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Dynamic Analysis of Multi Storied Building with and without Shear Wall and Bracing

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Abstract

Now a day the number of buildings are constructed and designed on the basis of architectural requirement and aesthetic view. Most of buildings are constructed in some spatial configuration like X shape, V shape with x and y co-ordinates non parallel to the structure. Earthquake is causing more damage to different configuration of building and their main problem is in the slenderness ratio. The main goal of this project is to make a comparative study of dynamic behavior of buildings with different configuration of structure in all seismic zones and different types of soils. In this study, a spatial configuration structure of 20stories up to 70m height of each storey height of 3.5m, with Shear wall and bracing at a different location in building is considered. The dynamic behavior of the building in all seismic zones II, III, IV, V and on different types of soil say hard, medium and soft soil was studied .The structure has outer periphery beams carrying R.C Shear wall of 200 mm thickness. The response spectrum analysis was carried out by using software of ETAB's version 9.7.4.considering bracing and shear wall at a different location in the building. The following seismic parameters were analyzed and the behavior of the structure was studied in detail.

Keywords- Drift and Displacement, Base Shear and Storey Shear, Time Period and Natural Frequency

I. INTRODUCTION

A. General

Most of the countries are suffering damage from earthquake which is one of major effects on building. Usually loads coming on the buildings are horizontal loads as well as vertical loads. The horizontal loads are wind load and earthquake load. The vertical loads are dead weight of all structural members and imposed load.

Shear wall is a most efficient to resist lateral load and wind force and it helps to improve the seismic response of building. Present decades multi-storey buildings are constructed widely as they ultimately collapse due to inadequate lateral stiffness and strength of structural member against seismic effect. Reinforced concrete shear wall is best suited in building at especially in high seismic zone prone area because it provides adequate stiffer connection between structural elements and avoid the numerous hazards on building. Seismic behaviour of building depends on location of shear wall in building and many research papers have not mentioned the exact location of shear wall in building to improve the maximum stiffness and strength against lateral force.

B. Lateral Load Resisting Systems

1) Reinforced Concrete Shear Wall

Shear wall is a best lateral load resisting system in tall building at high seismic zone areas. It is a concrete cantilever wall provided in a RC frame building to give flexural stiffness and strength to the structural members against earthquake. Construction of shear wall in building is economical only up to limited stories. Shear wall will give rigid connection between wall and frame members and it is usually provided in lift core, stair case and instead of conventional load bearing walls.

2) Bracing System

Bracing is a most efficient and economical lateral load resisting system in tall building either of steel or R.C frame to give better performance against earthquake different types of bracings are available like single diagonal bracing, double diagonal bracing, K bracing, V-bracing and Knee bracing are available.

II. LITERATURE REVIEW

Abhyudy Titiksu and Dr. M.K.Gupta (2015)
The different structural configurations were provided in structure like steel frame, special moment resisting frame and ordinary moment resisting frame in high seismic zone V of building height G+4 as per Indian codes.

To efficient structural system to withstand the lateral load and gravity loads on structure was studied. After analyzing model in ETAB the evaluate storey drift, base shear and deflection of different cases of structure was studied. After comparing the results the bracing steel frame was found better to withstand seismic forces but it was uneconomical with a greater service life compared to other system. (10)
Abhijeet Bairikar and Kanehan Kanagali (2014)
In this paper a square grid building of different heights was considered with different lateral load resisting system like
1) Shear wall
2) Bracing

Response like deformation, base shear and storey drift were analysed using different soils condition as per IS 1893-2002 for high seismic zones of V.

Conclusion of this work is base shear and storey drift gradually increase in different soil condition. Time period in a bare frame building is high but after providing shear wall and bracing in the building reduces time period and also storey drift and displacement. (7)
Er .Nishant Rana and Siddhant Rana (2014)
The various types of structural forms like outrigger, shear wall. Hybrid system and brace frame were studied. The various structural forms are enhanced the good efficient connection between the various structural elements.

Conclusion of this project was that the behaviour of all structure forms in building play major role during seismic hazards.
Mohd Atif and Vikrant Nair (2015)
A building with stiffener along with shear wall and bracing was considered. Different seismic zones like II, III, IV and V Were considered for dynamic analysis.

A simple and symmetrical building of G+15 were modelled in STADD-PRO and seismic analysis is done as per IS 1893(part I)-2002 with different earthquake zones. The dynamic performance of shear wall and bracing was compared.

Shear wall was more efficient and also economical in construction and for minimizing damage of earthquake brace frame absorbed a major portion of the seismic energy compared to shear wall.(2)
Ghalimath A.G, Waghmare Y.M, and Chaudhari A.R (2015)
Static and dynamic analysis is carried out to examine the performance of building with different types of frame against the lateral and gravity loading and compared the results like storey drift, base shear, deflection, axial force and bending moment.

Conclusion of this work was that natural period reduced in dual system compared to bare frame and infill frame, Storey drift, displacement at the top of bare frame, infill frame and dual system are increased according to different types of zones and different types of soil and base shear is increased in RC framed building with shear wall. Shear force and bending moment were reduced by provided shear wall in building. (13)
Verma S.K, Roshan Lal and Raman Kumar (2014)
The performance of 10- storey and 15-storey RC frame modelled in a STAAD-Pro with shear wall at different location like internal frame, external frame, central frame and combine external internal frame were studied.

Seismic analysis is carried out in a STAAD-PRO by seismic response method and finally compared the results of storey drift, average displacement of model with 4 different location of shear wall in building to arrive at the ideal location of shear wall. Conclusion of this work is location of shear wall in building i.e. internal frame is better to minimize displacement, storey drift and it is effective in building and shear wall at corner it gives the better performance and most efficient and also reduce the storey drift and displacement of tall building.(14)
Shraddhaj.Patil and R.S.Talikoti (2015)
Wind analysis of a G+19 building by using in ETAB and the behaviour of wind load and seismic parameters like storey drift, stress in beam, bending moment, and shear force were studied. Torsion, storeys drift and shear force were focused as a part of study. (3)

III. METHOD OF ANALYSIS

A. Introduction

Irregular configuration buildings are likely to suffer more damage from earthquake than the regular building, because their structural configuration were unsymmetrical and also structural members doesn't have enough stiffness against lateral loads.

Hence stiffness in the building member is increased by providing shear wall, bracing, outrigger and tubular structure etc. Shear wall is a most efficient structural configuration against earthquake as compared to other configuration because shear wall is good energy absorber and resistant damages from earthquake forces to the building. In tall building with bare frame configuration the size of beams and columns are very large, hence it requires high amount of reinforcement in members and mass of the building is very high and also stiffness in the building is very less hence easily attract earthquake force and wind loads. By providing the shear wall in tall building the members size become reduced and lateral stiffness become very high.

Building behaviour also depends upon different types of soils like soft, medium, hard soil in each zone. For example the building constructed in soft soil requires the good foundation system because the total mass of the building should transfer through the structural members to the foundation. In soft soil during earthquake there is more damage to the building so while constructing tall building in soft soil one has to be careful about design and configuration of buildings which have to be always symmetrical. If unavoidable building configurations can be unsymmetrical such that adequate care is given to the design.

In the Present work lateral load resisting system of spatial configuration building with different locations of shear wall and bracing are designed by static and dynamic analysis by using ETAB software 9.7.4.

B. *Need for Present Work*

From different literature review following observations are made.

1) Most of the buildings were considered only regular with x direction and y direction parallel to the building and static and dynamic analysis were done but x-y direction non parallel to the building has not been emphasised.
2) Shear wall and bracing were provided in simple configuration building at a particular location only, shear wall and bracing at different location in spatial configuration of tall building were not considered.

C. *Scope*

- Study a typical 20 stories spatial configuration R.C building with 'X' shape has been considered for present study.

Storey height = 3.5 m typical

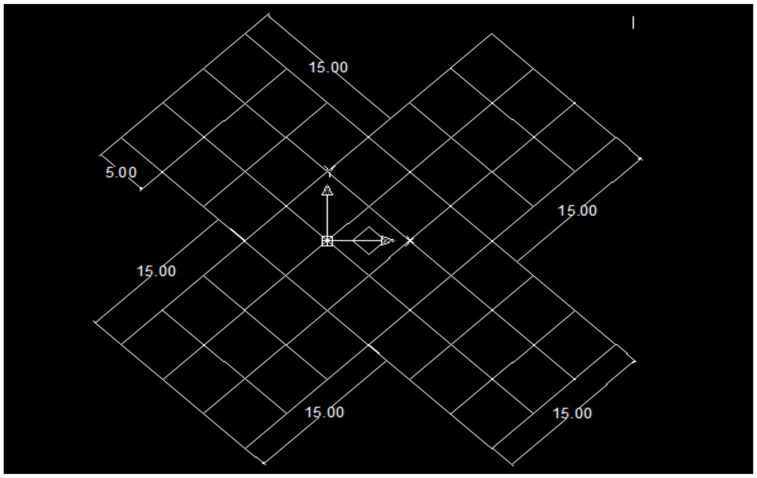


Fig. 1: Plan – 'X' spatial configuration

- Shear wall and bracing have been located at various locations and the dynamic performance was analysed for the 'X' shape spatial configuration building.

Shear wall thickness = 200 mm
Bracing = ISMB 350 @ 52.4 kg/m

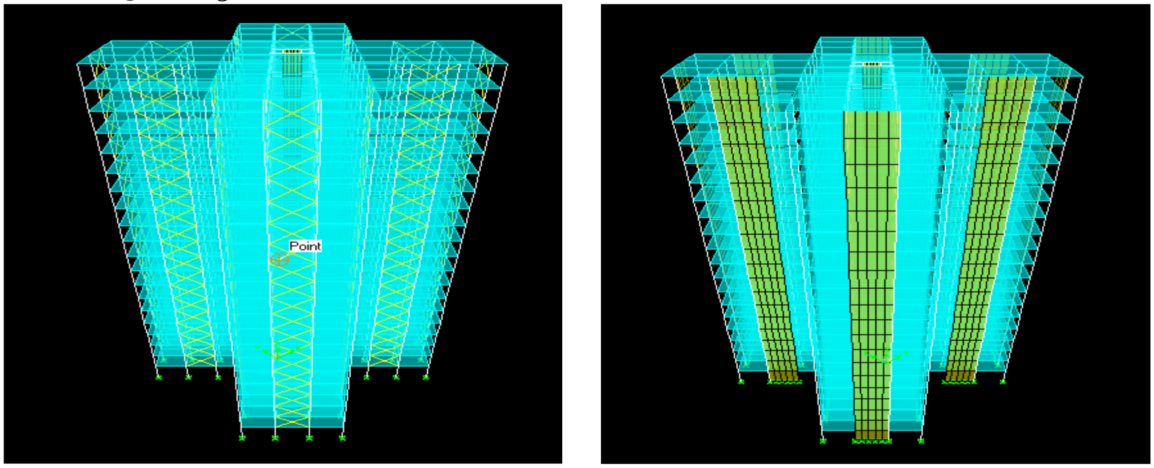


Fig. 2: Bracing and Shear Wall at middle of the building

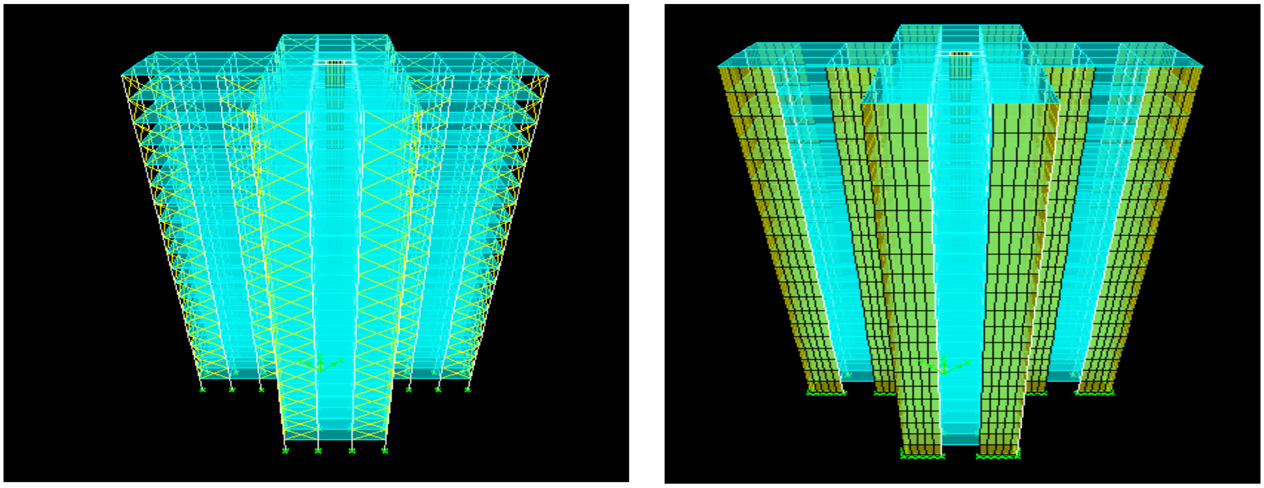


Fig. 3: Bracing and Shear Wall at corner of the building

D. Cases of Study

Case A - Bare frame (BF)
Case B - Bracing at External Frame Middle (BEFM)
Case C - Shear Wall at External Frame Middle (SWEFC)
Case D - Bracing at External Frame Corner (BEFC)
Case E - Shear Wall at External Frame Corner (SWEFC)

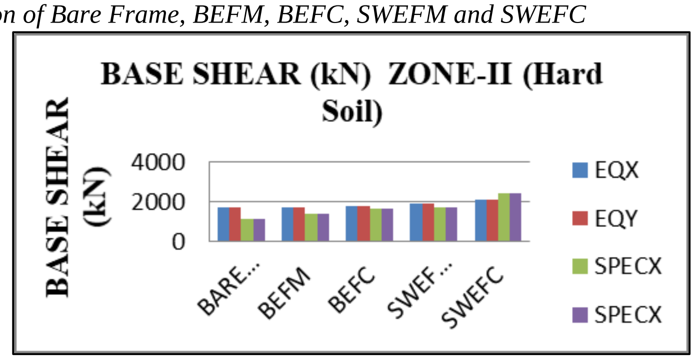
IV. RESULTS AND DISCUSSION

A. Introduction

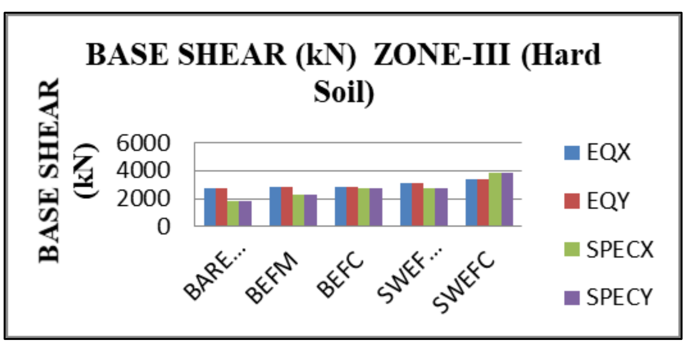
The results of static and dynamic analysis of spatial configuration G+19 stories building at different locations of shear wall and bracing in different zones I, II, III and different types soils like soft soil, medium soil and hard soil are listed below Complete details of results and discussion are included in this chapter.

B. Base Shear

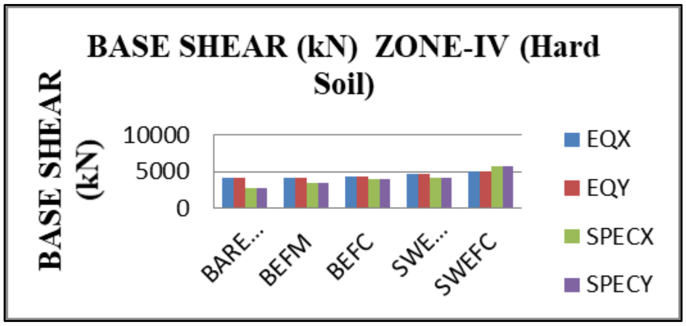
1) Base Shear Comparison of Bare Frame, BEFM, BEFC, SWEFM and SWEFC



Graph 1: Base shear for Case I (Hard Soil)



Graph 2: Base shear for Case 2 (Hard Soil)



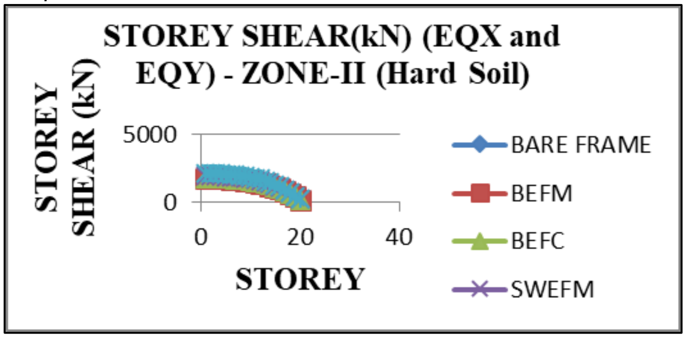
Graph 3: Base shear for Case 3 (Hard Soil)

2) Discussion - Base Shear

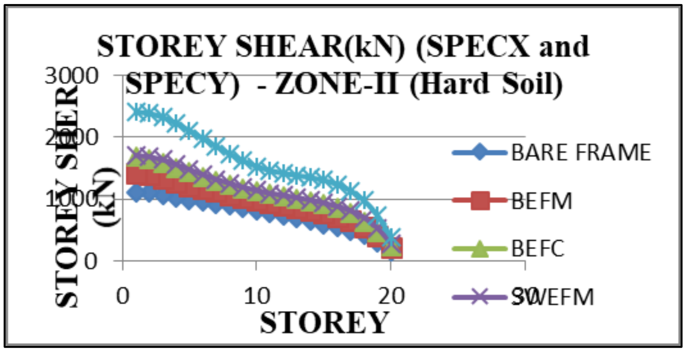
- As the stiffness increase the base shear increases due to increase in the structural rigidity contributed by lateral load resisting elements like beams, shear wall and bracing.
- For all types of building configuration its base shear in zone-II is very less as compared to different types of zones for same soil because base shear depends on type of zone areas.
- For all types of building configuration the base shear increases from hard soil to soft soil because base shear depends on the strength of the soil.
- It is observed that Shear wall at external frame corner has a higher base shear than bare frame.

C. Storey Shear

1) Storey Shear Comparison of Bare Frame, BEFM, BEFC, SWEFM and SWEFC



Graph 4: Storey Shear for Case 1 (Hard Soil) in EQX and EQY



Graph 5: Storey Shear for Case 1 (Hard Soil) in SPECX and SPECY

2) Discussion - Storey Shear

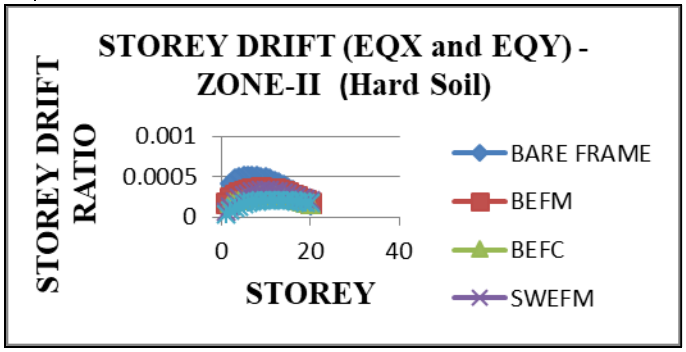
- Storey shear depends upon the building rigidity contributed by the different types of building configuration.
- In ZONE-II for different building configuration the storey shear increases as it directly depend upon the stiffness of building from bare frame to shear wall at external frame corner and the behavioural pattern holds good for different zones.
- The value of storey shear in shear wall at external frame corner in building is more compared to other configuration due to high stiffness in shear wall at external frame corner.
- The storey shear value changes depending on earthquake zones and soil types.
- It is observed that storey shear value is less in top storey and high in bottom storey.

D. Storey Drift

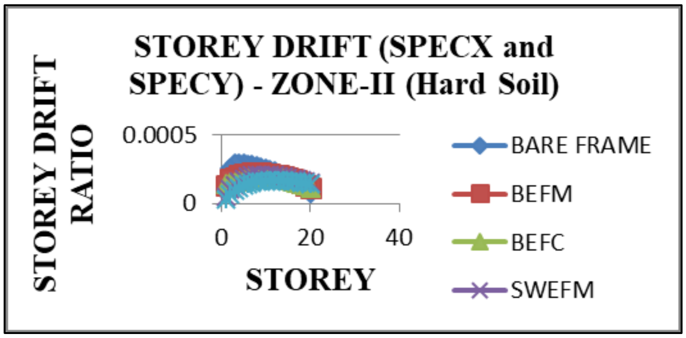
Storey drift is the displacement of one level to the other level above or below. Storey drift ratio for different zones and soil type is as shown in given figures. In software values of storey drift ratio is as defined below.

$$\text{Storey Drift Ratio} = \frac{\text{Difference between displacement of two stories}}{\text{Height of one storey}}$$

1) Storey Drift Comparison of Bare Frame, BEFM, BEFC, SWEFM and SWEFC



Graph 6: Storey Drift for Case 1 (Hard Soil) in EQX and EQY



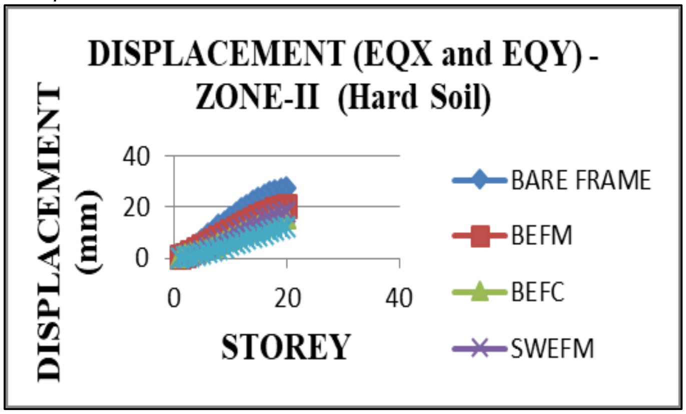
Graph 7: Storey Drift for Case 1 (Hard Soil) in SPECX and SPECY

2) Discussion - Storey Drift Ratio

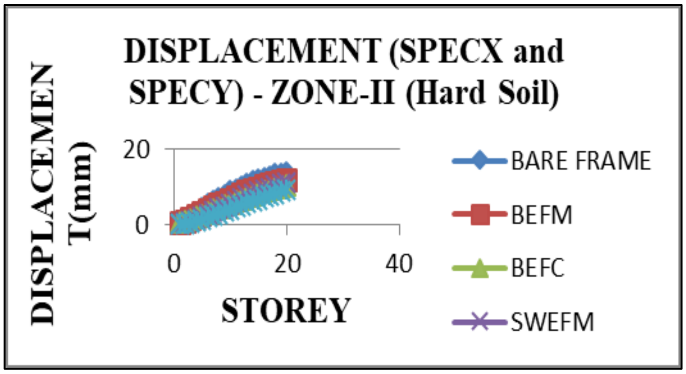
- Storey drift value depends on stiffness of building. If stiffness of the building is high the storey drift value is less.
- For comparing all the building models the storey drift for bare frame value is high in all zones because bare frame doesn't have enough stiffness.
- But in all cases the provided shear wall at external frame corner has storey drift value less in all zones and different soils due to shear wall at external frame corner introduced in the building which develops high amount of stiffness in the building.
- Bracing at external frame middle, Bracing at external frame corner, Shear wall at external frame middle are found to be less effective when compared to shear wall at external frame corner as the variation of study drift ratio is well under control.

E. Displacement

1) Displacement Comparison of Bare Frame, BEFM, BEFC, SWEFM and SWEFC



Graph 8: Displacement for Case 1 (Hard Soil) in EQX and EQY



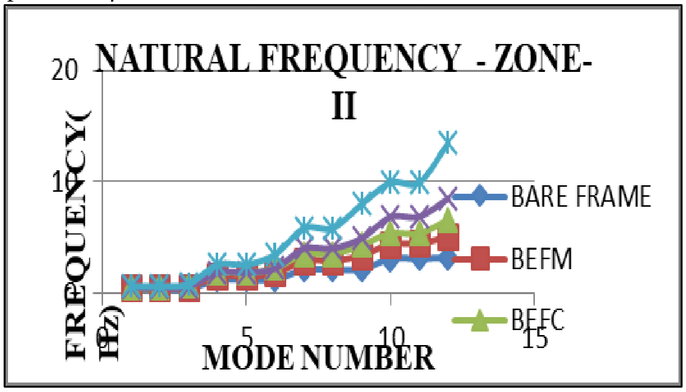
Graph 9: Displacement for Case 1 (Hard Soil) in SPECX and SPECY

2) Discussion – Displacement

- The displacement depends on the stiffness of building.
- The displacement goes on increasing from zone-II to zone-V as earthquake effect on structure in higher zone is large.
- There is a variation of around 55% in displacement for spatial configuration along with shear wall at external frame corner when compared to conventional configuration without any shear walls.
- By introducing bracing and shear wall in building it reduces the displacement in structure.
- The displacement value is higher in top storey and less in bottom storey.

F. Natural Frequency

1) Natural Frequency Comparison of Bare Frame, BEFM, BEFC, SWEFM and SWEFC



Graph 10: Natural Frequency for ZONE-II (All soil types)

2) Discussion - Time Period and Natural Frequency

- Time period directly depends on the mass of the structure and height of the structure.
- When the mass of structure is increased the time period gets decreased.
- With the introduction of extra mass like bracing and shear wall in building it reduces the time period.
- Time period is independent of zone and soil type.
- Natural frequency is inversely proportional to the time period.
- It is observed that all models natural frequency for bare frame is less.
- Natural frequency also doesn't change in all zones it depends on building configuration with add-ons like bracing and shear walls.

V. ACKNOWLEDGEMENT

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VI. CONCLUSION

As per the study made the following conclusion have been arrived at

- Shear wall at external frame corner is a better option in case of tall building where the storey shear, storey drift, displacement and time period can be brought well into control.

- Provision of shear walls ideally at the corner yield satisfactory results to modulate seismic response parameters effectively.
- The infill can have a good bond with the shear wall and thus generate a satisfactory seismic resistant structure.
- Shear wall at external frame middle is also a good option of regulating seismic responses compared to bracing.

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