# Seismic Analysis of Lateral Systems in Tall Buildings for Different Soil Type and Seismic Zones

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*Abstract*— Buildings are subjected to different earthquake loading and behaves differently with diversification in the types of soil condition, such as dense soil, medium and soft soil. Different soil properties can affect seismic waves as they pass through a soil layer. When a structure is subjected to an earthquake excitation, it interacts with the foundation and soil, and thus changes the motion of the ground. It means that the movement of the whole ground structure system is influenced by type of soil as well as zone by the type of structure. As the seismic waves transfer from the ground which consist of alteration in soil properties and performs differently according to soil's respective properties. Efficient lateral systems, decreases the lateral deformations caused by the seismic forces in the buildings. In this work, it is proposed to carry out an analytical study, on multistory buildings of 15 stories, was carried out accounting for different seismic zones and soil types. The suitability and efficiency of different lateral bracing systems that are commonly used and also that of concrete in fills are investigated. The different bracing systems viz., X-brace, V-brace, inverted V or Chevron brace, Outriggers and in fills, are introduced in the buildings through analytical models. These were analyzed in 45m height, using ETABS software, for the action of lateral forces employing linear static and linear dynamic methods as per IS 1893 (Part I): 2002. The results of the analyses, in terms of lateral deformations and Base shears, Displacement, Drift, storey shear were obtained for all the different conditions discussed above The suitability of the types of lateral system for the buildings is suggested based on the soil type in particular zone.

***Key words:*** Seismic Analysis, Seismic Zones

## I. INTRODUCTION

Today's tall buildings are becoming more and more slender, leading to the possibility of more sway in comparison with earlier high-rise buildings. This has brought more challenges for the engineers to cater both gravity loads as well as lateral loads, earlier buildings were designed for the gravity loads but now because of height and seismic zone the engineers has take care of lateral loads due to earthquake and wind forces. Seismic zone plays an important role in the earthquake resistant design of building structures because the zone factor changes as the seismic intensity changes from low to very severe. Another important aspect in the design of earthquake resistant structures is soil type, as the soil type changes the whole behavior and design of the structure changes. So to cater all the lateral forces, we have to design the structure very uniquely so that the structure can withstand for the maximum time period so that there is no harm to the society.

In order to increase the stiffness of the columns and to reduce their net longitudinal reinforcement decreasing their effective length can be a good solution but the challenge is to how can we do so without changing the general building specifications (specially architectural) and not disturbing the basic building frame structure as a whole.

This study seeks to understand the evolution of the dif emerged and its associated structural behavior bracings are introduced in RCC building model at the same location to understand the Building is remaining constants such as the size of the columns, beams, bracings and thickness of slabs. In this analysis is carried out in four zones with zone factor (10, 16, 24, 32) & three soil types hard, medium, loose.This study is done under considering the IS code for different soil done in ETABS. The major goal is to appraise the lateral deformations occurs by considering the above parameters. The seismic motion that reaches a structure on the surface of the earth is influenced by the local soil conditions.

Fig. 1 shows X –bracing

Fig. 2 shows V- Bracing

Fig. 3: shows INVERTED V-bracing

According to IS CODE: 456-2000. In this, M40 mix & Fe 415 steel are used and Dimensions of Columns & Beams are designed.

## II. BUILDING DIMENSIONS

### A. Column Size

From ground floor to fourth floor: 9000mm X 1000mm,
From fourth floor to tenth floor: 7000m X 8000m,
From tenth floor to fiftieth floor: 4000mm X 6000mm,

### B. Beam Size

From ground floor to fifteenth floor: 600 mx800mm
Bracing size: 230mmx230mm,
Slab thickness: 120mm,
Live load: 2KN
Floor Finish: 1KN
Static & dynamic Loading:

- 1.5(Dead load + Live load)
- 1.2(Dead load + Live load + Lateral load in X direction)
- 1.2(Dead load + Live load - Lateral load in X direction)
- 1.2(Dead load + Live load + Lateral load in Y direction)
- 1.2(Dead load + Live load - Lateral load in Y direction)
- 1.5(Dead load + Lateral load in X direction)
- 1.5(Dead load - Lateral load in X direction)
- 1.5(Dead load + Lateral load in Y direction)
- 1.5(Dead load - Lateral load in Y direction)
- 0.9(Dead load) + 1.5(Lateral load in X direction)
- 0.9(Dead load) - 1.5(Lateral load in X direction)
- 0.9(Dead load) + 1.5(Lateral load in Y direction)
- 9(Dead load) - 1.5(Lateral load in Y direction)

From the above combination the load combination 1.2DLLLEQX has shown critical

### C. Load Combination:

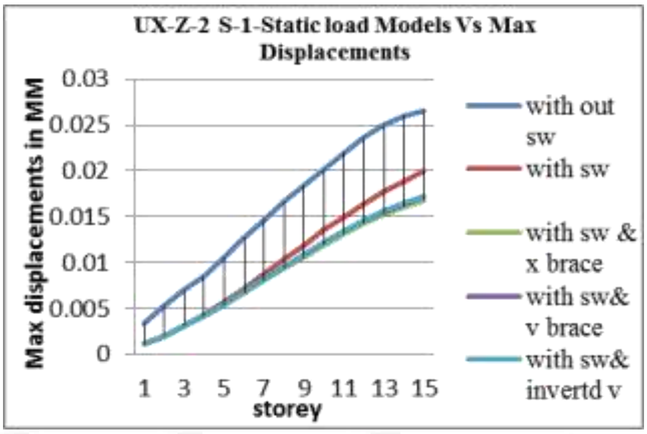
DLLLEQX1.2

- Dead load - 1.2
- Live load - 1.2
- EQX - 1.2
- Windward Coefficient : 0.8
- Leeward coefficient : 0.5

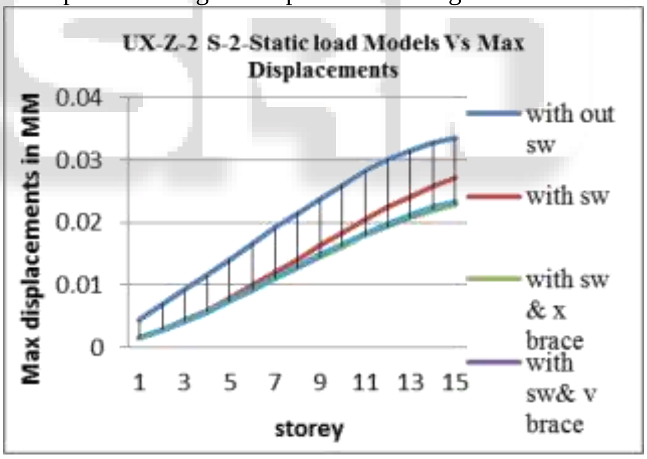
After assigning the dimensions, analysis is carried out in UX & UY directions and obtained results of displacements and Results are compared for five models i.e.,, without shear wall, with shear wall, with shear wall & X bracing, with shear wall & V bracing, with shear wall & inverted V bracing results are compared with in the type of soil for five models and also compared with four ZONES & three SOILS in both UX & UY directions.

Here the displacement in both UX & UY directions are shown with comparison of models vs displacement in soils & also the displacement with zones vs soils

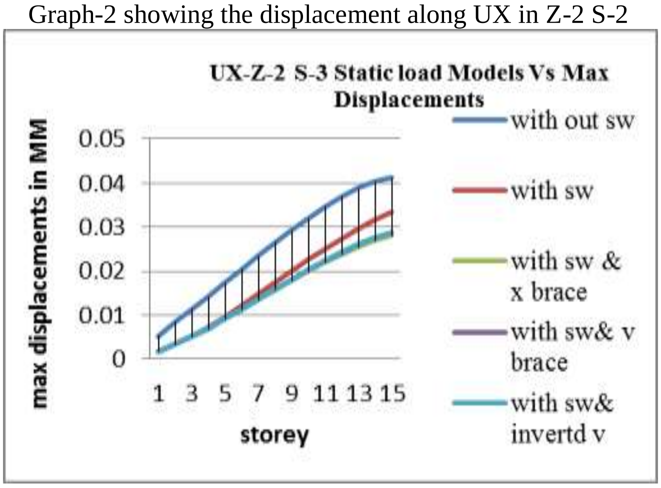
## III. DISPLACEMENT ALONG UX WITH STATIC LOADING




Graph-1 showing the displacement along UX in Z-2 S-1

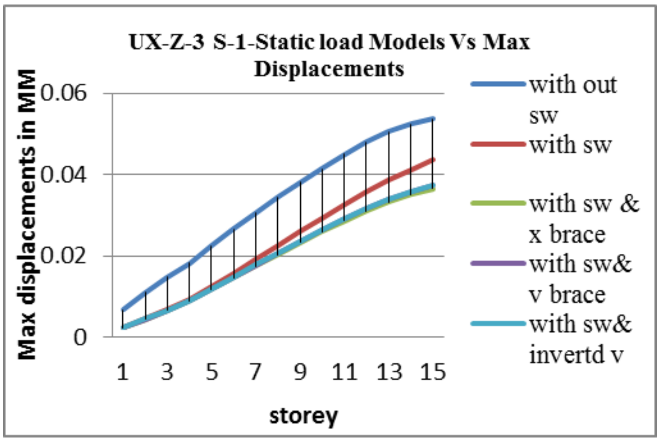



Graph-2 showing the displacement along UX in Z-2 S-2

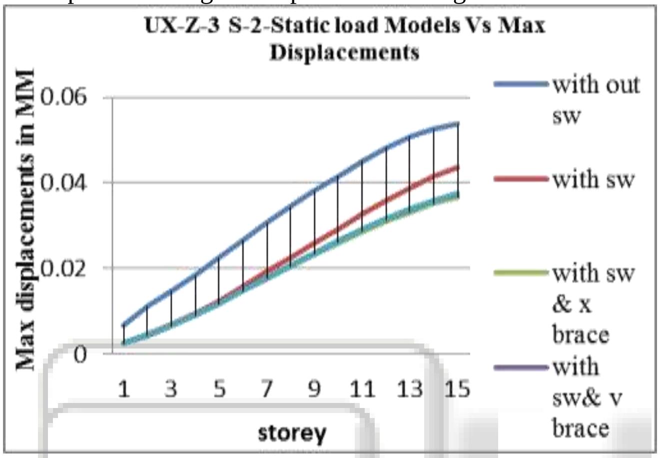



Graph-3 showing the displacement along UX in Z-2 S-3

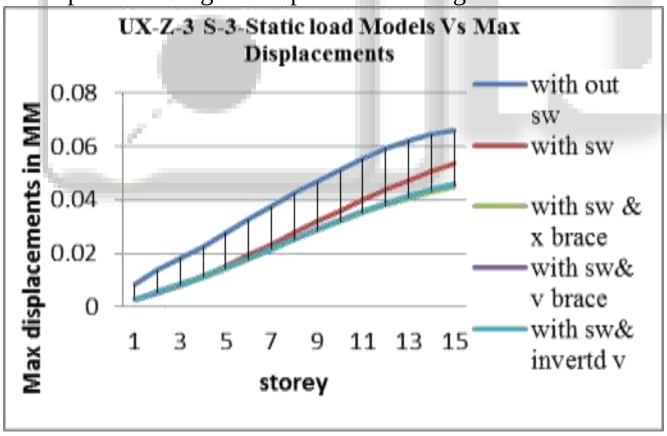
 



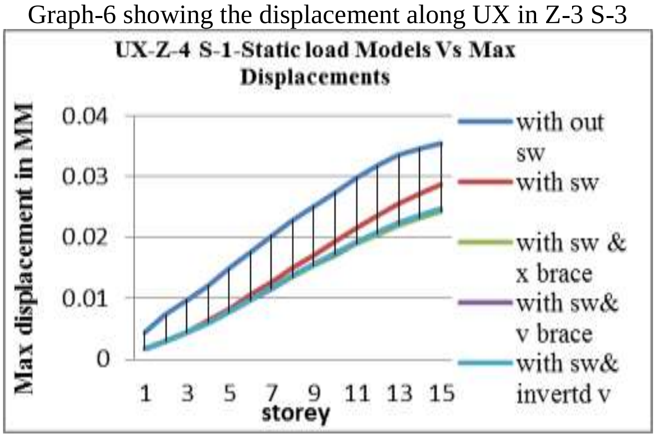

Graph-4 showing the displacement along UX in Z-3 S-1



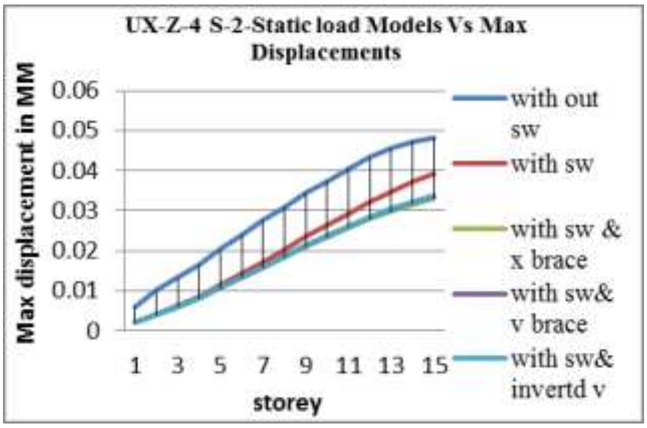

Graph-5 showing the displacement along UX in Z-3 S-2



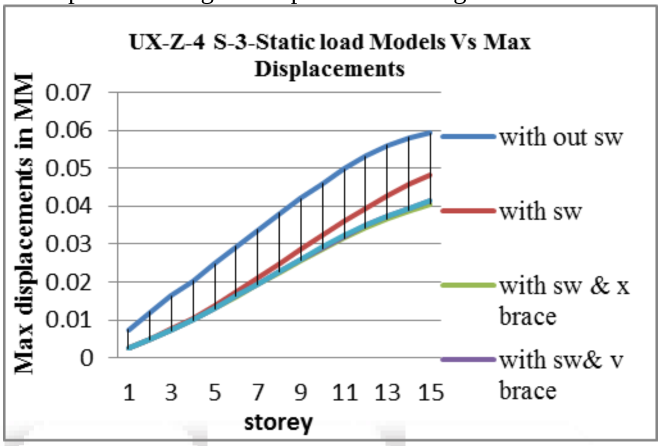

Graph-6 showing the displacement along UX in Z-3 S-3



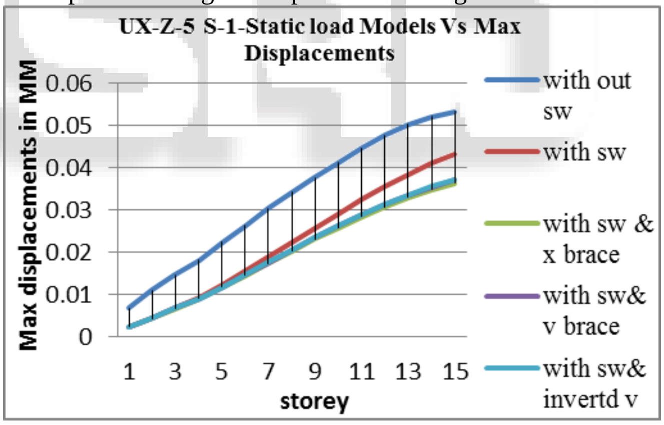

Graph-7 showing the displacement along UX in Z-4 S-1



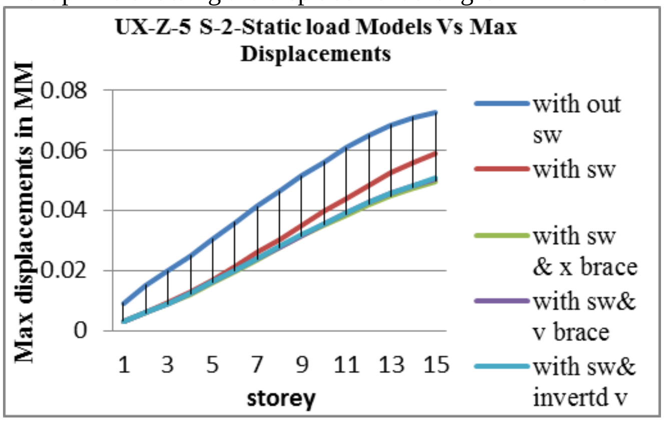

Graph-8 showing the displacement along UX in Z-4 S-2



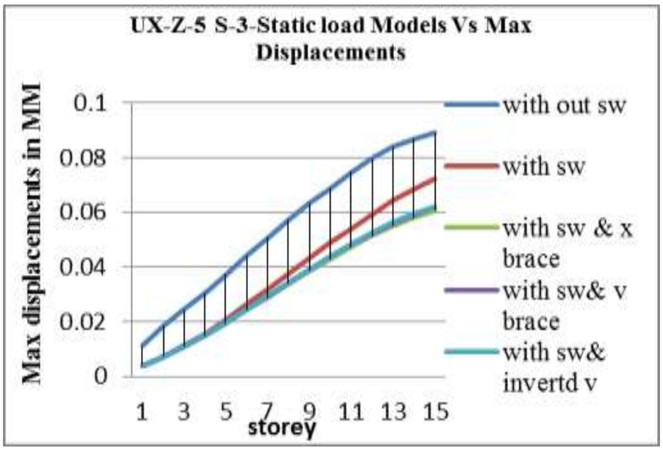

Graph-9 showing the displacement along UX in Z-4 S-3




Graph-10 showing the displacement along UX in Z-5 S-1



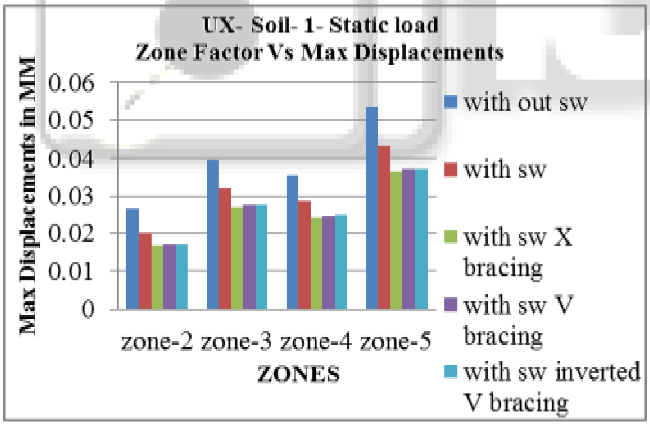

Graph-11 showing the displacement along UX in Z-5 S-2




Graph-12 showing the displacement along UX in Z-5 S-3

| zones | lateral displacements | | | | |
|---|---|---|---|---|---|
| | without SW | with SW | with SW x Bracing | with SW V Bracing | with SW inverted V Bracing |
| zone 2 | 0.0266 | 0.02 | 0.0168 | 0.0172 | 0.0172 |
| zone 3 | 0.0395 | 0.032 | 0.0269 | 0.0275 | 0.0276 |
| zone 4 | 0.0355 | 0.0288 | 0.0242 | 0.0247 | 0.0248 |
| zone 5 | 0.0533 | 0.0433 | 0.0364 | 0.0371 | 0.0372 |

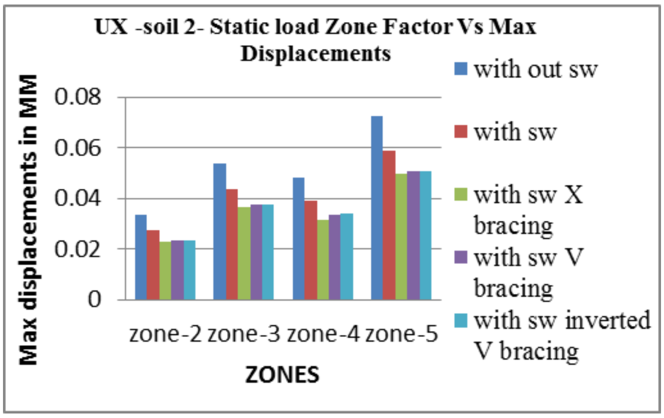
Table-1 Showing Lateral Displacements with respect to all Zone Factors FOR Soil Type-I in Ux Direction Loading Static




Graph-13 showing max displacement for different zones & soil-1 along UX

| zones | lateral displacements | | | | |
|---|---|---|---|---|---|
| | With out SW | with SW | with SW x Bracing | with SW V Bracing | with SW inverted V Bracing |
| zone 2 | 0.0335 | 0.0272 | 0.0229 | 0.0234 | 0.0234 |
| zone 3 | 0.0537 | 0.0436 | 0.0366 | 0.0376 | 0.0374 |
| zone 4 | 0.0483 | 0.0392 | 0.0316 | 0.0316 | 0.0336 |
| zone 5 | 0.0724 | 0.0588 | 0.0495 | 0.0495 | 0.0505 |

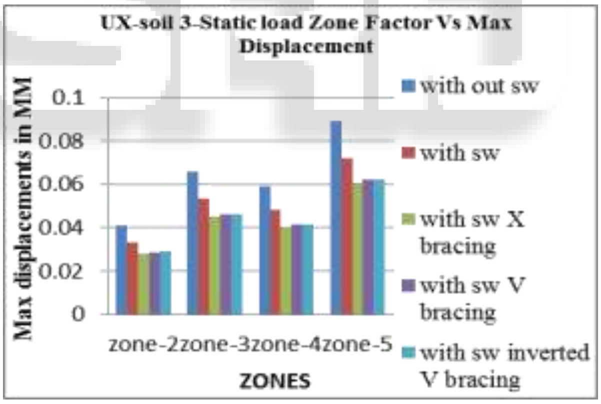
Table-2 Showing Lateral Displacements with respect to all Zone Factors FOR Soil Type-II in Ux Direction Loading Static




Graph-14 showing max displacement for different zones & soil-2 along UX

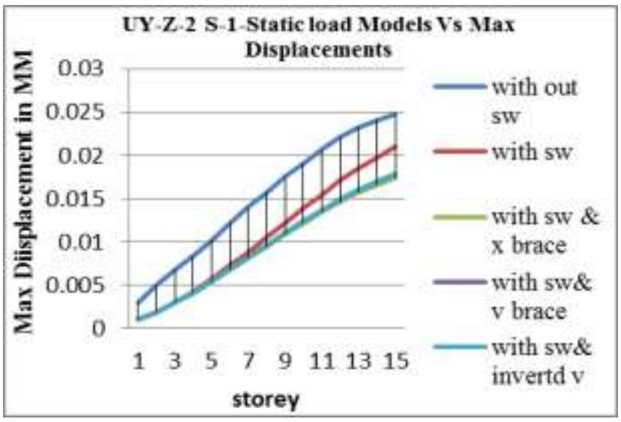
| zones | lateral displacements | | | | |
|---|---|---|---|---|---|
| | without SW | with SW | With SW x Bracing | with SW V Bracing | with SW inverted V |
| zone 2 | 0.0412 | 0.0334 | 0.0281 | 0.0287 | 0.0288 |
| zone 3 | 0.0659 | 0.0535 | 0.045 | 0.0459 | 0.0461 |
| zone 4 | 0.0593 | 0.0482 | 0.0405 | 0.0413 | 0.0414 |
| zone 5 | 0.089 | 0.0722 | 0.0607 | 0.062 | 0.0622 |

Table-3 Showing Lateral Displacements with respect to all Zone Factors FOR Soil Type-III in Ux Direction Loading Static



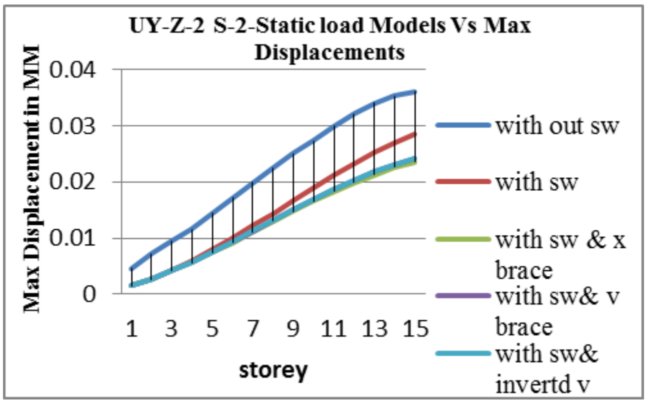

Graph-15 showing max displacement for different zones & soil-3 along UX

## IV. DISPLACEMENT ALONG UY WITH STATIC LOADING

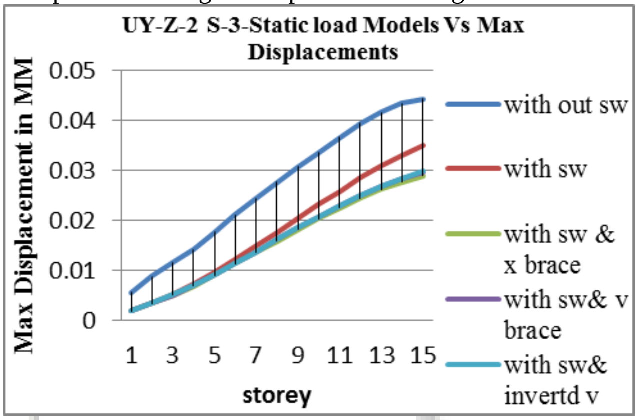



Graph-16 showing the displacement along UY in Z-2 S-1

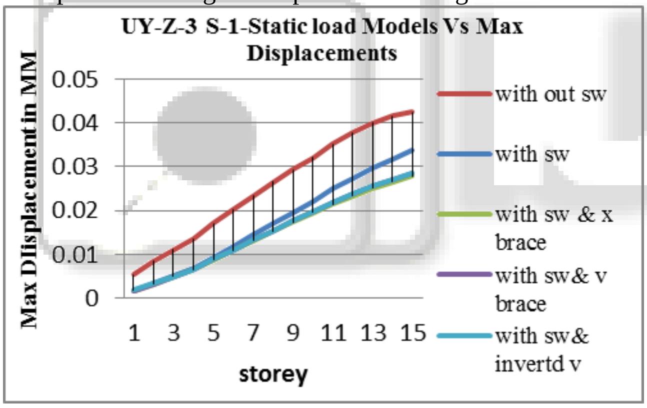
 



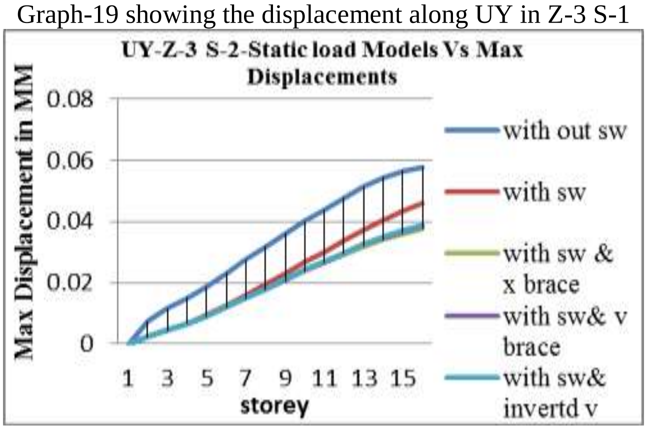

Graph-17 showing the displacement along UY in Z-2 S-2



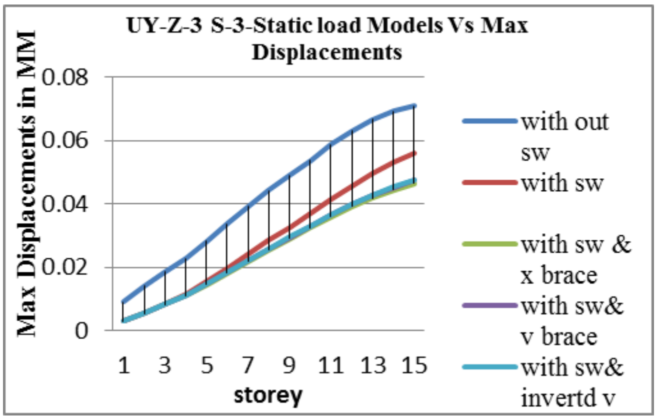

Graph-18 showing the displacement along UY in Z-2 S-3



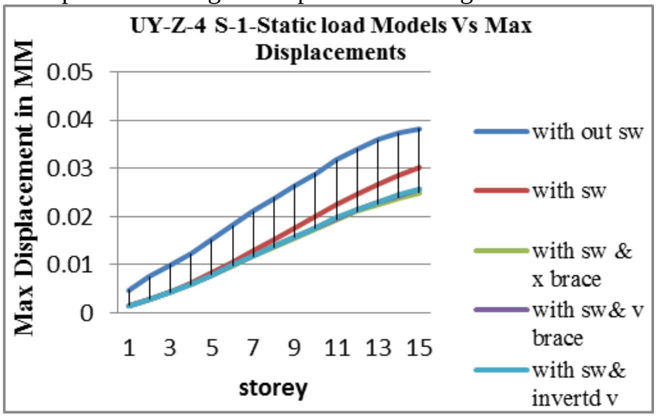

Graph-19 showing the displacement along UY in Z-3 S-1



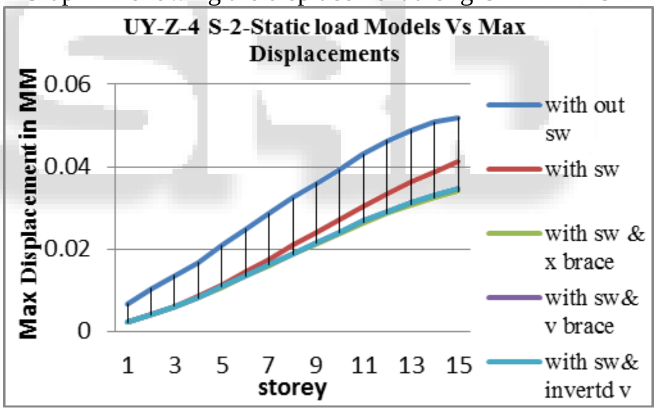

Graph-20 showing the displacement along UY in Z-3 S-2



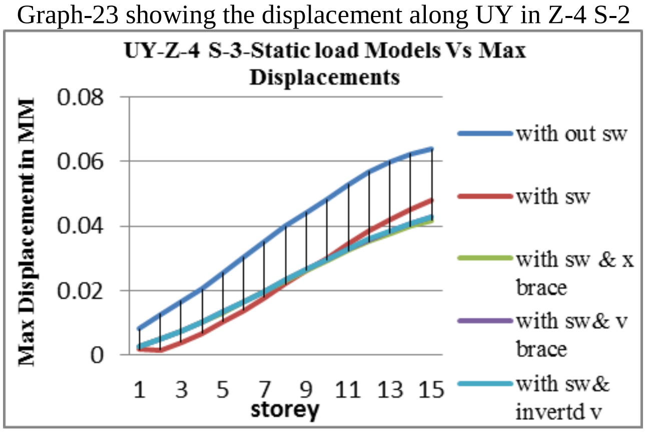

Graph-21 showing the displacement along UY in Z-3 S-3




Graph-22 showing the displacement along UY in Z-4 S-1

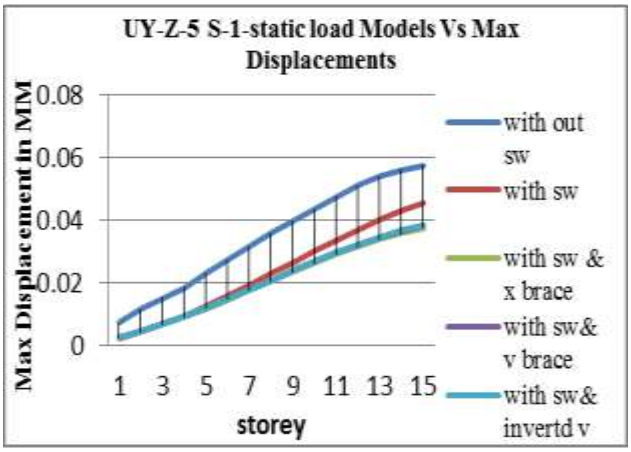



Graph-23 showing the displacement along UY in Z-4 S-2

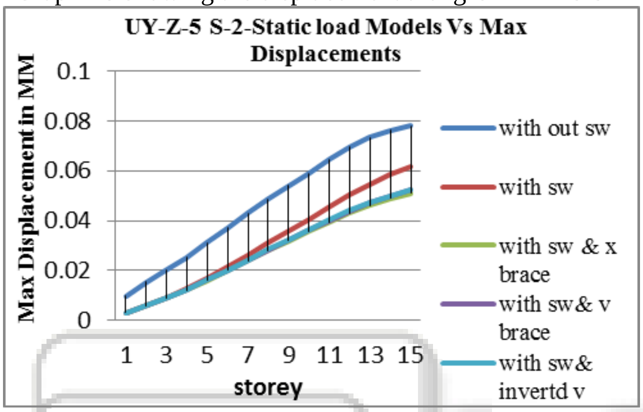



Graph-24 showing the displacement along UY in Z-4 S-3

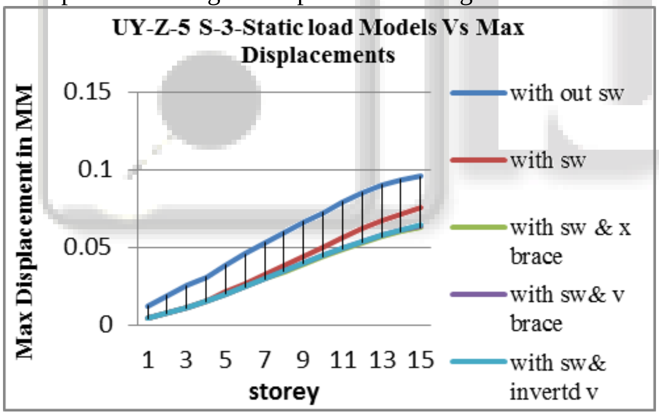
 




Graph-25 showing the displacement along UY in Z-5 S-1



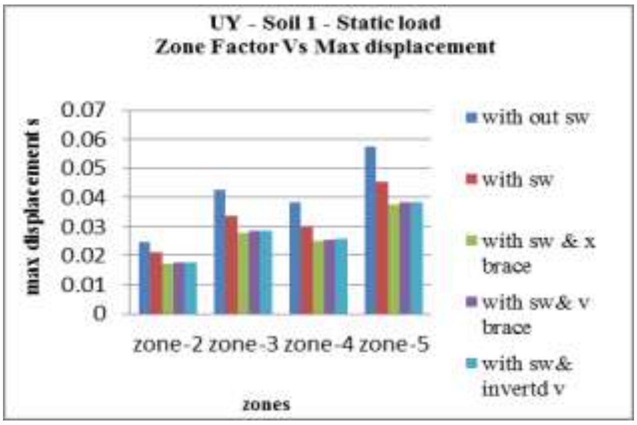

Graph-26 showing the displacement along UY in Z-5 S-2




Graph-27 showing the displacement along UY in Z-5 S-3

| zones | lateral displacement | | | | |
|---|---|---|---|---|---|
| | with out sw | with sw | with sw X Bracing | with sw V Bracing | with sw inverted V Bracing |
| zone 2 | 0.0247 | 0.021 | 0.0174 | 0.0178 | 0.0178 |
| zone 3 | 0.0425 | 0.0337 | 0.0278 | 0.0284 | 0.0285 |
| zone 4 | 0.0383 | 0.0303 | 0.025 | 0.0256 | 0.0257 |
| zone 5 | 0.0574 | 0.0454 | 0.0375 | 0.0383 | 0.0385 |

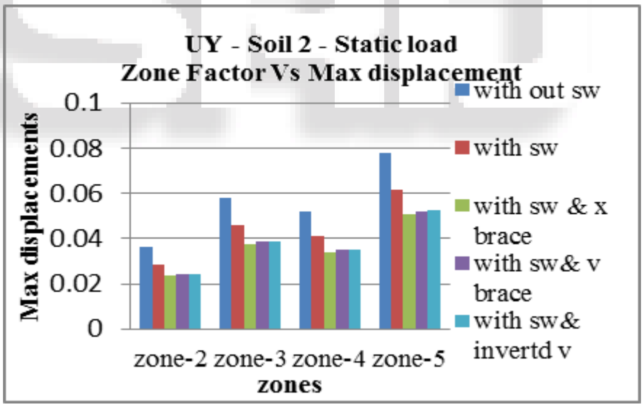
Table-4 Showing Lateral Displacements with respect to all Zone Factors for Soil Type-I in UY Direction Loading Static




Graph-25 showing max displacement for different zones & soil-1 along UY

| zones | lateral displacement | | | | |
|---|---|---|---|---|---|
| | with out sw | with sw | with sw X Bracing | with sw V Bracing | with sw inverted V Bracing |
| zone 2 | 0.0361 | 0.0286 | 0.0236 | 0.0241 | 0.0242 |
| zone 3 | 0.0578 | 0.0458 | 0.0378 | 0.0386 | 0.0388 |
| zone 4 | 0.052 | 0.0412 | 0.034 | 0.0348 | 0.0348 |
| zone 5 | 0.078 | 0.0618 | 0.051 | 0.0522 | 0.0523 |

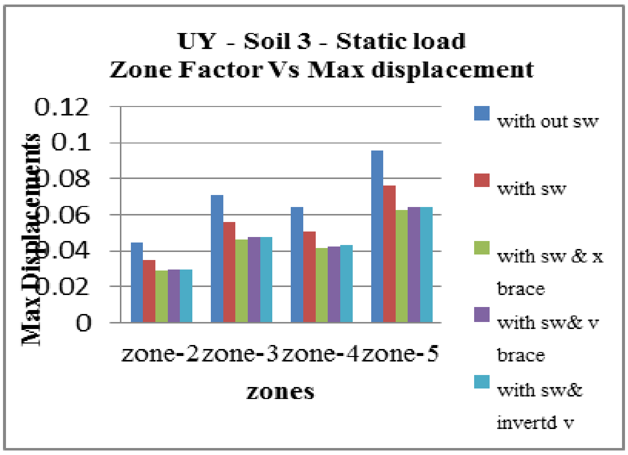
Table 5: Showing Lateral Displacements with respect to all Zone Factors for Soil Type-II in UY Direction Loading Static




Graph-26 showing max displacement for different zones & soil-2 along UY

| zones | lateral displacement | | | | |
|---|---|---|---|---|---|
| | with out sw | with sw | with sw X Bracing | with sw V Bracing | with sw inverted V Bracing |
| zone 2 | 0.0444 | 0.035 | 0.029 | 0.0296 | 0.0298 |
| zone 3 | 0.071 | 0.0562 | 0.0464 | 0.0474 | 0.0476 |
| zone 4 | 0.0639 | 0.0506 | 0.0418 | 0.0427 | 0.0428 |
| zone 5 | 0.0958 | 0.0759 | 0.0627 | 0.064 | 0.0643 |

Table-6 Showing Lateral Displacements with respect to all Zone Factors for Soil Type-III in UY Direction Loading Static




Graph-27 showing max displacement for different zones & soil-3 along UY

## V. CONCLUSIONS

- The structural performance is analysed in both the directions i.e., UX & UY for five different models i.e.,, without SW, with SW, with SW & X bracing, with SW & V bracing , with SW & inverted V bracing but the displacement is reduced only when the lateral systems are provided.
- Soil wise i.e., soil-1 soil-2, soil-3 Displacement is decrease in without shear wall and with shear wall and providing Bracings also decreases in soil wise.
- Zone wise i.e., zone-2, zone-3, zone-4, zone-5, the displacement is increase when the lateral systems are providing.
- Which the provision of bracings, infills the stiffness of the structure is increasing and there by the base shear is decreasing with the increase in height of the structure.

## REFERENCES

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