetrical building and un-symmetrical building. In L-shaped building when shear wall is provided on the larger side of the building results in a decrease of 4.3% in base shear and 58.15% in roof displacement and when provided on smaller side results in a decrease of 7.97% in base shear and 55.43% in roof displacement. Hence in unsymmetrical buildings shear wall must be provided on smaller side of building. The performance based seismic design obtained by above procedure satisfies the acceptance criteria for immediate occupancy and life safety limit states for various intensities of earthquakes. Performance based seismic design obtained leads to a small reduction in steel reinforcement when compared to code based seismic design (IS 1893:2002) obtained by STAAD.Pro.

"PERFORMANCE BASED ANALYSIS OF R.C.C. FRAMES" by *Mrugesh D. Shah at*
NCRTET (2011)
It is limit states design extended to cover complex range of issues faced by earthquake engineers. Two typical new R.C.C. buildings were taken for analysis: G+4 and G+10 to cover the broader spectrum of low rise & high-rise building construction. Different modelling issues were incorporated through nine model for G+4 building and G+10 building were; bare frame (without infill), having infill as membrane, replacing infill as a equivalent strut in previous model. All three conditions for 2×2, 3×3, 4×4 bays. Comparative study made for bare frame (without infill), having infill as membrane, replacing infill as an equivalent strut.
From the results for G+4 and G+ 10 stories in bare frame without infill have lesser lateral load capacity (Performance point value) compare to bare frame with infill as membrane and bare frame with infill having lesser lateral load capacity compare to bare frame with Equivalent strut.

METHODOLOGY

Following is flowchart of work for Project: -

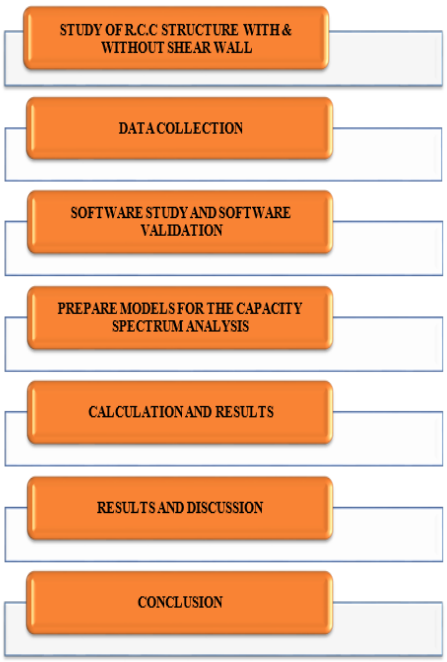


Fig 3. 1Flowchart.

PROBLEM STATEMENT

Employing ETABS Software, a dynamic analysis using the response spectrum approach is created for a G+8 irregular L-shaped structure with several shear wall sites. Understanding thefunctioning of a structure based on the magnitude of the earthquake beneath the various kindsof ground on which it is constructed. In Study IS1893 (Part 1), the years 2016 and IS875 wereused, and the outcomes were compared.

Most frequently used software packages in architecture include the capacity to build uniaxial springs representing support flexibility. Nonetheless, some cannot simulate compression-onlystructures that may be adequate for non-embedded foundations (e.g., Surface). Advanced systems allow for a range of spring assumptions and arguments, as well as a mix of basic inputand three-line interactions.

Preliminary data required for Analysis: -

5 bays	**4**	m each , in X -direction	X - Span =	**20**	m
5 bays	**4**	m, each in Y-direction	Y - Span =	**20**	m
9 storey	**3**	m, each in Z - direction	Total Height =	**30**	m
Plinth height; h =	**3**	m			
Assuming, depth of slab; D =	**0.12**	m			

Shear Wall -250mm Width

Gravity Loads:

Dead Load =	self-weight of structure		
Live Load =		**2.5**	kN/m^2
Floor Finish =		**0.5**	kN/m^2
Roof Finish =		**0.5**	kN/m^2
Infill walls =	Not considered		

Seismic Parameters:

Zone factor, Z =	**0.36**
Importance Factor, I =	**1**
Natural Period, T_{nx} =	**0.96**
T_{ny} =	**0.96**
Soil type, $(S_a/g)_x$ =	**1.04**
$(S_a/g)_y$ =	**1.04**
Response Reduction Factor, R =	**5**

Material Properties:

Concrete, M	**30**
Rebar, Fe	**500**

Section Properties:

length of beam in X - direction =	**4**	m	assuming; L/D = 12	
			D ~	**0.33**
			D =	**450**
			b >	**150.00**
			b =	**300**
Beam cross-section;	**300**	**x**	**450**	
length of beam in Y - direction =	**4**	m	assuming; L/D = 12	
			D ~	**0.333**
			D =	**450**
			b >	**150**
			b =	**300**
Beam cross-section;	**300**	**x**	**450**	
Column cross-section;	**450**	**x**	**600**	

RESULT AND DISCUSSION

The analysis of the seismic performance of reinforced concrete structures has been a subject ofextensive research over the past few decades. The capacity spectrum analysis is a widely accepted method for evaluating the seismic performance of structures. It involves the use of astructural capacity curve, which represents the capacity of a structure to resist seismic loads asa function of the inter-story drift. This method is used to compare the seismic performance of different structural systems and to identify the most efficient design strategies. In this chapter,we present the results and discussion of the capacity spectrum analysis of reinforced concrete structures with and without shear walls in plan symmetry and asymmetry. The purpose of thisstudy is to investigate the effects of shear walls on the seismic performance of reinforced concrete structures in plan symmetry and asymmetry. We have considered a range of structural configurations, including structures with and without shear walls, as well as those with plan symmetry and asymmetry. Overall, the results and discussion presented in this chapter provide valuable insights into the seismic performance of reinforced concrete structures with and without shear walls in plan symmetry and asymmetry. The findings can be used to inform the design of more efficient andeffective structural systems for seismic-resistant buildings.

5.1 Case No 1 – Symmetrical Building Without Shear Wall Prepare Model in ETABS: -

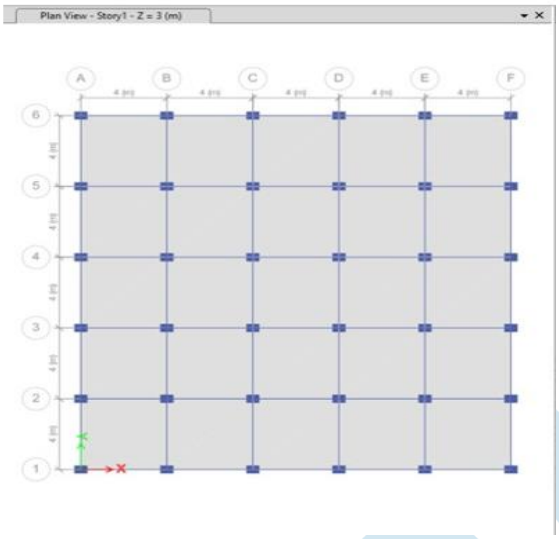


Fig 5. 1 Symmetrical plan view model

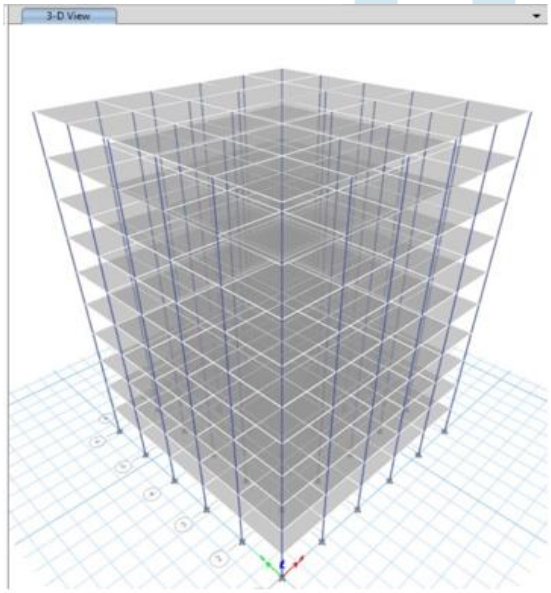
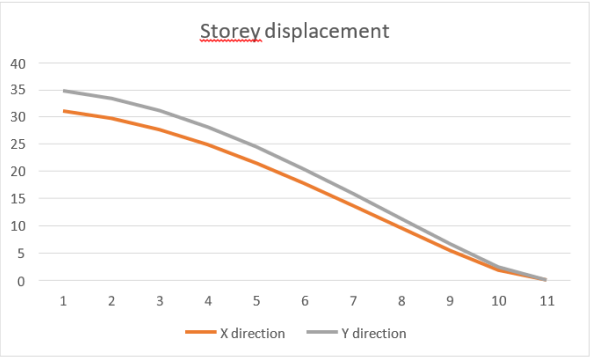


Fig 5. 2 Symmetrical 3D view model

- **Results Displacement**

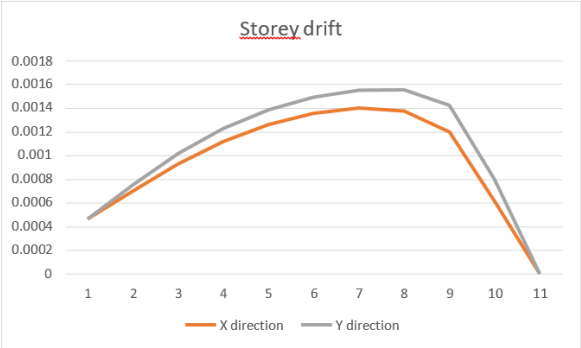


Graph 5. 1 Storey displacement

The graph shows the storey displacements in the X and Y directions for a symmetrical buildingmodel without a shear wall. The building has 9 stores, with the ground floor being denoted as storey 0 and the top floor as storey 9. The

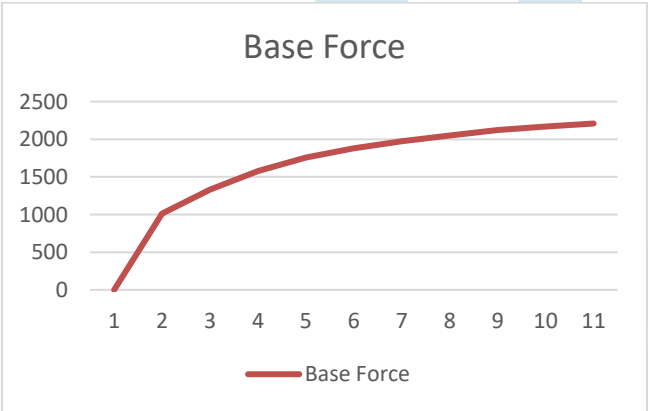
displacement is the amount of movement or deformation that the building experiences in response to external loads, such as earthquakes orwind. The X direction refers to the direction along the length of the building, while the Y direction refers to the direction perpendicular to the length of the building. Therefore, the displacements in the X direction represent the lateral movement of the building, while the displacements in the Y direction represent the vertical movement of the building.

- **Storey drift**



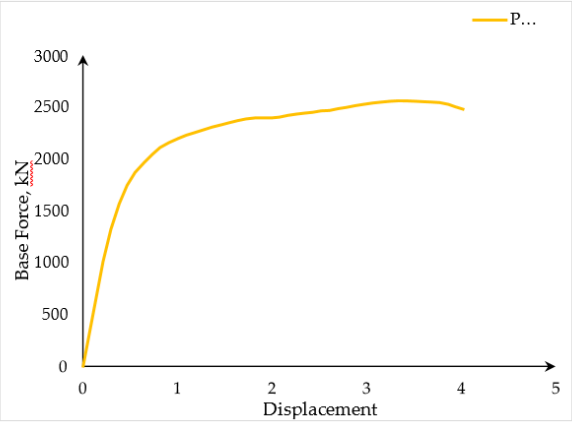
The given information is related to a symmetrical building model with a shear wall, and it describes the storey drift for each level in the X and Y directions. Storey drift refers to the lateral displacement or movement of a particular floor or storey of a building due to external loads such as wind or seismic activity. In this model, the storey drift is presented in units of length, and the results show that as we move up the building from the ground floor (storey 0) to the top floor (storey 10), there is an increase in the amount of drift in both X and Y directions.The values for storey drift in the X direction range from 0.00046 at the top floor to 0 at the ground floor. In the Y direction, the drift values range from 0.000462 at the top floor to 0 at the ground floor. This suggests that the building is more prone to lateral displacement in the Xdirection as compared to the Y direction.

- **Storey shear**

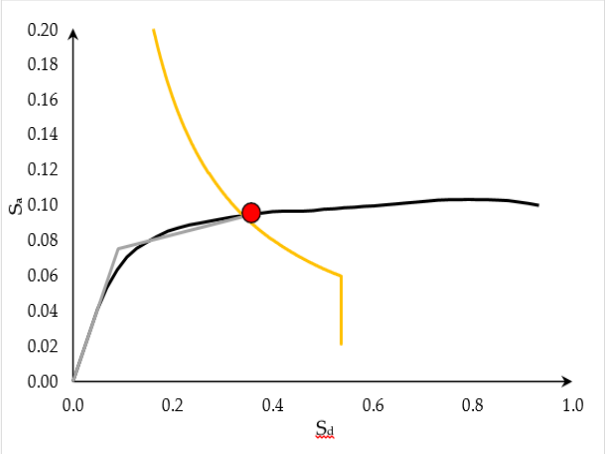


The graph you provided represents the base forces acting on each storey of a symmetrical building model that does not have a shear wall. The base forces are measured in units of kN (kilonewtons). The symmetrical model without a shear wall is a type of structural system where the loads are distributed equally across all the columns and beams in the building. This results in a symmetrical distribution of forces throughout the building, which is reflected in the graph. The base force values increase as you move down from the top floor to the ground floor. This is because the weight of the building and any loads it is supporting are transmitted downwards through the columns and beams to the foundation.

Pushover curve



Performance Point



- **Symmetrical building with shear wall**

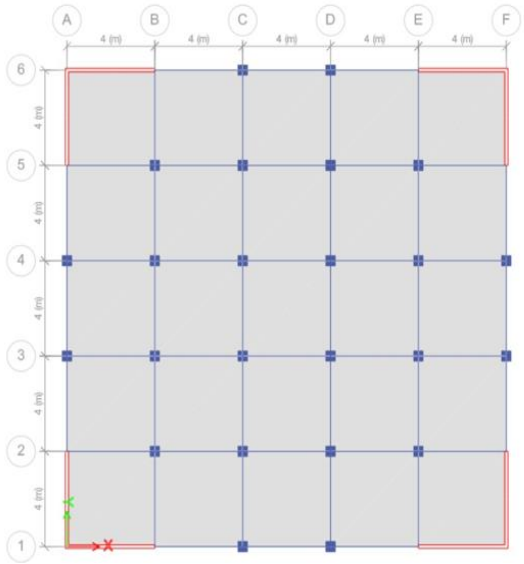


Fig 5. 3 Symmetrical plan view model with shear wall

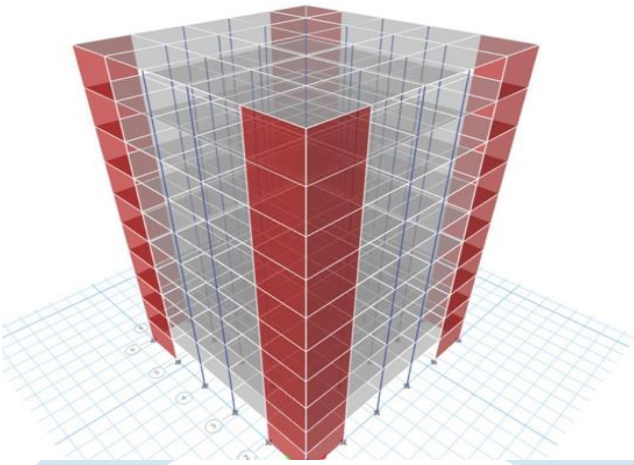
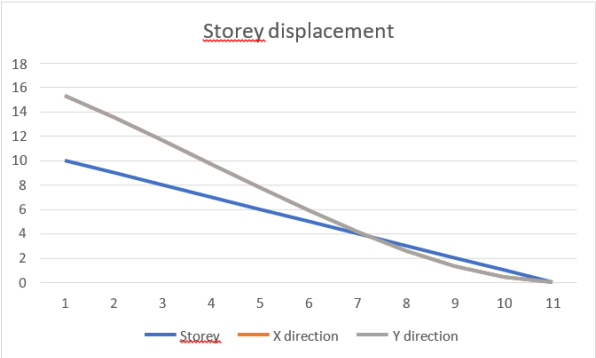


Fig 5. 4 Symmetrical 3D view model with shear wall

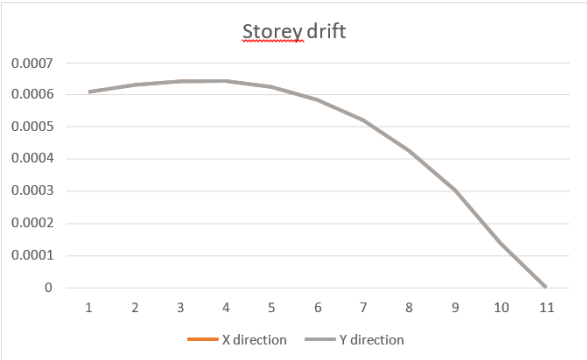
- **Displacement**



Graph 5. 2 Storey displacement

The provided data is related to a symmetrical building model with a shear wall. The Displacement In Building is Less than Building Without Shear Wall. The data shows the storeydisplacements in the X and Y directions for each of the 9 storeys of the building. The term "symmetrical" suggests that the building model is designed to be balanced in terms of its geometry, structural elements, and load distribution. This is important for ensuring that the building behaves predictably under loading and doesn't suffer from unbalanced forces that could lead to instability or failure. The presence of a "shear wall" suggests that this building model includes a wall or walls designed to resist lateral loads such as wind or earthquake forces.Shear walls are typically made of reinforced concrete or masonry and are placed at strategic locations throughout the building to provide resistance against lateral loads. The storey displacements provided in the graph show how much each storey of the building moves or deforms in the X and Y directions under load. The values are given in millimetres or inches, depending on the unit system used.

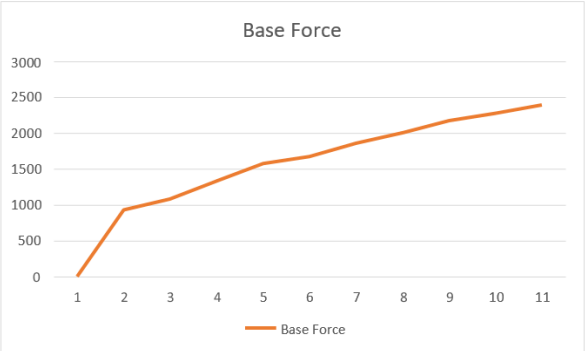
- **Storey drift**



The data provided is related to a symmetrical building model that includes a shear wall system.The values represent the

storey drift of the building in the X and Y directions, which are important indicators of the building's lateral stability during seismic events. Storey drift is thelateral displacement or deformation of a building's floor relative to its base, caused by lateral loads such as wind or earthquake. It is an important parameter to consider in the design and analysis of buildings, as excessive drift can result in damage or even collapse during extreme events.

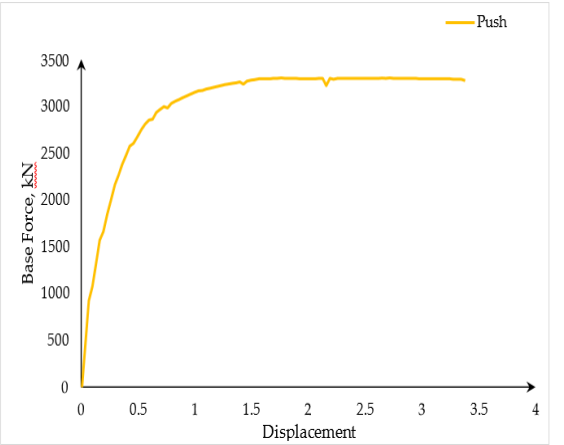
- **Storey shear**



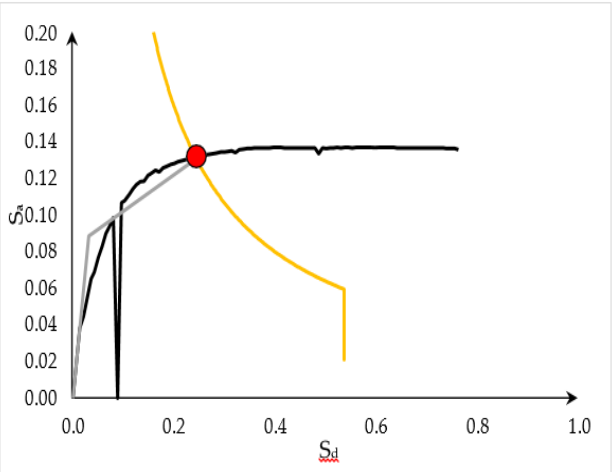
Graph 5. 3 Storey shear

The graph appears to be displaying the base shear forces for a symmetrical building model thatdoes not have any shear walls. The model has ten stories, with the ground level being labelledas "0" and the top level being labelled as "9." The values in the "Base Force" column representthe amount of force in kips (a unit of force commonly used in engineering) that each level of the building would experience in the event of a seismic or other lateral force. The base force for the ground level (Level 0) is the highest, at 2387.25 kips, and the forces gradually decreaseas you move up the building, with the force at the top level (Level 9) being 0 kips.

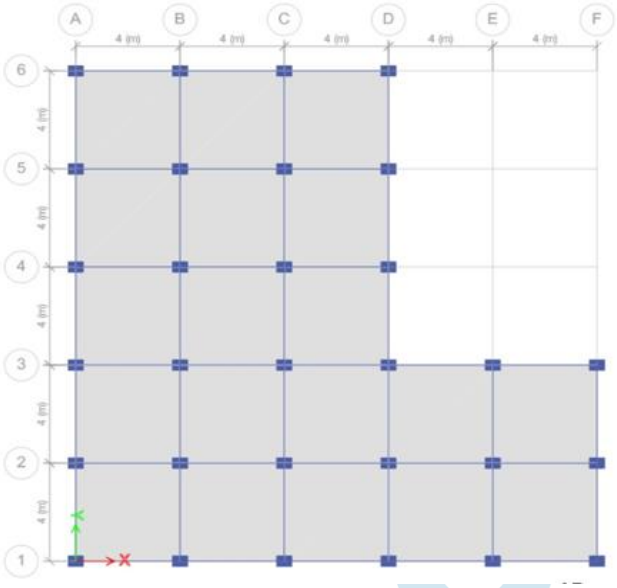
- **Pushover curve**



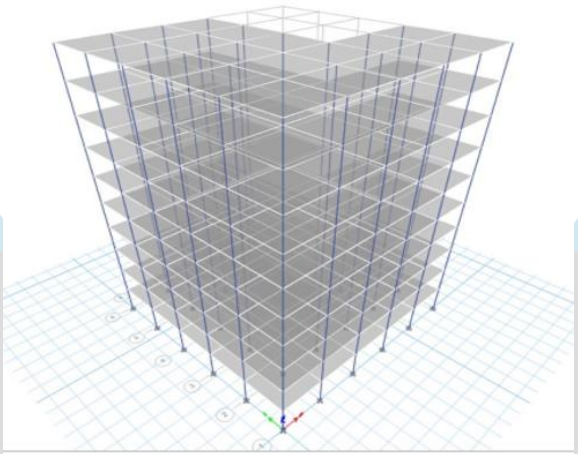
performance point



- **Asymmetrical building**

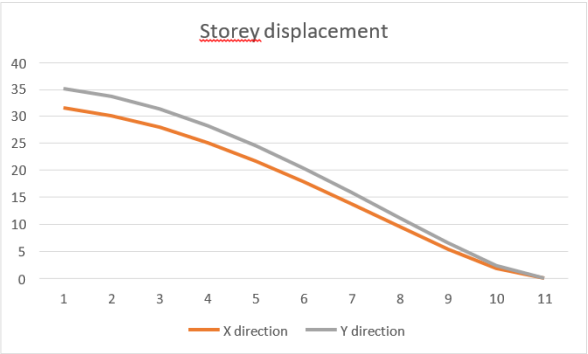


Graph 5. 4 Asymmetrical plan view model



Graph 5. 5 Asymmetrical 3D view model

Displacement

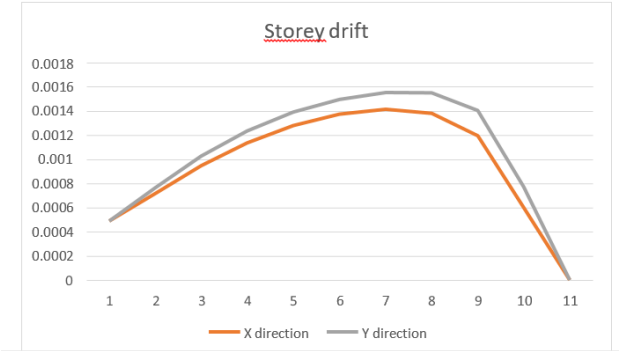


Graph 5. 6 Storey displacement

This data represents the storey displacement of a 9-storey building in the X and Y directions, where there is no shear wall to resist lateral loads. The displacement values are provided for each storey, with the highest displacement occurring at the top storey (storey 9) and graduallydecreasing as we move towards the bottom. This is expected because

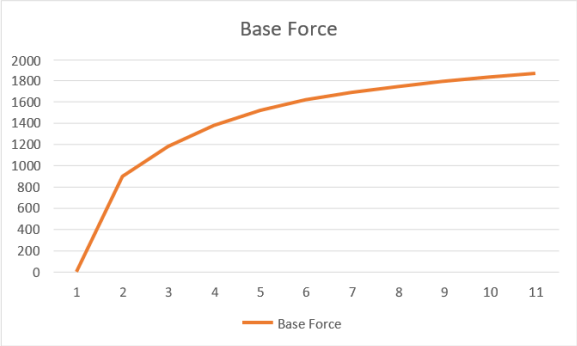
the top floors of the building experience greater lateral loads due to their increased height and less restraint from the lower floors. The maximum displacement values for the building are 31.557 mm in the X direction and 35.048 mm in the Y direction, which occur at storeys 10 and 10 respectively.

Storey drift



The given data appears to be related to the storey drift of a symmetrical building model withouta shear wall. Storey drift refers to the relative horizontal displacement or deformation of different floors of a building due to lateral forces such as wind or earthquake. The data showsthe storey drift values for each floor of the building in the X direction and Y direction respectively. The values in the graph indicate that as we move up the building from the groundfloor (storey 0) to the top floor (storey 10), the storey drift increases in both X and Y directions.

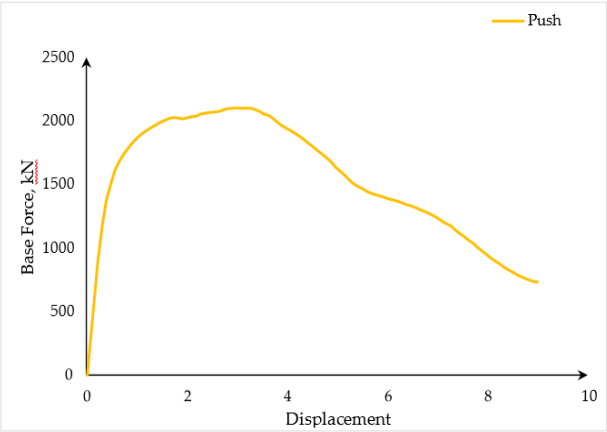
Storey Shear



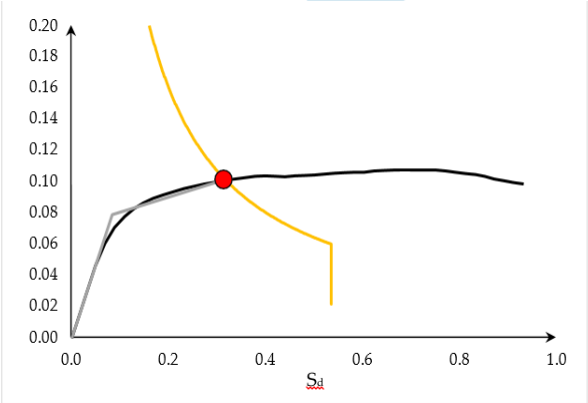
Graph 5. 7 asymmetrical model without shear wall

The graph represents the base shear force for a 10-storey building model that does not have a shear wall, which means that it is an asymmetrical structure. The base shear force is the lateralforce that is applied to the foundation of the building due to the lateral loads such as wind or earthquake. The values in the graph indicate the amount of force in kN (kilo Newtons) that is required to resist the lateral loads for each floor of the building. As per the graph, the base shearforce is zero for the top floor of the building, while it gradually increases as we move down tothe lower floors. The highest base shear force is observed at the bottom floor, which is 1870.95kN. The asymmetrical nature of the building implies that the distribution of the base shear forceis not uniform throughout the height of the building. As we can see, the difference in base shearforce between the top and bottom floors is significant, indicating that the building is more vulnerable to lateral loads at the lower floors.

Pushover curve



Performance point



- **Asymmetrical building with shear wall**

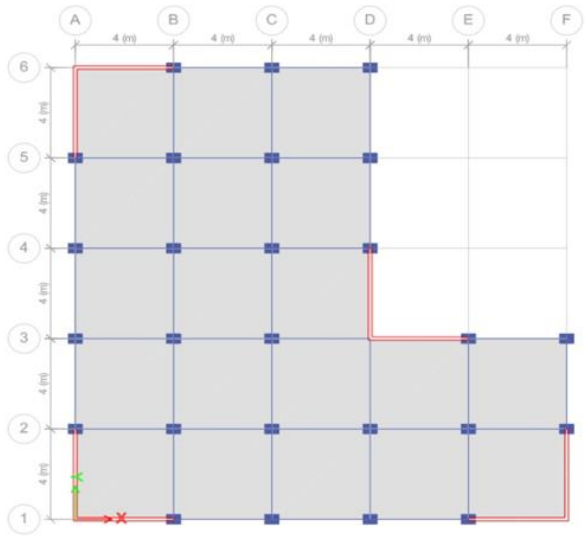


Fig 5. 5 Asymmetrical plan view model with shear wall

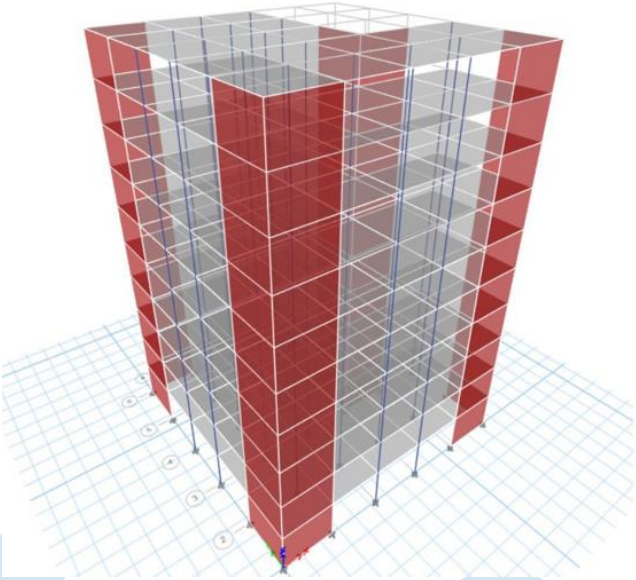
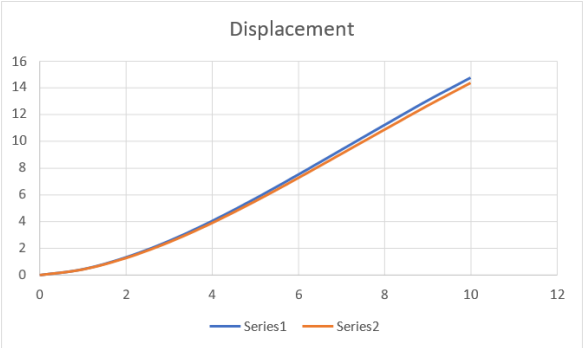


Fig 5. 5 Asymmetrical 3D view model with shear wall

Displacement



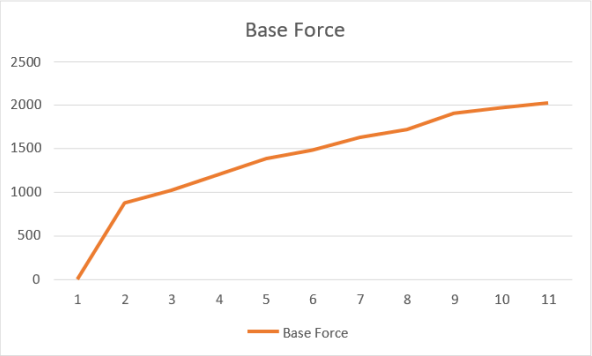
The given information describes an asymmetrical building model with a shear wall, the Displacement is Less than Asymmetrical Model Without Shear Wall. and provides the storey displacement values in the X and Y directions for each of the ten storeys in the building. The storey displacement values refer to the lateral movement or displacement of each floor relative to the ground floor, which is assumed to have zero displacement. The displacement values in the X direction refer to the movement in the horizontal direction parallel to the orientation of the building, while the values in the Y direction refer to the movement in the horizontal direction perpendicular to the orientation of the building. The values suggest that the buildingis undergoing lateral deformation due to an external force such as seismic activity or wind. The values in the X and Y direction are not equal, indicating that the building is not symmetric in its lateral stiffness and that there is an inherent torsional motion. The asymmetry in stiffness islikely due to the presence of a shear wall, which is a structural element designed to resist lateralforces.

Storey drift

Graph 5. 8 symmetrical model without shear wall

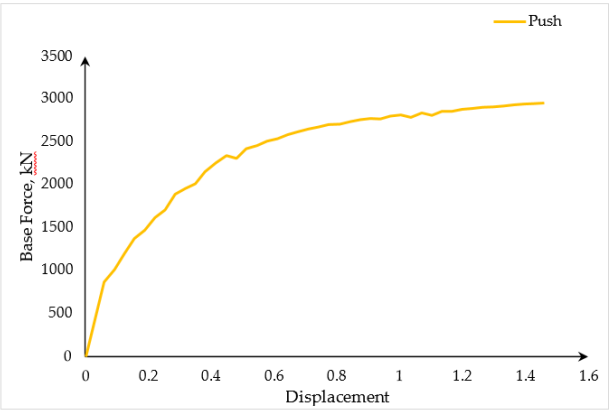
This graph shows the storey drift values for a symmetrical building model without shear wallsin both X and Y directions. Storey drift refers to the lateral displacement or movement of a building at each storey level due to a lateral force such as an earthquake or wind load. The values in the graph represent the amount of storey drift in decimal format for each storey, withstorey 9 at the top and storey 0 at the base of the building. From the graph, it can be observedthat the storey drift values generally decrease as we move down the storeys of the building, which is expected in a well-designed building. The values for the X direction are slightly smaller than those for the Y direction, indicating that the building is stiffer in the X direction.

Storey shear

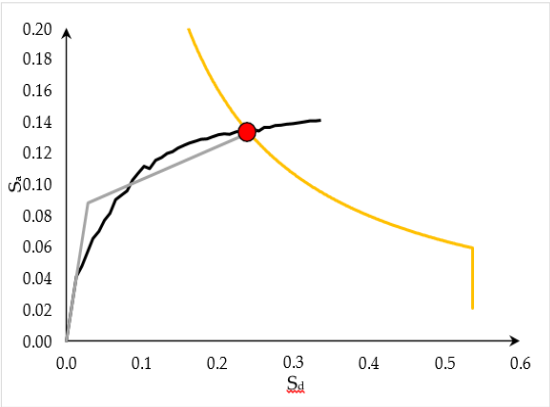


The given data appears to be the results of a seismic analysis for an asymmetrical building model that includes a shear wall. The building has 9 storeys and the base force is the total seismic force acting on the building's foundation due to earthquake loading. The values of thebase shear force for each storey indicate that the higher the storey, the lower the base shear force. This is because the building's shear wall provides resistance against the lateral seismic forces and transfers them to the foundation. As a result, the lower storeys experience a greaterbase shear force due to the higher seismic forces in those areas, while the upper storeys experience lower base shear forces due to the wall's resistance.

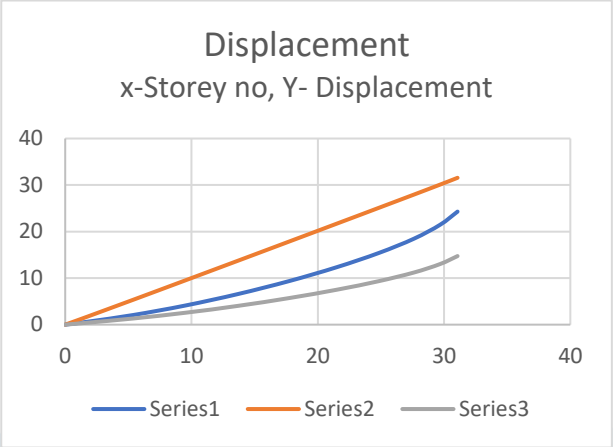
- **Pushover curve**



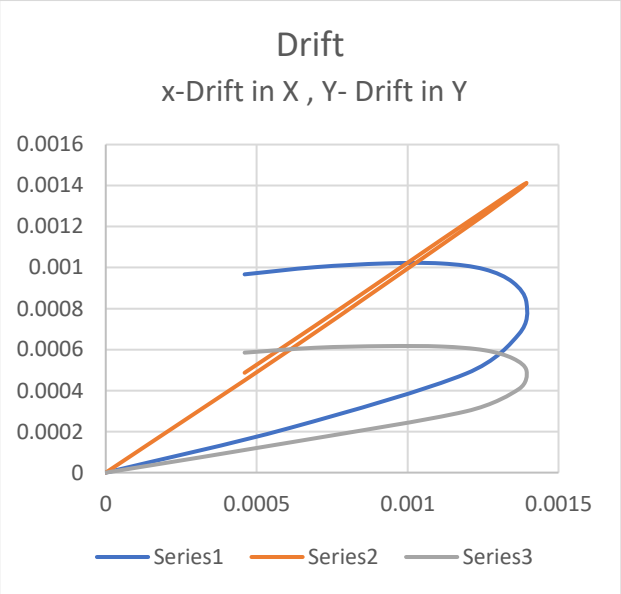
- **Performance Point**



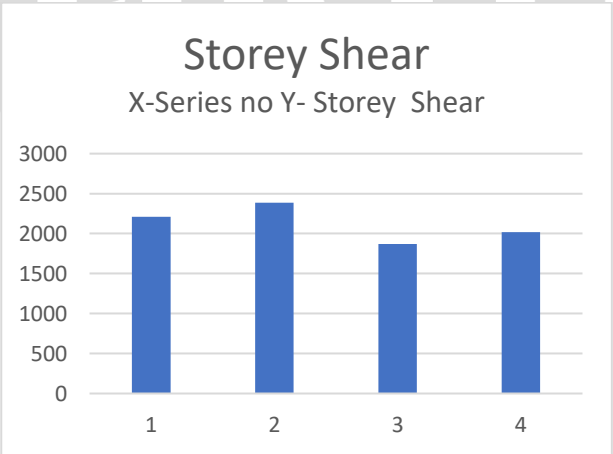
Comparison of All Models



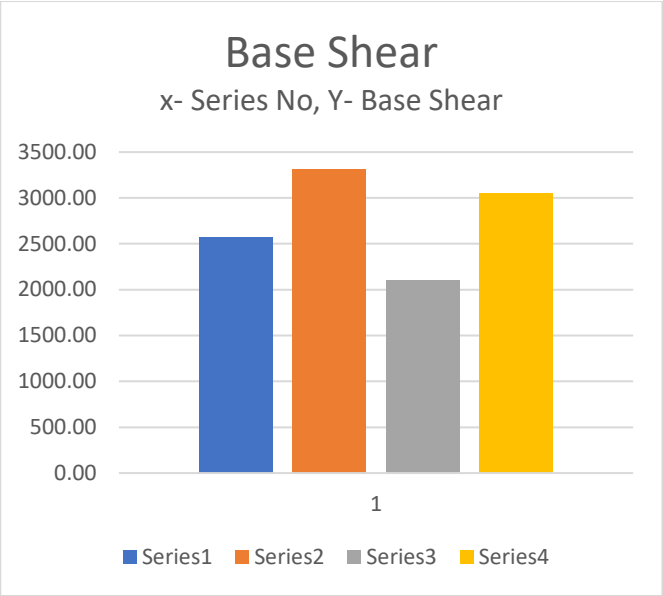
Graph 5. 9 Displacement



Graph 5. 10 Drift



Graph 5. 11 Storey Shear

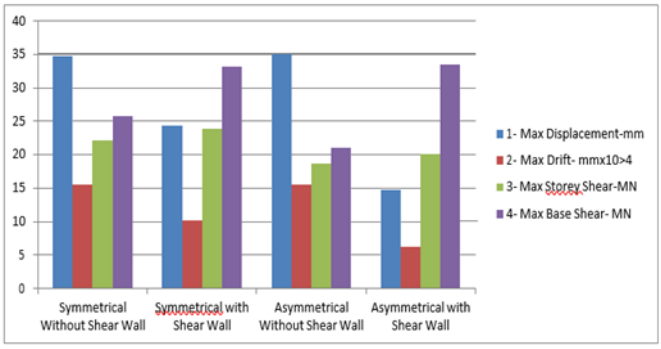


Graph 5. 12 Base shear:

Results:

The analysis results showed that the symmetrical building without shear walls had a lower capacity curve as compared to the building with shear walls. The symmetrical building with shear walls showed a higher capacity curve, indicating that the shear walls significantly improved the seismic performance of the building. The asymmetrical building without shear walls showed a capacity curve with a lower peak as compared to the building with shear walls. The asymmetrical building with shear walls showed a higher capacity curve, indicating that the shear walls significantly improved the seismic performance of the building. The analysis also showed that the asymmetrical building was more vulnerable to seismic loads as compared to the symmetrical building.

	Symmetrical Without Shear Wall	Symmetrical with Shear Wall	Asymmetrical Without Shear Wall	Asymmetrical with Shear Wall
1- Max Displacement-mm	34.802	24.29	35.048	14.737
2- Max Drift-mmx10>4	15.47	10.2	15.5	6.2
3- Max Storey Shear-MN	22.08	23.87	18.7	20.17
4- Max Base Shear- MN	25.71	33.1	21.04	33.44



CONCLUSION

- **Displacement**
- Displacement in Symmetrical model with shear wall is reduced by 30.21% than it is of symmetrical model without shear wall.

- Displacement in asymmetrical model with shear wall is reduced by 57% than of asymmetric model with shear wall.
- Displacement in Asymmetric model without shear wall is increased by 1.07% than the symmetrical model without shear wall.
- Displacement in symmetrical model with shear wall is increased by 39.35% of Displacement in asymmetric model with shear wall.
- **Drift**
- Drift in Symmetrical model with shear wall is reduced by 0.52% than it is of symmetrical model without shear wall.
- Drift in asymmetrical model with shear wall is reduced by 60% than of asymmetric model without shear wall.
- Drift in Asymmetric model without shear wall is increased by 0.19% than the symmetrical model without shear wall.
- Drift in symmetrical model with shear wall is Increased by 39.21% of Drift in asymmetric model with shear wall.
- **Max Base Shear**
- Base Shear in Symmetrical model with shear wall is Increased by 28.76% than it is of symmetrical model without shear wall.
- Base Shear in asymmetrical model with shear wall is Increased by 44.65% than of asymmetric model without shear wall.
- Base Shear in Asymmetric model without shear wall is Reduced by 18.15% than the symmetrical model without shear wall.
- Base Shear in symmetrical model with shear wall is increased by 8.06% of Base Shear in asymmetric model with shear wall.
- **Performance Point**
- Performance Point in Symmetrical model with shear wall is Reduced by by 28.76% than it is of symmetrical model without shear wall.
- Performance Point in asymmetrical model with shear wall is reduced by 15.44% than of asymmetric model without shear wall.
- Performance Point in Asymmetric model without shear wall is increased by 11.76% than the symmetrical model without shear wall.
- Performance point in symmetrical model with shear wall is Increased by 9.13% of that in asymmetric model with shear wall.

Displacement in symmetrical model with shear wall is reduced by 39.35% of Displacement inn asymmetric model without shear wall In conclusion, the Capacity Spectrum Analysis (CSA) technique has been widely used for seismic performance evaluation of reinforced concrete.

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